Creative Sensor Technology

Frequently Asked Questions

Flow Sensors
Series FSI-S



The following questions have been asked about CST flow sensors. Before calling CST Customer Support, please review to see if your question may be answered here.

1. Explain the difference between flow rate and velocity.

Flow rate is a measurement of the volume of water moving through the pipeline in a period of time and velocity is the measurement of its speed. In the United States in non-agricultural irrigation applications, flow rate is most commonly expressed in gallons per minute or gpm. Other common measurements of flow rate are: gallons per hour, liters per second, or cubic feet per minute. All of these are measurements of volume per unit of time. Velocity is a description of how far something moves in a period of time and is generally stated in feet per second (f/s). Flow rate and velocity are inter-related.

Volume changes with the pipe size:

1 foot of water in a 11/2 inch pipe contains .12 gallons
1 foot of water in a 3 inch pipe contains .41 gallons
1 foot of water in a 6 inch pipe contains 1.46 gallons.

So, at a constant velocity of 1 f/s the flow rate increases with the pipe size from 7.2 gpm in 1-1/2 inch pipe to 24.6 gpm in 3 inch and to 87 gpm in the 6 inch pipe.[1] Conversely, at any given velocity the flow rate goes down as the pipe size goes down. If you keep the flow rate constant, then the velocity goes up as the pipe size is decreased and the velocity goes down as the pipe size increases.

1. To convert f/s to gpm multiply the volume of water in one foot of pipe length times 60 to get the flow rate in gpm for each pipe size.

2. How do I size a flow sensor?

Flow sensors should be sized to accommodate the range of flows they will measure, rather than match the size of the pipeline. Generally accepted design practices recommend that the maximum velocity of water in PVC piping systems does not exceed velocities of 5 feet per second (f/s). Keeping the velocity below this level helps minimize the effects of water hammer and protects the pipe. In addition, pipe size may be oversized to reduce pressure drop caused by friction losses.

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Irrigation systems don't operate at a fixed flow rates; there are always variations in the size of flow zones or differences in the types of sprinkler heads or emitters used. Often times the velocity in the pipeline is far less than the maximum flow and can be so low that it can't be detected. No flow sensor can measure down to zero flow. There is always a minimum flow rate or velocity below which there is not enough energy in the water to turn the impeller and generate a flow signal. CST flow sensors have a wide measurement range from ¼ foot per second to 15 feet per second. This means that a 2 inch flow sensor can easily handle the design flow rate of a 3 inch pipeline without exceeding its maximum velocity[1]. More often, the lower limit of the flow range is far more important. With the new water conserving technology of stream rotors, micro-sprays and low volume drip emitters, it is easy to reduce irrigation zone flow rates below minimum velocity ranges of line-sized sensors.[2] Check the irrigation program or flow zones to determine minimum and maximum flow rates. Then use this table to select the flow sensor size with the best fit between these ranges.

CST Flow Sensor Model		FSI-T10	FSI-T15	FSI-B15	FSI-T20	FSI-S30	FSI-S40	FSI-S60
Nominal Pipe Size		1"	1 1/2"	1 1/2"	2	3	46	6
Sensor Type		PVC Socket Tee	PVC Socket Tee	Brass FTHD Tee	PVC Socket Tee	PVC Saddle	PVC Saddle	PVC Saddle
	FEET/SEC	GPM	GPM	GPM	GPM	GPM	GPM	GPM
Minimum Flow	0.25	0.86	1.8		2.8	6	10	
	0.50	1.72	3.6	2.8	5.6	12	20	45
	12	42	87	66	136	288	480	1080
Maximum Flow [1]	15	52	108	83	170			
Working Pressure Rating		240 psi	240 psi	250 psi	240 psi	150 psi	150 psi	150 psi
Friction loss at Maximum flow		0.25 PSI	0.18 PSI	0.18 PSI	0.15 PSI	0.15 PSI	0.15 PSI	0.15 PSI

Note 1 Number represents a practical maximum, sensors can operate at triple the stated velocity

The CST sensor is designed for minimal pressure loss at high velocities, so pressure drop should not be a concern when reducing sizes.

1. 5 f/s velocity in 3 inch Class 200 PVC is 123 gpm. The same flow rate in a 2 inch CST flow sensor is 11 f/s, below its maximum range of 15 f/s. So a 2 inch sensor can handle the design flow of a 3 inch pipe.
2. At the low end of the range, ¼ f/s in 3 inch Class 200 PVC is 6 gpm while ¼ f/s in a 2 inch flow sensor is just under 3 gpm. Not only will a 2 inch sensor accommodate the maximum design flow rate of 3 inch pipe but it will also measure flow at more critical lower flow rates.

3. What is a K and Offset?

K and Offset numbers are the calibration constants used to convert the frequency produced by the turning flow sensor impeller into a measurement of flow rate. When a flow sensor impeller is turned by the water flowing through the sensor tee, it produces an electrical data signal that is proportional to its speed**.** The raw signal is measured in pulses per second or frequency. This frequency is converted into a unit of measure like gallons per minute (GPM) using the formula:

FREQUENCY = (GPM / K) – Offset.

The K number or “Constant” is a specific multiplier for the unit of measure and tee size for each CST flow sensor. A second number, called the Offset, is added to the formula to account for the slippage of the impeller in the fluid. Adding this Offset number to the formula improves the sensor accuracy.

The K and Offset numbers for gallons per minute are listed for each flow sensor size in the Flow Sensor Installation Guide (shipped with each sensor) and they are available by visiting our website www.creativesensortechnology.com or by calling customer service at 508-763-8100. Conversion factors for other units of measurement are available upon request.

Remember, the K and Offset numbers are specific for each CST flow sensor size. Do not attempt to use K and Offset numbers from another manufacturer.

4. How far away from a controller can I install a flow sensor?

Generally speaking, you may install a flow sensor up to 2,000 feet from the controller or other receiving device using a shielded and jacketed twisted pair communication cable. The type of jacketing may vary with the type of installation. For underground installation, the cable must be rated UF and may require armor or conduit for extreme situations. Size of the conductors is not as important as the twisting and shielding because flow sensor signals are more subject to interference from outside sources than from line losses. Outside interference may be generated by electrical wiring for motors, lights or signals that cross or pass close by the flow sensor cable. Interference may result in momentary loss of flow signal or an increase in signal frequency resulting in flow measurement errors. The chance for interference increases with the increase in distance between the flow sensor and the receiving device. Use good installation practices when installing communication cables. Also avoid splices in the flow sensor cable if possible. If splices are required, make sure they are mechanically tight, waterproofed and shielded. In longer runs, over 500 feet, it is always a good practice to connect one end (only) of the cable shield to a properly installed 8 foot copper ground rod.

5. What is the pressure rating of the flow sensor?

CST flow sensors have been burst tested at independent laboratories. The results of these destructive tests allow us to rate our 1, 1 ½ and 2 inch sensors at a working pressure of 240 psi.

6. Why do I need sections of straight pipe before and after the flow sensor?

The straight sections of pipe eliminate distortions in the water flow that cause inaccurate measurements. When water moves through a pipeline at the rates associated with pressurized irrigation systems, it moves at about the same velocity all across the pipe. It moves a little faster in the center of the pipe and a little slower closer to the inside wall in a predictable shape called a ballistic profile. When water is forced to bend around an elbow, the water takes a longer path around the outside than the inside changing the local velocity and distorting the profile. Other distortions may be caused by valves or fittings that produce eddy currents (swirls in the flow) as they change the path of the water. If these profile distortions are close to the sensor impeller they will change its speed and produce inaccurate measurements.

The minimum length of straight pipe needed to correct these distortions is generally given as 10 times the diameter of the pipe before (upstream of) the flow sensor and 5 times the diameter of the pipe after (downstream of) the sensor. If possible, provide more than these minimum lengths.

7. Is the CST sensor output the same as a Data Industrial sensor?

Yes, from an electrical standpoint, the signal output is the same as Data Industrial's. Any controller that will accept a Data Industrial flow sensor input can use the flow signal from a CST sensor. There is however, a difference in the calibration constants used to convert the signal into a flow rate. The control device receiving a flow signal from a CST sensor needs to be reprogrammed to accept the unique K and Offset numbers for each sensor. For help in reprogramming, consult the controller operator's manual or call CST Customer Service.

8. Will a flow sensor still work if the pipe isn't full?

It might, depending on how it's mounted on the pipe, but unless the pipe is full, the measurement won't be accurate. The sensor has a small impeller that is turned by the moving water. It measures the speed or velocity of the water. The speed is then converted into a volumetric flow using a formula containing the conversion factors or **K** and **Offset** numbers. These numbers, unique for each sensor size, are based on the area inside the tee and assume that the area is filled with water.

9. Can I measure flow in a vertical pipe?

Yes, as long as the pipe is full. If the direction of flow is up and you observe our minimum requirements for straight pipe, you may assume the pipe is full and the sensor will measure accurately. If the flow direction is down however, the pipe may not be full unless there is sufficient back pressure. In closed irrigation systems with valves and sprinklers that create backpressure, then most likely the pipe is full and the sensor will measure accurately. Be cautious with piping systems that have open discharges, it's common for these to be only partially full.

10. Does the sensor need to be installed in a certain position?

The sensor may be installed radially around the pipe in any position. Sensor tees are usually positioned with the insert located in the 12:00 o'clock position in underground piping systems for ease of service through an access box. In complex installations involving multiple pipelines and equipment in restricted locations, make sure to install the sensor in a position that allows removal of the insert by providing at least 3 ¾ inches clearance over the tee. This may require installing the sensor at an angle away from the vertical position.

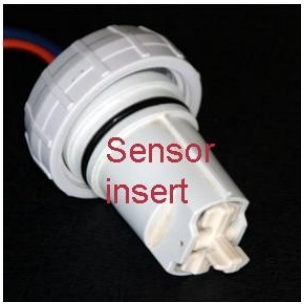
11. What happens if I put the sensor in backwards?

The sensor should always be installed with the printed arrow pointing in the direction of flow because the calibration constants were developed with flow in this direction.



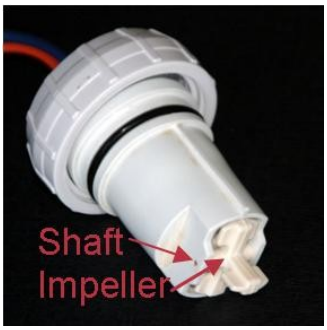
The sensor insert and the tee are keyed so the sensor can only be properly installed in one direction. The sensor insert has a small arrow embossed on its top edge that should point in the same direction as the arrow printed on the tee. Both of these indicators should point towards the downstream flow in the pipe and away from the source. When installing the insert into the tee, rotate the insert until you feel the ridge enter the guide slot before tightening the retaining nut.

12. Can I use the insert from one size sensor in another size tee?



Yes, any CST insert that has a model number ending in -001 may be used in any size FSI series tee. However, there are flow sensor inserts with different electronic configurations that are specific to one size or have different uses. If the last three digits of the model number are not –001, check with CST Customer Service.

13. Can I wear out a sensor?



Yes, over time, the impeller and shaft may become worn and need to be replaced. Wear depends on how much time the sensor is used, the amount and kind of solids suspended in the water and the speed or velocity that the water is flowing. Replacement parts are available by ordering the FSI-T00-01 Repair Kit.

14. Can I connect a flow sensor to more than one controller?



Yes, if you electrically isolate the output to each controller using an Isoflow manufactured by CST or a similar device. Every two wire flow sensor draws its power and sends its signal along the same wires. Connecting any device to two different power supplies may cause problems because of differences in the voltage levels or current cycles. The cross connection of two flow sensor inputs can cause erroneous readings and may cause permanent damage to the controller circuitry.

See our website for more information about CST Isoflow devices.

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15. How do I troubleshoot a flow sensor?

You think water is flowing but your display reads zero flow. How do you decide if the problem is with the flow sensor or somewhere else? If you could remove the sensor from the mounting tee and spin the impeller by hand, you could tell instantly. But in a pressurized, water filled piping system, there is rarely a way to isolate the sensor and remove it. The next best thing is to eliminate every other possibility in the flow monitoring scheme.

A. Check the controller to confirm that the flow sensor circuit is turned on and the correct sensor size and parameters are programmed in.

B. Check the piping system. In a looped system, or one with multiple points of connection, it is possible to back feed or provide an alternative path for the water to flow. Make sure that no valves are closed blocking flow to the flow sensor.

C. Recheck the wiring to make sure the Red (+) lead of the flow sensor is connected to the + terminal of the controller and the Black (-) lead is connected to the – terminal. Make sure to maintain polarity when extending sensor cables. If the wires are reversed, the sensor will not be harmed, but it will not produce a signal.

D. To check all the wiring, splices and the controller circuit, go to the flow sensor and disconnect it from the field wiring. Take the bare ends of the field wiring that leads back to the controller and tap (don't hold) the two wires together at about one second intervals. Touching the wires together will simulate the flow sensor signal and produce a flow rate on the controller display. Tapping the wires together faster will display a higher flow rate. Make sure the controller is in the flow monitoring mode. This might mean starting a manual program. If the controller displays flow, then the controller and the wire path is good.

E. If no flow rate is displayed, then disconnect the field wiring at the flow sensor input terminals of the controller, make a jumper out of a short length of wire and perform the "tap test" again across the flow sensor input terminals. If the controller now displays a flow rate, then the problem is in the field wiring, but if not, the problem is in the controller.

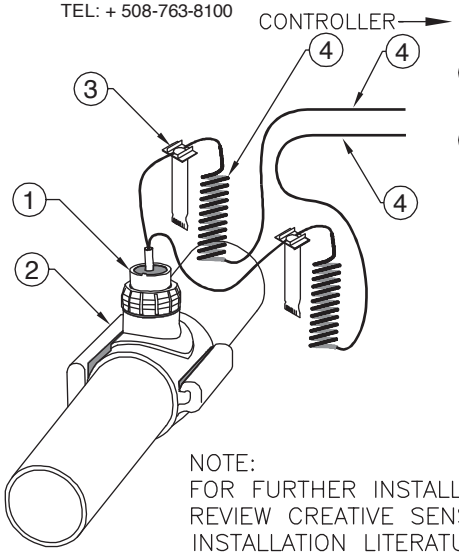
F. Isolate field wiring problems using the process of elimination.

1. Most wiring problems resulting in "no flow" readings are the result of an open or break in the wire. A short circuit will usually blow a fuse or trip a circuit breaker.
2. Check any known splices first.
3. Check any location where trenching or digging may have crossed the wire path and caused a break.
4. Divide the total distance of the wire path in half and check the integrity of each half with a cable fault finder or ohm meter.
5. Keep dividing the problem length in half to locate the cable break or reduce the problem area to a manageable length.

G. When all the above possibilities have been checked and eliminated, then make sure that the system is depressurized and drained before attempting to change the flow sensor. Serious injury may occur if you loosen the retaining nut of a sensor under pressure.

H. Remove the sensor from the tee and with the wires attached, spin the impeller to see if it produces a flow display on the controller. If it does, check to see that it spins freely. If not, remove the impeller by pressing the shaft out of the housing to clean or replace it. Also examine the interior of the mounting tee and remove any foreign material that could hinder the impeller from turning. After cleaning, if the sensor does not display a flow on the controller, replace the sensor insert.

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1. FLOW SENSOR – CREATIVE SENSOR TECHNOLOGY SERIES FSI–SXX. SIZE FLOW SENSOR FOR GPM REQUIREMENTS OF SYSTEM. SEE SIZING CHART.
2. PVC SADDLE, SEE MATERIAL SCHEDULE ON PLANS FOR SIZE. CONTRACTOR WILL SPECIFY SIZE OF SADDLE WHEN ORDERING. USE 1 3/4–INCH HOLE SAW ONLY TO DRILL ENTRY HOLE IN PIPE.
3. WATERPROOF WIRE SPLICE, 3M SCOTCHPACK OF EQUIVALENT, 2 SPLICES ARE REQUIRED.
4. DIRECT BURIAL 1 PAIR, TWISTED SHIELDED CABLE–MINIMUM CONDUCTOR SIZE 20 AWG. DO NOT EXCEED 2,000 FEET IN LAYING DISTANCE FROM FLOW SENSOR TO IRRIGATION CONTROLLER. INSTALL WITH A MINIMUM OF 30–INCH LOOPED WIRE EXPANSION COIL.

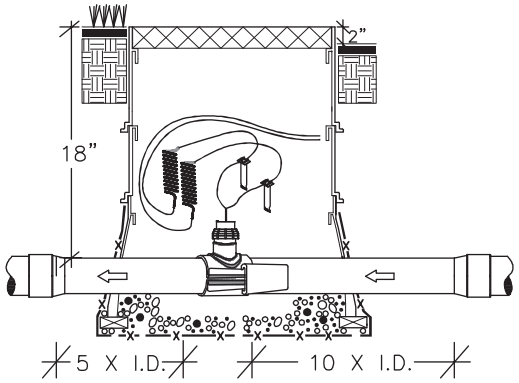
SIZING CHART:

MODEL#	SIZE	OPERATING RANGE–GPM
FS300P	3"	6 – 300
FS400P	4"	10 – 480

NOTE:
FOR FURTHER INSTALLATION INSTRUCTIONS REVIEW CREATIVE SENSOR TECHNOLOGY INSTALLATION LITERATURE.

NOTE:
THE CONTRACTOR MAY REDUCE PIPE SIZE TO KEEP FLOW SENSOR SIZED TO PROJECT REQUIREMENTS. PIPE SIZE TRANSITIONS MUST BE MADE 10 PIPE DIAMETERS UPSTREAM AND 5 DIAMETERS DOWNSTREAM OF SENSOR. MAKE SURE DIRECTION ARROW POINTS IN DIRECTION OF FLOW.

TYPICAL INSTALLATION



DO NOT INSTALL FITTING'S OR OTHER EQUIPMENT 10 PIPE DIAMETERS UPSTREAM OF FLOW METER OR 5 PIPE DIAMETERS DOWN–STREAM.

1 PVC SADDLE MOUNT FLOW METER

N.T.S.

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