Technical Reference Section: Flow

Velocity-based Flow Measurement Technologies

All of the flow sensors featured in the +GF+ SIGNET catalog belong to the broad category of velocity-based flow measurement devices. This vast offering includes paddlewheel, electromagnetic, vortex, in-line rotor, and turbine flow sensors. Principles of operation vary considerably for each type, but some very important installation considerations are common throughout. The following discussion plus the general selection guidelines at the front of the catalog should help the user choose the appropriate sensor type and obtain optimal flow measurement results.

All manuals, data sheets, and additional helpful information are available at **www.gfsignet.com.**

Fully Developed Turbulent Flow

Velocity-based flow sensors depend on fully developed turbulent flow for accurate and repeatable measurements. Fully developed turbulent flow occurs in Newtonian fluids with a Reynolds Number (Re) greater than 4,500. Low flow rates, viscous liquids, and large pipe sizes make fully developed turbulent flow more difficult to achieve. The opposite is also true. That is, for a given set of conditions, simply reducing the pipe size to increase the local flow velocity will produce a higher Reynolds Number.

Note: Vortex sensors require higher minimum thresholds than paddlewheel sensors.

Re: Reynolds Number

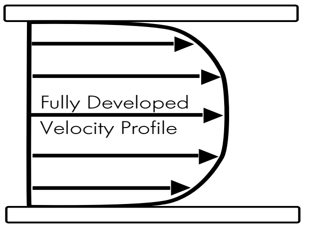
Re = 3,162.76 x Q x Sg/(μ x ID)

where: Q = Flow Rate in US GPM
Sg = Specific Gravity
μ = Dynamic Viscosity in Centipoise (cP)
ID = pipe inside diameter in inches

OR

Re = DN x V/ν

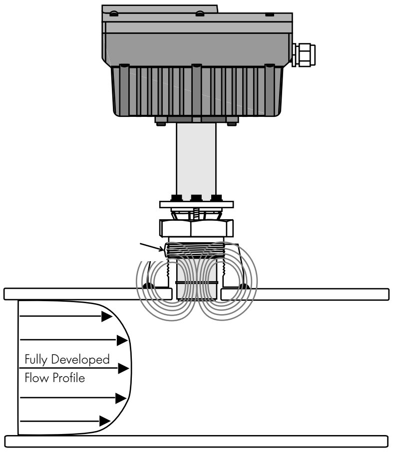
where: DN = pipe inside diameter (m)
V = flow velocity (m/s)
ν = kinematic viscosity (m^2/s)
(ν of water = 1×10^{-6} m^2/s)



Principles of Operation

- **Electromagnetic** flow sensors, like +GF+ SIGNET's Models 2550 and 2560, operate on Faraday's principle of electromagnetic induction, and have no moving parts. As fluid (must be conductive) moves through the magnetic field produced at the sensor tip, a voltage occurs that is directly proportional to the fluid velocity. Internal electronics then convert this voltage into a frequency and/or a 4 to 20 mA output. +GF+ SIGNET electromagnetic flow sensors are insertion-style, suitable for use in a wide range of pipe sizes.

2550 or 2560



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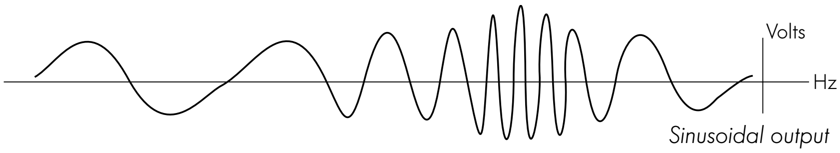
Principles of Operation (continued)

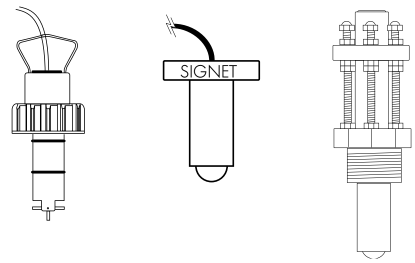
- **Paddlewheel** flow sensors are insertion devices, mounted perpendicular to the piping system, and rely upon the energy in the flow stream to spin a rotor (paddlewheel) around a stationary shaft. Most paddlewheel flow sensors utilize rotors with magnets embedded in each blade. The magnets are typically used either in conjunction with a coil internal to the sensor housing to produce a sinusoidal output (self-generating, non-powered sensors), or to trigger an internal electronic switch to produce a square-wave output (transistor-type, powered sensors). Either way, the resulting frequency is directly proportional to the fluid velocity.

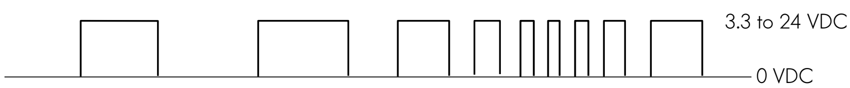


Sinusoidal output

1) Sinusoidal sensors output a signal typical of self-generating, non-powered paddlewheel sensors such as the Model 515, 525, or 2517. The frequency and amplitude (voltage) both vary directly with flow rate.

515 *525* *2517*

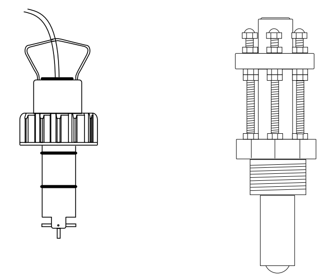




Square wave output

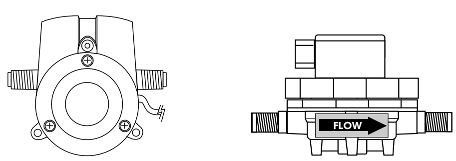
2) Transistor-type sensors output a signal typical of powered sensors such as the Model 2536, 2540, and all other +GF+ SIGNET powered flow sensors with frequency output.

2536 *2540*



- **In-Line Rotor** flow sensors like the +GF+ SIGNET Models 2000 and 2507 are similar to paddlewheel sensors, except the rotor is positioned in a flow cell. These types of sensors have a transistor-type output signal and are able to measure lower flow rates.

2000 *2507*



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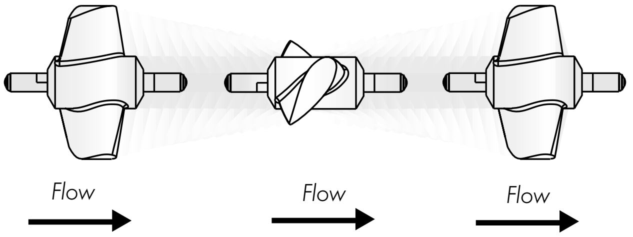
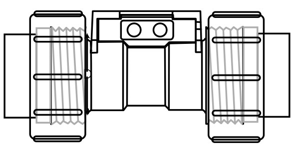
Principles of Operation (continued)

- **Turbine** flow sensors are full-bore devices designed for low-flow measurements. +GF+ SIGNET Model 2100 is offered in 6.4 mm and 12.7 mm (1/4 in. and 1/2 in.) line sizes. Many self-aligning end-connector options are available for installation simplicity and application versatility. Similar to paddlewheels, they rely upon the energy in the flow stream to spin a rotor (turbine). The difference is that the shaft is in the center of, and parallel to, the flow stream. The velocity of the fluid spins the turbine for detection by external electronic circuitry, producing a transistor-type square wave output with a frequency directly proportional to the flow rate.

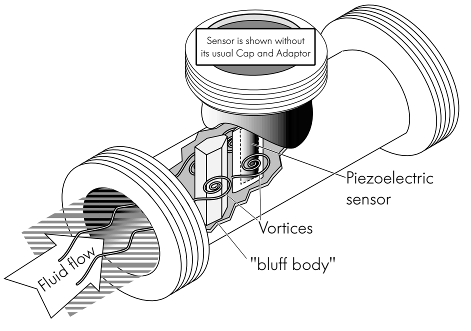


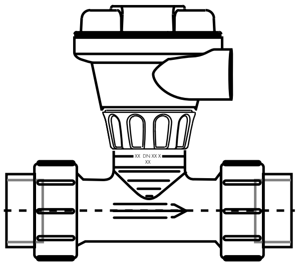
2100



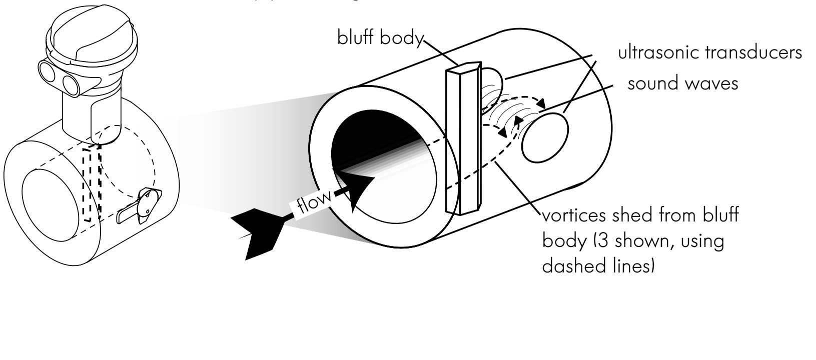
- **Vortex** flow sensors have no moving parts and utilize a naturally occurring phenomenon in which whirling masses of liquid, or vortices, are shed downstream of a stationary object within a flow stream, and at a rate directly proportional to the velocity of the flow stream. Each vortex causes a local pressure fluctuation that can be detected. +GF+ SIGNET Models 7000 and 7001 Vortex Flow Sensors, sizes DN 15 to DN 50 (1/2 in. to 2 in.), develop vortices around a narrow bluff body and direct them to an encapsulated piezoelectric sensor. +GF+ SIGNET Model 7002 Vortex Flow Sensors, sizes DN 80 and DN 100 (3 in. and 4 in.), utilize a state-of-the-art ultrasonic technique for detecting vortices shed by a bluff body. Factory calibration and electronic conditioning produce an extremely accurate and reliable output that is strictly proportional to the fluid flow rate.

Model 7000/7001Vortex Flow Sensors DN 15 to DN 50 (1/2 in. to 2 in.)





Model 7002 Vortex Flow Sensors DN 80 and DN 100 (3 in. and 4 in.)



Technical Reference Section: Flow

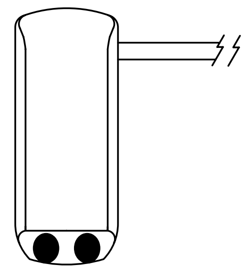
Principles of Operation (continued)

- **Ultrasonic Doppler** sensors have a transducer that emits an acoustic signal which penetrates the fluid flow and is returned after reflecting from particles and air bubbles within the flow. The difference in frequency is proportional to the stream velocity.

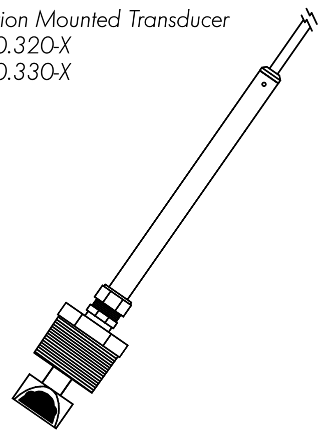
  In full or partially full pipes, the velocity of the flow stream varies markedly across the cross-section of the pipe. Typically, velocity is zero along the wall of the pipe and increases to a maximum at or about the center of the pipe. The +GF+ SIGNET 3300 instrument receives reflected frequencies from particles moving at these different velocities and then calculates the average velocity of the stream.

  Depth is measured with a ceramic-based pressure transducer integrally mounted in a surface mount velocity sensor.

Strap Mounted Transducer
3500.31X-X



Insertion Mounted Transducer
3500.320-X
3500.330-X



View of Cross-Section of Typical Pipe Installation