

# Technical Reference Section: Flow

## Velocity-based Flow Measurement Technologies

All of the flow sensors featured in the Signet catalog, belong to the broad category of velocity-based flow measurement devices. This vast offering includes paddlewheel, electromagnetic, 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 to obtain optimal flow measurement results.

All manuals, data sheets, and additional information are available at [www.gfpiping.com](http://www.gfpiping.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.

### Re: Reynolds Number

$$Re = 3,162.76 \times Q \times Sg / (\mu \times ID)$$

where:

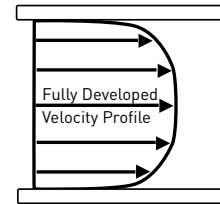
- Q = Flow Rate in GPM
- Sg = Specific Gravity
- $\mu$  = Dynamic Viscosity in Centipoise (cP)
- ID = pipe inside diameter in inches

OR

$$Re = DN \times V / \nu$$

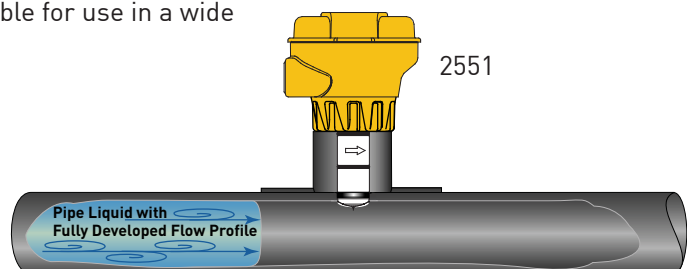
where:

- DN = pipe inside diameter (m)
- V = flow velocity (m/s)
- $\nu$  = kinematic viscosity (m<sup>2</sup>/s)
- ( $\nu$  of water =  $1 \times 10^{-6}$  m<sup>2</sup>/s)



## Principles of Operation

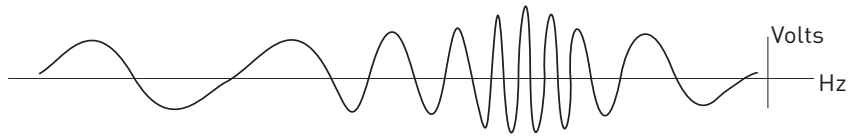
- **Electromagnetic** flow sensors, like Signet's Models 2551 and 2552, operate on Faraday's principle of electromagnetic induction, and have no moving parts. As fluid (must be conductive <math><20 \mu S</math>) moves through the magnetic field produced at the sensor tip, a voltage occurs that is directly proportional to the fluid velocity. Internal electronics then convert this voltage into a frequency and/or a 4 to 20 mA output. Signet electromagnetic flow sensors are insertion-style, suitable for use in a wide range of pipe sizes.



# Technical Reference Section: Flow

## 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.



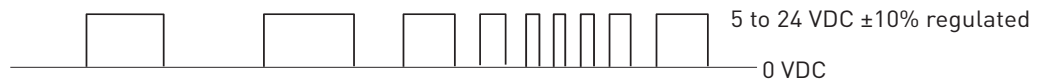
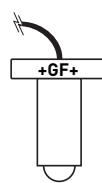
Sinusoidal output

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

515



525



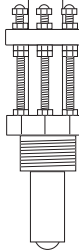
Square wave output

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

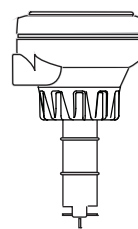
2536



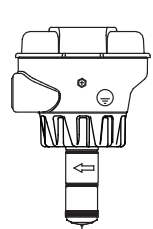
2540



2537



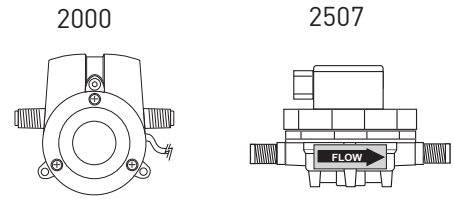
2551



# Technical Reference Section: Flow

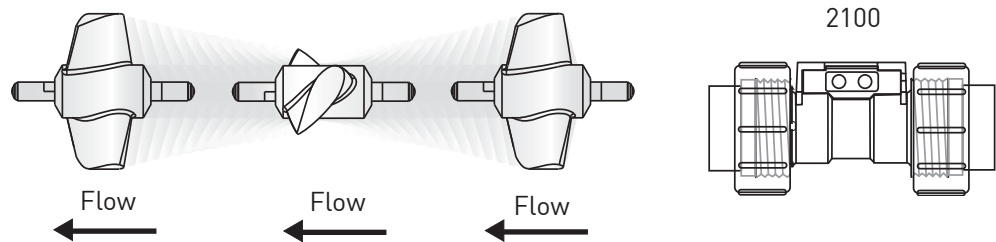
## Principles of Operation (continued)

- **In-Line Rotor** flow sensors like the 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.



- **Turbine** flow sensors are full-bore devices designed for low-flow measurements. 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.



# Technical Reference Section: Flow Flow Range Charts (GPM)

## Paddlewheel and Electromagnetic Sensors

Signet Models 515, 525, 2536, 2537, 2540, 2551, 2552

GPM Flow Rates for DN15 to DN450 (½ in. to 18 in.) pipe sizes

Nominal Pipe Size		2551/2552		2536/8512/2540		515 and 8510		525	
Inch	Metric DN (mm)	Min	Max	Min	Max	Min	Max	Min	Max
		0.15 ft/s	33 ft/s	0.3 ft/s	20 ft/s	1 ft/s	20 ft/s	1.6 ft/s	20 ft/s
0.5	15	0.14	31.25	0.28	18.94	0.95	18.94	1.52	18.94
0.75	20	0.25	54.85	0.50	33.24	1.66	33.24	2.66	33.24
1	25	0.40	88.89	0.81	53.88	2.69	53.88	4.31	53.88
1.25	32	0.70	153.84	1.40	93.24	4.66	93.24	7.46	93.24
1.5	40	0.95	209.40	1.90	126.91	6.35	126.91	10.15	126.91
2	50	1.57	345.15	3.14	209.18	10.46	209.18	16.73	209.18
2.5	65	2.24	492.45	4.48	298.46	14.92	298.46	23.88	298.46
3	80	3.46	760.39	6.91	460.84	23.04	460.84	36.87	460.84
4	100	5.95	1309.40	11.90	793.57	39.68	793.57	63.49	793.57
5	125	9.35	2057.74	18.71	1247.12	62.36	1247.12	99.77	1247.12
6	150	13.51	2971.57	27.01	1800.95	90.05	1800.95	144.08	1800.95
8	200	23.39	5145.63	46.78	3118.57	155.93	3118.57	249.49	3118.57
10	250	36.87	8110.73	73.73	4915.59	245.78	4915.59	393.25	4915.59
12	300	52.33	11512.97	104.66	6977.56	348.88	6977.56	558.20	6977.56
14	350	-	-	126.49	8432.82	421.64	8432.82	-	-
16	400	-	-	165.24	11015.97	550.80	11015.97	-	-
18	450	-	-	209.16	13943.74	697.19	13943.74	-	-

# Technical Reference Section: Flow

## Flow Range Charts (LPM)

### Paddlewheel and Electromagnetic Sensors

Signet Models 515, 525, 2536, 2537, 2540, 2551, 2552

LPM Flow Rates for DN15 to DN450 (½ in. to 18 in.) pipe sizes

Nominal Pipe Size		2551/2552		2536/8512/2540		515 and 8510		525	
Inch	Metric DN (mm)	Min	Max	Min	Max	Min	Max	Min	Max
		0.05 m/s	10 m/s	0.1 m/s	6 m/s	0.3 m/s	6 m/s	0.5 m/s	6 m/s
0.5	15	0.6	117.6	1.2	70.6	3.5	70.6	5.9	70.6
0.75	20	1.0	206.4	2.1	123.9	6.2	123.9	10.3	123.9
1	25	1.7	334.5	3.3	200.7	10.0	200.7	16.7	200.7
1.25	32	2.9	579.0	5.8	347.4	17.4	347.4	28.9	347.4
1.5	40	3.9	788.1	7.9	472.8	23.6	472.8	39.4	472.8
2	50	6.5	1298.9	13.0	779.4	39.0	779.4	64.9	779.4
2.5	65	9.3	1853.3	18.5	1112.0	55.6	1112.0	92.7	1112.0
3	80	14.3	2861.7	28.6	1717.0	85.9	1717.0	143.1	1717.0
4	100	24.6	4927.8	49.3	2956.7	147.8	2956.7	246.4	2956.7
5	125	38.7	7744.2	77.4	4646.5	232.3	4646.5	387.2	4646.5
6	150	55.9	11183.3	111.8	6710.0	335.5	6710.0	559.2	6710.0
8	200	96.8	19365.3	193.7	11619.2	581.0	11619.2	968.3	11619.2
10	250	152.6	30524.2	305.2	18314.5	915.7	18314.5	1526.2	18314.5
12	300	216.6	43328.4	433.3	25997.0	1299.9	25997.0	2166.4	25997.0
14	350	-	-	523.7	31419.1	1571.0	31419.1	-	-
16	400	-	-	684.1	41043.4	2052.2	41043.4	-	-
18	450			865.9	51951.7	2597.6	51951.7		

# Technical Reference Section: Flow

## Flow Range Charts (GPM and LPM)

### In-line Rotor and Turbine Sensors

Signet Models 2000, 2100, and 2507

GPM and LPM Flow Rates

Model and Size:	Description	GPM		LPM	
		Min	Max	Min	Max
3-2000-1X	MicroFlow -Low	0.030	0.700	0.110	2.600
3-2000-2X	MicroFlow - High	0.300	3.200	1.130	12.110
3-2100-XL and -31 Kits	Turbine Low - 1/2" Tubing	0.100	1.000	0.380	3.800
3-2100-XL and -32 Kits	Turbine Low - 3/8" Tubing	0.100	1.000	0.380	3.800
3-2100-XL and -33 Kits	Turbine Low - 1/4" Tubing	0.100	1.000	0.380	3.800
3-2100-XL and -34 thru -38 Kits	Turbine Low - 1/2" Pipe	0.100	1.000	0.380	3.800
3-2100-XH and -31 kits	Turbine High - 1/2" Tubing	0.800	10.000	3.000	38.000
3-2100-XH and -34 thru -38 Kits	Turbine High - 1/2" Pipe	0.800	10.000	3.000	38.000
3-2507.100-2V	Mini Flow - 2mm Insert	0.106	0.740	0.500	2.800
3-2507.100-3V	Mini Flow - 3mm Insert	0.198	1.123	0.750	4.250
3-2507.100-4V	Mini Flow - 4mm Insert	0.330	1.585	1.250	6.000
3-2507.100-6V	Mini Flow - 6mm Insert	0.792	3.170	3.000	12.000