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The Essential Guide to

Flow Measurement

ABB manufactures more types of flowmeters than any other manufacturer and is the only manufacturer who can give totally unbiased advice as to which flowmeter is suitable for a given application. This wall-chart details the 10 major flow measurement techniques, their capabilities and their suitability for an application.

Magnetic

Service: Electrically conductive liquids or slurries (>5µs/cm).

Design Pressure: Up to 3600 psig (250 bar).

Design Temperature: Up to 360°F (180°C).

Flow Range: 4 cc/min to 1,100,000 gpm (240 cm^3/h to 250,000m^3/h).

Scale: Linear.

Signal: Analog electronic; digital; Smart protocols; Bus protocols.

Accuracy: up to ± 0.15% of rate: factory calibrated.

Rangeability: up to 1500:1.

End Connections: Flanged, Sanitary, or Wafer; Dresser and Victaulic ends available in larger sizes.

Sizes: 1/25" to 120" (1mm to 3m) probe available.

Advantages: Widely used in the water industry for both clean and dirty water applications excellent for slurry measurements. Unaffected by changes in fluid density viscosity; zero head loss; by directional; no flow obstruction; dc and battery powered versions available.

Limitations: Liquids or slurries only; required minimum electrical conductivity varies with manufacturer.

Target

Service: Liquids and gases including steam.

Design Pressure: Up to 10,000 psig (690 bar).

Design Temperature: Up to 750°F (400°C).

Flow Range: 0.07 to 7000gpm (0.016 to 1,600m^3/h) liquid; 0.3 to 28,000 scfm. (0.5 to 48,000 Nm^3/h) gas.

Scale: Square root.

Signal: Analog electronic or pneumatic.

Accuracy: ± 0.5% to ± 5% of full scale; factory calibrated.

Rangeability: 3:1*.

End Connections: Flanged, Threaded.

Sizes: Up to 20" (500mm) (sampling types available).

Advantages: No moving parts; relatively inexpensive; good for hot, tarry and sediment bearing fluids.

Limitations: Requires 20 diameters upstream and 10 diameters downstream of straight pipe to maintain accuracy; reading is per cent of scale; limited range.

*10.1 span adjustment plus 3:1 range for any given span setting.

Ultrasonic

	Transit Time (Pulsed type)	Doppler (Frequency shift)
Service:	Relatively clean liquids (some designs for flare gas).	Liquids with entertained gas or suspended solids.
Design Pressure:	Wetted transducer; 100 psig (7 bar) Clamp-on equivalent to pipe rating.	Wetted transducer: 100 psig (7 bar) Clamp-on equivalent to pipe rating.
Design Temperature:	-300°F to 500°F (-180 to 260°C).	-300°F to 500°F.
Flow Range:	Up to 40 ft/sec (12 m/s).	Up to 40 ft/sec (12 m/s).
Scale:	Linear.	Linear.
Signal:	Analog electronic or digital.	Analog electronic or digital.
Accuracy:	± 1% of rate or ± 5% of full scale depending on type and calibration.	± 5% of full scale or better.
Rangeability:	Up to 40:1.	Typically 10:1.
End Connections:	Flanged and Clamp-on design.	Clamp-on versions available.
Sizes:	1/2" (15mm) and upward.	1/4" up (7mm) and upward.
Advantages:	No flow obstruction; can be bi-directional; use with practically any clean liquid. Versions for gas. Clamp-on versions available.	Can handle slurries and aerated liquids; clamp-on version can be installed without process shut-down.
Limitations:	Straight upstream piping required to provide uniform flow profile; clean liquids only.	Not suitable for clean liquids; requires straight upstream piping.

Weirs and Flumes

Service: Liquids in open channels.

Flow Range: From 1/2 gpm (0.1m^3/h) and upward.

Scale: Proportional to the measured head to the 3/2 power for rectangular and trapezoidal weirs and parshall flumes; proportional to the measured head to the 5/2 power for V-notch weirs.

Signal: Analog electronic.

Accuracy: 2% to 5% full scale.

Rangeability: 75:1 rectangular, trapezoidal weirs, Parshall flumes; 50:1 V-notch weirs; Palmer-Bowlus flumes 10:1.

Advantages: Ideal for water and waste flows, flumes have low head loss, low cost.

Limitations: Weirs are more accurate than flumes but require cleaning; flumes are self cleaning.

Mass

	Coriolis Effect	Thermal
Service:	Liquids, slurries and gas.	Gas (some designs for liquid).
Design Pressure:	Up to 6500 psig (450 bar).	Up to 5800 psig (400 bar).
Design Temperature:	Up to 650°F (340°C).	Up to 570° F (300°C).
Flow Range:	Up to 33,000 lb/min (15,000kg/m).	Up to 4000 gpm liquid gas (900m^3/h) Up to 100,000 lb/min (45,000kg/m).
Scale:	Linear.	
Accuracy:	±0.15% of rate or better.	±1% of rate.
Rangeability:	40:1 or better.	100:1 or better.
End Connections:	Threaded, Flanged, Sanitary	Threaded, flanged, hose.
Sizes:	1/16" to 12" (1.5mm to 300mm).	1/8" to 10" (3mm to 250mm) Probe available for pipes up to 3000mm; bypass type available.
Advantages:	Measures mass flow temperature and fluid density directly. Handles difficult applications.	Measures mass flow directly. Very low pressure loss. Good for low velocity gas measurement.
Limitations:	Moderate to high cost. Installation requirements vary with manufacturer. Head loss may be high. Sensitive to plant vibration and fluid pulsation. Care must be taken with 2 phase flow.	Affected by coatings. Some designs are fragile.

Oscillatory

	Vortex Shedding (Bluff body)	Fluidic (Coanda Effect)	Swirlmeter
Service:	Liquids and gases including steam.	Liquids.	Liquids, gases and steam.
Design Pressure:	Up to 3600 psig (250 bar).	Up to 600 psig (40 bar).	Up to 2400 psig (160 bar).
Design Temperature:	Up to 750°F (400°C).	0 to 250°F (-20 to 120°C).	-40°F to 550°F (-40 to 280°C).
Flow Range:	3 to 10, 586 gpm (0.4 to 2400m^3/h) liquid; 100 to 720,000 acfh (20,000m^3/h) gases.	1 to 1000 gpm (0.2 to 230m^3/h).	0.3 to 6600 gpm (0.1 to 1800m^3/h) liquid; 88 to 706,300 acfh (2.5 to 20,000m^3/h) gases.
Scale:	Linear at high Reynolds No.	Linear at high Reynolds No.	Linear at high and low Reynolds No.
Signal:	Frequency or Analog electronic	Analog electronic or pneumatic; pulse.	Pulse or analog output.
Accuracy:	±0.75% of rate or better on liquid: factory calibrated; ± 1% of rate on gas.	±1% of rate or better; factory calibrated.	±0.5% of rate or better; liquids, gas or steam.
Rangeability:	20:1.	Up to 30:1.	25:1 turn down average (determined by size, application)
End Connections:	Flanged, Threaded, Wafer or Insert; also can be used as by-pass meter around mainline orifice.	Mounts between flanges.	Flanged.
Sizes:	1.2" to 12" (15mm to 300mm) (sampling and by-pass types available).	1" to 4" (50mm to 100mm) by-pass types available.	0.5" to 16" (15mm to 300mm).
Advantages:	No moving parts: suitable for wide variety of fluids: excellent combination of price and performance.	No moving parts: suitable for wide variety of fluids: excellent combination of price and performance.	No moving parts, 3 upstream pipe diameters, ideal for light gases, works with entrained liquid.
Limitations:	Straight piping required; sensitive to increasing viscosity below a given Reynolds number.	Straight piping required; sensitive to increasing viscosity below a given Reynolds number.	Limited viscosity range.

			Clean Liquids	Dirty Liquids	Corrosive Liquids	Viscous Liquids	Abrasive Slurries	Fibrous Slurries	Low Velocity Flows	Vapor or Gas	Hi Temp. Service	Cryogenic Service	Semi-filled Pipes	Non-Newtonians	Open Channel
Magnetic		ABB													
Mass	*Coriolis*	ABB													
	Thermal	ABB													
Oscillatory	*Vortex Shedding*	ABB													
	Fluidic														
	Swirlmeter	ABB													
Positive Displacement															
Target															
Turbine		ABB													
Ultrasonic	*Transit Time*														
	Doppler														
Differential Pressure	*Orifice*	ABB													
	Venturi	ABB													
	Flow Nozzles & Tubes	ABB													
	Pilot Tubes	ABB													
	Wedge	ABB													
Variable Area		ABB													
Weirs and Flumes		ABB													

Flowmeter Applications — *Designed for this Service*; *Normally applicable for this service*; *Applicable for this service under certain conditions, consult manufacturer*; *Not applicable for this service*

Differential Pressure

	Orifice	Venturi	Flow Nozzles and tubes	Pitot	Wedge
Service:	Liquids and gases including steam.	Liquids and gases including steam.	Liquids and gases including steam.	Liquids and gases.	Liquids and gases.
Design Pressure:	Determined by transmitter.	Determined by transmitter.	Determined by transmitter.	Determined by transmitter.	Determined by transmitter.
Design Temperature:	Determined by materials.	Determined by materials.	Determined by materials.	Determined by materials.	Determined by materials.
Flow Range:	From 0.1 cc/min (0.1m^3/m) and upward or gas equivalent.	From 5 gpm (1m^3/h) liquid; 20 scfm (30 Nm^3/h) gas; and upward, determined by pipe size.	From 5 gpm (1m^3/h) liquid; 20 scfm (30 Nm^3/h) gas and upwards.	Determined by pipe size.	Determined by pipe size.
Signal:	Analog electronic or pneumatic.	Analog electronic or pneumatic.	Analog electronic or pneumatic.	Analog electronic or pneumatic.	Analog electronic or pneumatic.
Accuracy:	± 0.6% of max flow uncalibrated including transmitter; sizes smaller than 2" usually calibrated.	± 1% of max flow or better; uncalibrated including transmitter.	± 1%full scale including transmitter, flow calibration recommended.	± 1% full scale or better including transmitter.	± 0.5% of actual flow when operated in the calibrated range.
Rangeability:	4:1 for given transmitter span setting.	4:1 for given transmitter span setting.	4:1 for given transmitter span setting.	4:1 for given transmitter span setting.	4:1 for given transmitter span setting.
End Connections:	Mounts between flanges.	Flanged.	Flanged or mounted between flanges.	Insert probe.	Flanged or mounted between flanges.
Sizes:	Determined by pipe size.	Up to 72" (1800mm) larger possible	3" to 48" (80mm to 1200mm).	Unlimited probe length.	Up to 48" (1200mm).
Advantages:	Easy-to-install; uses one transmitter regardless of pipesize; low cost; wide variety of types and material available; easy-to-change capacity. Versions available that do not require power.	Low permanent loss; good for slurries and dirty fluids; uses one transmitter regardless of pipe size.	Economical, low permanent loss; uses one transmitter regardless of pipe size; nozzle commonly used for steam and has higher capacity for same generated D P.	Very low cost; uses one transmitter regardless of pipe size. Averaging types available.	Very economical; easy-to-install; uses one transmitter regardless of pipe size; can be bi-directional; low pressure loss. Minimum upstream piping required.
Limitations:	Uses eccentric orifices or segmental plates for very dirty liquids or slurries; quadrant orifice for viscous liquids; venturi, flow tube, pitot, or elbow taps to reduce energy consumption; straight run of upstream and downstream piping required. Some fluid must leave pipe except when chemical seal protectors are used. Accuracy affected by wear.	Most expensive D P producer; generally limited to air and water; big and heavy especially in larger pipe sizes. Accuracy affected by wear.	Flow tubes lack extensive background data compared to orifice plates; application on viscous liquids limited. Calibration recommended for optimum performance.	Doesn't sample full stream; limited accuracy. Low differential pressure for given flow rate.	Not good for very low velocity.

Positive Displacement

Service: Clean liquids and gases.

Design Pressure: Up to 1400 psig for liquid or gas (100 bar).

Design Temperature: Up to 600°F (315°C) liquids; up to 250°F (120°C) gas.

Flow Range: 0.18 to 9000 gpm (0.04 to 2000m^3/h) liquid; 0 to 100,000 scfh (0 to 2800 Nm^3/h)gas.

Scale: Linear.

Signal: Pulse or analog electronic.

Accuracy: ± 0.5% of rate on liquid; ± 1% of full scale on gas; factory calibrated.

Rangeability: Typically 10:1.

End Connections: Flanged or Threaded.

Sizes: Up to 12" (300mm).

Advantages: Ideal for viscous liquids; good for custody transfer, batching, blending: simplest versions don't require electrical power; very little straight upstream pipe required.

Limitations: Subject to mechanical wear; requires periodic proving; sensitive to dirt and may require upstream filters; larger sizes are excessive in size and weight, may require special installation.

*Ultra-low flow rate versions also available.

Turbine

Service: Clean liquids and gases.

Design Pressure: Up to 60,000 psig (4000 bar).

Design Temperature: - 450° to 1200°F (-270 to 650°C).

Flow Range: 0.001 to 40,000 gpm (200cm^3/h to 9000m^3/h) liquids, up to 10,000,000 scfm (17,000,000 Nm^3/h) gas.

Scale: Linear when Reynolds number is 10,000 or higher.

Signal: Frequency or analog electronic.

Accuracy: ± 0.25% of rate liquids; ± 1% of rate gas: factory calibration should simulate operating viscosity and lubricity for liquids.

Rangeability: 10:1.

End Connections: Flanged, Threaded, Sanitary, Grayloc.

Sizes: Up to 24" (600mm) (sampling types available): also used as by-pass meter around mainline orifice.

Advantages: One of the most accurate liquid meters; good operating range, easy-to-install and maintain very low flowrate designs available; small in size; lightweight. Versions optimised for gas; sampling types for steam. Some versions do not require external power.

Limitations: Sensitive to increasing viscosity; avoid use where state may change from liquid to gas: gas versions require care when used in varying flow rate applications straight upstream pipe is required; flow straighteners may be recommended.

Variable Area

Service: Liquids and gases including steam.

Design Pressure: Up to 300 psig (20 bar) glass tube, Up to 720 psig (52 bar) metal tube.

Design Temperature: Up to 250°F (120°C) glass tube, Up to 1000°F (500°C) metal tube.

Flow Range: Liquids 0.01 cc/min to 300 gpm (0.6cm^3/h to 68m^3/h) gases 0.3cc/min to 2000 scfm (5 Ncm^3/h to 3600 Nm^3/h) gasses.

Scale: Linear.

Signal: Visual; electronic or pneumatic analog.

Accuracy: ± 0.5% of rate to ± 10% of full scale depending on type, size, and calibration.

Rangeability: 5:1 to 12.1.

End Connections: Female pipe threaded or Flanged.

Sizes: Up to 4" (100mm) also used as a by-pass meter around a mainline orifice for larger pipe sizes.

Advantages: Inexpensive; insensitive to viscosity variations below a given threshold; direct indicating; no power required; can be direct mass device; no straight upstream piping required. Versions available with Teflon® liners.

Limitations: Requires accessories for data transmission; must be vertically mounted: gas use requires minimum backpressure.

For **technical advice** and further information on the **ABB** range of flow products call:

0870 600 6122

ABB Instrumentation alliance

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