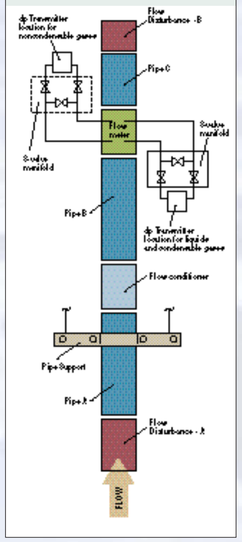
The Essential Guide to **Flowmeter Installation**

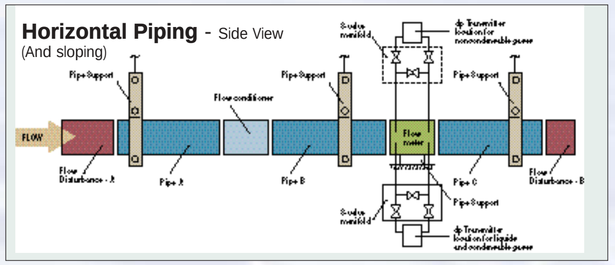
1 Differential Pressure

	Orifice	Venturi/Flow Nozzle	Flow Tube	Elbow	Pitot/Averaging Pitot	VA Meter
Minimum pipe length (diameters):	Concentric, eccentric, conical, quadrant and segmental types: Before plate 10; after plate 4. See Note 15.	Before meter, 6; After meter, 2. Note 15.	Before meter, 4; After meter, none.	Usually the same as a concentric orifice.	Before meter, 7; After meter, 3; Note 15.	None.
Power requirements:	DC or pneumatic.	DC or pneumatic.	DC or pneumatic.	DC or pneumatic.	DC or pneumatic.	None.
Piping connections:	Flanged, threaded, welded.	Flanged, threaded, welded, insert,	Flanged, insert.	Flanged, welded.	Insertion, hot tap.	Flanged, threaded.
Type of measurement:	Whole body. Concentric can be in a bypass configuration.	Whole body.	Whole body.	Whole body.	Sampling.	Whole body, by-pass.
Installation requirements:	Upstream pipe ID, circularity and roughness are important factors. Upstream pipe joints must be smooth and gaskets must not project into the flow.	The average diameter of the pipe at the meter inlet should be within ± 1% of the meter diameter and the pipe roundness should not exceed 2% of nominal. Gaskets must not project into the flow.	Types with manifolds which average local pressure are recommended if less than desirable flow profiles are anticipated.	Bidirectional when pressure taps are at 45º, Flow must enter end nearest pressure taps when using 22.5º taps. Inside diameter of elbow at taps and the radius of the bend must be measured for the best results: Pipe ID and elbow ID must agree within 1%. Gaskets must not project into flow.	Some designs bi-directional. Locate to assure developed turbulent flow.	Meter must be vertical. Avoid piping 2 or more sizes smaller than end connections.
Orientation requirements:	Orifice plate inlet must face upstream. The centerline of concentric orifice plates must be the same centerline as that of the pipe. Plane of orifice must be perpendicular to the centreline. Pressure tap orientation depends upon pipe orientation and the type of fluid being metered; see piping diagram.	Pressure tap orientation depends upon the pipe orientation and the fluid measured.	None.	None.	Dependent on pipe orientation and type of fluid. Tube must be within ± 3% of flow direction (yaw), ± 5% of transverse plane (pitch). And ± 3% of pipe centreline perpendicular to flow (roll).	Must be vertical.
Ancillary equipment requirements	Flow conditioners may be required when upstream straight pipe is limited. Drain, vent and blowoff valves may be needed. Shut off valves are usually. used at each pressure tap location.	Flow conditioners may be required when upstream straight pipe is limited. Shut-off valves are usually used at every pressure tap location.	Flow conditioners may be required when upstream straight pipe is limited.	Flow conditioners may be required when upstream straight pipe is limited, low range differential pressure transmitter required.	Flow conditioners may be required when for some applications , low range differential pressure transmitter required.	None.
Standards or recommended practices	AGA 3, ANSI/API 2530, ANSI/ASME MFC 3M, ASME Fluid meters, ISO 5167, Shell Flowmeter engineering handbook.	ANSI/API 2530, ANSI/ASME MFC 3M, ASME fluid Meters, ISO 5167.	None.	None.	ISO 7174 (pitot).	None.

Vertical Piping
Preferred Flow up



Horizontal Piping - Side View
(And sloping)



PIPING NOTES

Flow conditioner: includes conventional flow straighteners such as tube-bundles, plate or honeycomb types for swirl. For severely distorted flow profiles, jets, or persistent swirl patterns, proprietary flow conditioner designs are recommended for example Sprenke, Zanker, Mitsubishi, Vortab.

Flow Disturbance:

(A) Includes pipe fittings for example elbows or tees, fabricated pipe bends and other fabricated pipe configurations, equipment such as pumps, strainers and air eliminators, shut-off valves must be either fully opened or fully closed. Throttling valves must be located downstream of the meter (see Flow Disturbance B)

(B) Includes elbows, tees, and other pipe fittings as well as fabricated pipe bends or other fabricated pipe configurations, throttling or shut-off valves.

Flowmeter: Includes volumetric, velocity, and mass type flowmeters. Differential pressure types include all orifice variations; Venturis, flow nozzles, flow tubes, pitots, averaging pitots, and elbows, all of which require associated sensing piping (impulse lines), a 3-valve manifold and a dp transmitter. The transmitter location relative to the dp producer, is determined by the type of fluid being measured (liquid, gas, or steam). Orientation is important for some types of meters. Some types of turbine meters, for example, are intended only for installation in horizontal piping; installation in sloping or vertical piping must be reviewed with the manufacturer.

Pipe:

(A) Included in the upstream piping requirements when a flow straightener or flow conditioner is used. Pipe size should be the same as the meter size. Length is determined by Standards, Recommended Practices, or the Manufacturer's Specifications.

(B) Pipe size should be the same as the meter size. Pipe length is established by Standards, Recommended Practices, or Manufacturer's Specifications. The inside diameter of the pipe, and its condition may be important, concentricity of the pipe with the meter's inside diameter may also be important. Gaskets must not protrude into the flow stream.

(C) Pipe size should be the same as the meter size. Pipe length is defined by Standards, Recommended Practices, or Manufacturer's Specifications.

Pipe Support: Type hanger (from above), or support (from below) is influenced by the type of flow meter being used. Some flowmeter types can accept piping induced line stresses, and are handled as just another concentrated mass. Some types of flow meters must be isolated from external stresses including piping induced stresses. These meters require special care in the type and location of hangers/supports which are used. Although large and heavy meters include integral base supports, associated hanger/support requirements must be considered to minimise (eliminate) transfer of stresses to the flow meter housing.

2 Mass

	Thermal	Coriolis
Minimum pipe length (diameters):	Body type: Before meter, 10; After meter, 0. Insertion type: Before meter, 15; After meter, 5.	Some designs require upstream straight pipe, refer to manufacturer.
Power requirements:	AC/DC.	AC/DC.
Piping connections:	Flanged, threaded, sanitary.	Flanged, threaded, sanitary.
Type of measurement:	Whole body, by-pass, sampling.	Whole body.
Installation requirements:	In some insertion types, the sensor head must not touch the opposite pipe wall.	Pipe supports must be located on adjoining pipe and go to a common reference to minimize transfer of pipe stress to the meter. Meters in series must be separated by 15 pipe diameters. Some designs are bidirectional. Isolate meters from flow and pump pulsations and minimize external vibrations.
Orientation requirements:	Some types require installation with the same orientation used during calibration. Insertion types will have orientation requirements that vary with their design. Some designs require insertion plane to be parallel with flow plane to within ±2º.	Must be oriented so that any gas bubbles or sediment do not collect in the measuring region of the meter. Specific orientations allow self-draining and vary with the meter design.
Ancillary equipment requirements	None.	Block valves are recommended to perform zero adjustment with no flow.
Standards or recommended practices	ISO 14511.	California Weights & Standards Bureau PTB ISO 10790.

Meter Principle			Piping Requirements (note 1)												Ancillary Equipment Requirements (see piping diagram)							
									Meter Orientation				Support		Flow Conditioners							
No.	Category	Type	Upstream Pipe Length Note 2	Downstream Pipe Length	Pipe Material	Pipe Wall Thickness Note 3	Condition of Pipe ID	Concentricity of meter ID with pipe ID Note 4	Horizontal Note 5	Vertical Note 6	Sloping Note 7	By-Pass Piping Note 8	As a Valve Note 9	As a Pump Note 10	Plate, Tube or Honey-comb Note 11	Other Note 12	Strainer or Filter	Air Eliminator Note 13	Block Valves Note 14	Transmitter Location	Sensing Piping	Isolation Manifold
1	Differential Pressure	*Orifice*																				
		Venturi																				
		Flow Nozzle																				
		Flow Tube																				
		Elbow																				
		Pitot																				
		Averaging Pitot																				
		VA																				
2	Mass	*Coriolis*																				
		Thermal Insert																				
		Thermal Meter Body																				
3	Oscillatory	*Fluidic*																				
		Vortex Presession																				
		Vortex Shedding																				
4	Magnetic	*AC Excited*																				
		Pulse DC Excited																				
5	Turbine																					
6	Ultrasonic	*Dop. Clamp-on*																				
		Dop. Meter Body																				
		ToF Clamp-on																				
		ToF Meter Body																				
7	Target																					
8	Positive Displacement																					

*Installation requirements **essential** to good measurement*

*Installation requirements **recommended** for good measurement*

Consult manufacturer

Not a factor

3 Oscillatory

	Fluidic	Vortex Shedding	Vortex Precession
Minimum pipe length (diameters):	Follow recommendations for 0.7 Beta orifice meter.	Before meter, 10; After meter, 5. Varies with manufacturer. Note 15.	Before meter 3; After meter, 1.
Power requirements:	AC/DC, 2-wire DC available.	AC/DC, 2-wire DC , Battery power.	AC/DC, 2 wire DC.
Piping connections:	Flanged, flangeless (wafer style) Note 4.	Flanged, threaded, sanitary, weld ends, flangeless (wafer style) Note 4.	Flanged.
Type of measurement:	Whole body by-pass larger than 4 inches.	Whole body. Insertion type is sampling.	Whole body.
Installation requirements:	Pipe wall thickness should be specified. Gaskets must not project into the flow stream..	Gaskets should not protrude into flow stream; some designs require specific pipe inside diameter at meter entrance.	None.
Orientation requirements:	Horizontal plane is preferred.	Some designs require specific orientation based on the type of application or operating temperature, Check manufacturer.	None.
Ancillary equipment requirements	Flow conditioners are recommended for persistent swirl profiles or jet flow profiles.	Flow conditioners are recommended for persistent swirl profiles or jet flow profiles.	None.
Standards or recommended practices	None.	ASME.ANSI MFC 6M ISO 12764.	None.

4 Magnetic

Minimum pipe length (diameters): Before meter, 5; After meter, 2.

Power requirements: AC/DC battery.

Piping connections: Flanged, Victaulic, Dresser, Sanitary, Flangeless (wafer style) Note 4.

Type of measurement: Whole body. Insertion type is sampling.

Installation requirements: Some designs are bi-directional. Grounding is a function of the adjoining pipe material for most designs. Gaskets must not project into the flow. There are specific pipe support requirements for some designs. Note 10. Do not inject additives immediately upstream of the meter.

Orientation requirements: Larger sizes have an integral base support for installation on a slab at ground level.

Ancillary equipment requirements: None.

Standards or recommended practices ISO 6817.

5 Turbine

Minimum pipe length (diameters): Before meter, 10; After meter, 5; Note 15.

Power requirements: None for most versions. AC/DC or battery used for RF signal systems and accessories.

Piping connections: Flanged, Threaded Sanitary, Flangeless (wafer style) Note 4 and insertion.

Type of measurement: Whole body, insertion type is sampling.

Installation requirements: Locate meter as far as practical from flow disturbance. Strainers and flow conditioners must be specifically located; Varies with standards, recommended practices, and manufacturers. By-pass piping frequently recommended; it is essential for cryogenic applications. Clean piping before installing meter. Avoid abnormal pipe stresses at meter.

Orientation requirements: Some designs must be oriented as calibrated.

Ancillary equipment requirements: Flow conditioners and strainers or filters are usually required. A separator for condensate removal is recommended for gas flows.

Standards or recommended practices: AGA7, API 2534, API Manual for Petroleum Management Standards, Chapter 5, Section 3, ISO 2715, ASME Fluid Meters.

6 Ultrasonic

	Doppler (Dop.)	Time of Flight (ToF)
Minimum pipe length (diameters):	Follow recommendations for a 0.7 Beta ratio orifice meter installation. Swirling and jet flows must be avoided.	Before meter, 10; After meter, 2.
Power requirements:	AC/DC battery.	AC/DC
Piping connections:	Usually non-invasive (clamp-on); meter body types are also available.	Flanged; non-invasive (clamp-on) also available.
Type of measurement:	Sampling.	Sampling.
Installation requirements:	Allow adequate upstream pipe length following a disturbance to assure a fully developed turbulent profile. Avoid severely vibrating pipe sections. Deposits on pipe ID may affect the meters ability to make measurements. Clamp-on: Pipe material and or type of pipe lining may affect the measurement. Particle (bubble) velocity being sensed, so particles must be of uniform size, uniformly distributed, be of uniform materials, and have a velocity the same as the liquid. Meter location must be selected so there is adequate velocity to prevent particles from rising or settling which introduces measurement errors.	Allow adequate upstream pipe length to assure a fully developed turbulent profile. Clamp-on types are dependent on pipe material, pipe wall thickness and condition of pipe interior.
Orientation requirements:	Locate transducers so they look away from flow disturbances.	None.
Ancillary equipment requirements	None.	None.
Standards or recommended practices	None.	ANSI/ASME MFC-YY.

7 Target

Minimum pipe length (diameters): Before meter, 6; After meter, 3.5. Note 15.

Power requirements: AC/DC or pneumatic.

Piping connections: Flanged, threaded, flangeless (wafer style), Note 4, and insertion.

Type of measurement: Whole body: insertion type is sampling.

Installation requirements: Some designs require specific pipe IDs at meter entrance. Gaskets should not protrude into flow stream.

Ancillary equipment requirements: Flow conditioners recommended for some flow profiles to reduce upstream piping requirements. Strainers usually recommended.

8 Positive Displacement

Minimum pipe length (diameters): Before or after meter, none.

Power requirements: Basic versions do not require power, AD/DC or battery used for accessories.

Piping connections: Flanged, threaded, sanitary.

Type of measurement: Whole body (true volumetric).

Installation requirements: Larger and heavier designs require base mounting. Housing should not be subjected to undue pipe stress. By-pass piping may be required, especially where blocked flow due to meter failure is not acceptable. Drip traps for wet gas applications are recommended. Meters should be installed to allow draining to minimize deposits forming on meter internals. Piping interior should be flushed before meter is installed.

Orientation requirements: Meters should not be at low point in the piping where particulate matter would accumulate. Meter should be level.

Ancillary equipment requirements: Strainers and air eliminators are generally recommended. Flow restricting orifices or flow limiting valves used where transient high low rates are experienced. Air chambers or shock arrestor may also be recommended.

Standards or recommended practices: API-Chapter 5, Section 2, PD Meters: RP2535, Recommended Practice for Viscous Hydrocarbons: ASME Fluid Meters; ANSI: B109.1 and B109.2 for diaphragm type meters AGA 6; API 1101.

NOTES

1. When measuring liquids and slurries, pipe must be full. Flow through meters must be in the direction marked on the meter body.
2. Includes straight length of pipe before a flow conditioner as well as that at the meter entrance: see piping diagram.
3. Most meters prefer that the inside diameter of the upstream pipe be slightly greater than the meter inside diameter. For some meters, such as orifice, the inside diameter should be precisely known.
4. Concentricity is important to many meters including orifice types. It is essential to all wafer-style meters regardless of the operating principle. Wafer-style meters are either furnished with or recommend centering devices which must be used. Gaskets must not protrude into the flow stream.
5. Horizontal is the most common orientation, but special care must be taken when measuring liquids which have entrained gas or particles, and gases in which liquids are present. Some meters calibrated in the horizontal will require installation in that orientation.
6. Preferred flow direction is up to assure a full pipe; this is mandatory in gravity feed systems
7. Sloping lines are generally handled as horizontal lines.
8. The criteria are whether flow will be able to pass through the meter if there is a meter failure, whether the measurement is critical to the process or access to the meter, at any time, is important.
9. Many smaller meters are essentially another piece of pipe and can accept piping stresses. They are considered in the piping system as concentrated mass.
10. Some meters require that there are low (no) piping stresses transferred to the meter body (housing). Performance may be impaired if this criterion is not followed.
11. Plate, tube, honeycomb, and similar conditioners (flow straighteners) are beneficial for swirling flows. They may be detrimental if used when distorted profiles are present.
12. If profiles are severely distorted, or swirl flow is persistent, flow conditioners such as Mitsubishi, Sprenkle, Vortab, Zanker, and so on should be used. Pressure drops should be checked.
13. Entrained gas will affect the accuracy of volumetric liquid measurement and calibration; signal output is related to total volume, not just liquid phase. Air eliminators are an important consideration in custody transfer and billing applications. Some liquid mass meters have specific limits on percent gas they can tolerate (void fraction).
14. Block valves must be leak-tight so that a true no-flow condition is established. Similar requirements exist for by-pass piping arrangements.
15. The required length of straight upstream pipe increases with the need for accuracy. It also increases with an increasing Beta-ratio, where that is a factor. It also varies with the type of upstream disturbance and whether or not the correct flow conditioner is used.

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

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