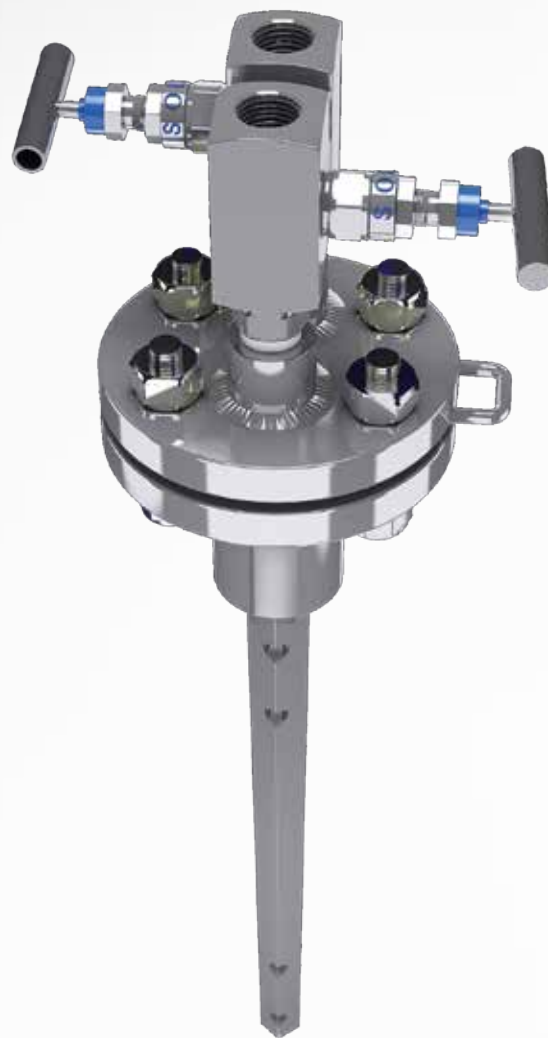# TEK-DP 1650A
DProbar
Multiport Self-Averaging Flow Meter

FLOW

Introduction

The Tek-DP 1650A DProbar is a multiport self-averaging flow meter (SAFM). It is designed using a classical and modern proven design as associated with averaging pitot tubes for clean process fluid measurement applications. It is a primary flow meter for the measurement of gas, liquid and vapors flowing in pipelines and ducts based on principles of differential pressure measurement (DP). Classical Pitot tubes are a common type of insertion flowmeter and were used for many years as single port designs, named after Henri Pitot who first used a bent glass tube to measure velocities of flowing rivers in France during the 1700s. His original principle stated that a total pressure head is generated in a tube facing a flowing fluid due to the fluid velocity, this 'velocity' head pressure is thus compared against a reference pressure / static pressure in the pipe. (See Figure 1 below).
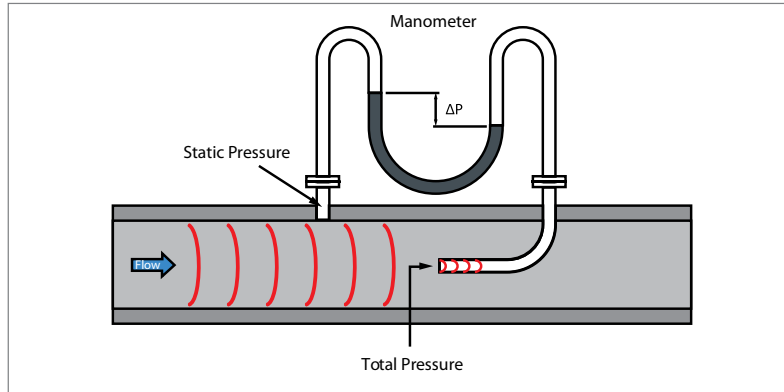

Fig 1: Henry Pitot Classical Design

The Tek-DP 1650A DProbar SAFM is a further development of Pitot's classical technology but with a Multiport Design! When using the DProbar Multiport Design, the total fluid pressure is evenly distributed across a diamond shaped Multiport Tube based on the velocity profile, so that a flow rate can be determined. Fluid flow rates are determined by applying a simple flow equation. (Note: Tube lengths are based on pipe/duct diameters).

The total pressure per port is averaged due to the 1650A's special meter design. (See Figure 2) Flow rates are then determined using a directly mounted Differential Pressure Transmitter with integral valve manifold connected electrically to a flow computer. Temperature is also measured using a downstream local RTD connected to the flow computer or on certain device types the temperature probe built into the head so that Corrected Fluid Flow Rates can be recorded / totalized at the operator's convenience.
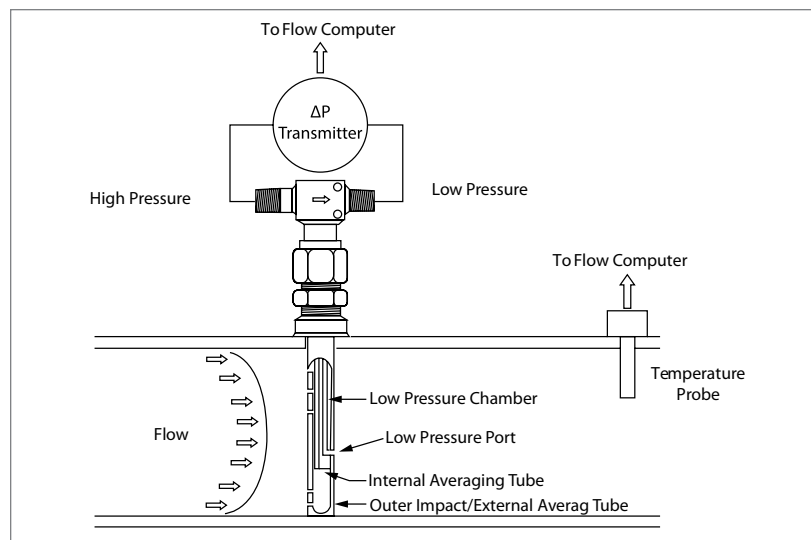

Fig 2: Tek DP 1650 SAF Meter Configuration

Tek-DP DProbar meters are now available with identical up and downstream ports for bi-directional flow measurement applications. Normally pitot tube sensors develop vortex pulses which vary according to fluid flowrate changes the diamond shape tube sensor and its strategically placed sharp edge fixes the fluid separation point to help compensate for this vortex effect. A 1650A DProbar meter comprises of four basic components, an Outer impact /external averaging tube, (Manufactured from a One-Piece Construction) Internal averaging tube, Low-pressure chamber, DP Head with HP, and LP impulse connections.

The outer impact tube has a number of pressure-sensing holes upstream, positioned at equal along the multiport tube per a logarithmic-linear relationship. (See Figure 3) this helps to average the flow correctly.

Due to the DProbar design, average composite static pressures are developed in the outer impact or external averaging tube, and also the internal averaging tube to provide higher accuracy and performance. This averaged static and pressure head is read at the meter head, the low-pressure value being located at a sensing port-hole in the downstream section (rear) of the tube assembly, therefore enabling flow rates to be correctly calculated.

This averaging technique also helps to compensate for certain non-ideal fluid flow velocity profiles and offers superior measurement accuracy over a wider flow range than basic Pitot tube designs.
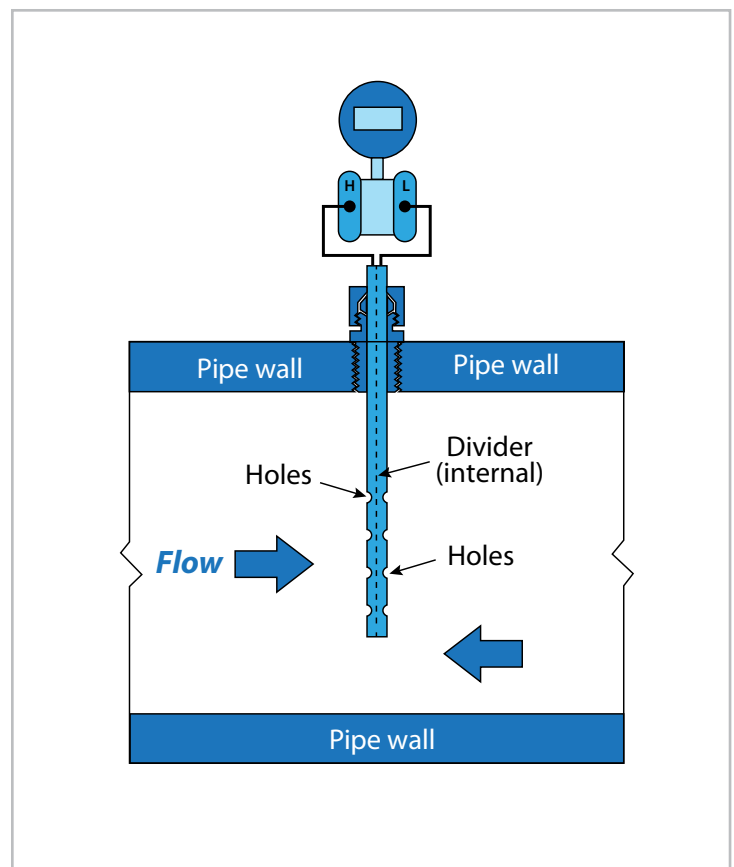

Fig 3: Tek-DP 1650A SAF Meter

Fig 4: Tek-DP 1650A SAF Meter(Bi - Directional)

Measurement Principle and Testing

All Tek-DP 1650A DProbar meters produce low and higher differential pressures (DP) based on Bernoulli's theory of conservation of mass and energy in a closed pipe enhanced by Henry Pitot's observations regarding the head pressure developed in a tube facing towards a flowing fluid versus static pressure. The flow equations to indicate a flowrate are as follows:

For a flow velocity: v

$$v = K \sqrt{\frac{2\Delta p}{\rho}}$$

K - the flow coefficient; Δp - the differential pressure; ρ - the liquid density.

To integrate for a volumetric flowrate:

$$q_v = KA \sqrt{\frac{2\Delta p}{\rho}}$$

q_v - the volumetric flow rate; A - the pipeline / duct internal cross-section area.

The values of K are generally determined on the basis of probe calibration. For lower flow rate values the parameter K is related to the Reynolds number (Re_D) and a value rise along with velocity increases.
Values of K vary depending on Reynolds number values are determined by the manufacturer per process conditions and the shape of the probe in the DProbar design is a diamond (See Figure 5).
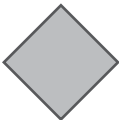
	Diamond Shape	K=0.5 - 0.65

Fig 5: DProbar probe shape (Diamond) K - Factor Values

Computational fluid dynamic simulations (CFD) show that multiport averaging Pitot tubes with a diamond shape produce a higher static pressure distribution than circular shaped probes as some manufacturers supply, (See Figure 6). The diamond shape geometry (See Figure 7 is more defined) determines the location of flow separation that is key driver in providing higher performance, repeatability and accuracy!
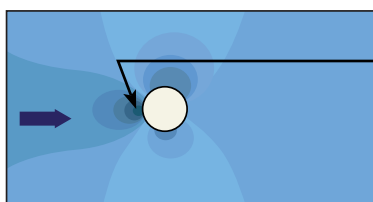

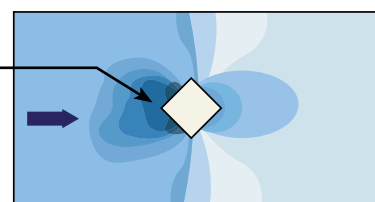Fig 6: CFD Image Curved Multiport Pitot Shape

Fig7: CFD Image Diamond DProbar Meter

CFD tests of cross section multiport averaging Pitot tubes also shows flow velocity vectors profiles appear more prominent/defined than circular shaped probe designs (See Figure 7 DProbar & Figure 8 Circular)
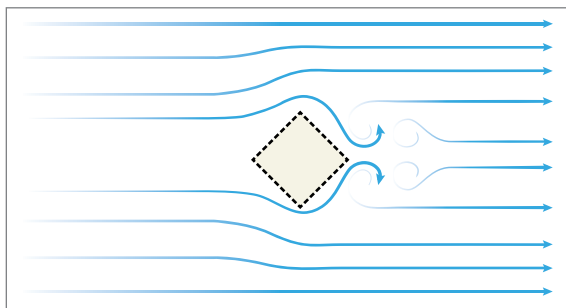
Fig 8: DProbar, Flow Velocity Vectors
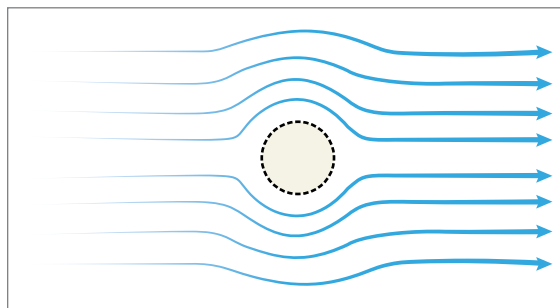
Fig 9: Curved Type, Flow Velocity Vectors

High pressure
sensing port

Direction
of flow

Low pressure
sensing port

4½"

2¼"

1	Sensor
2	Mounting hardware
3	Sensor flange
4	Gasket
5	Nut ½"UNC
6	Stud ½"UNCx65.0
7	Inst. valve neddle
8	Tag
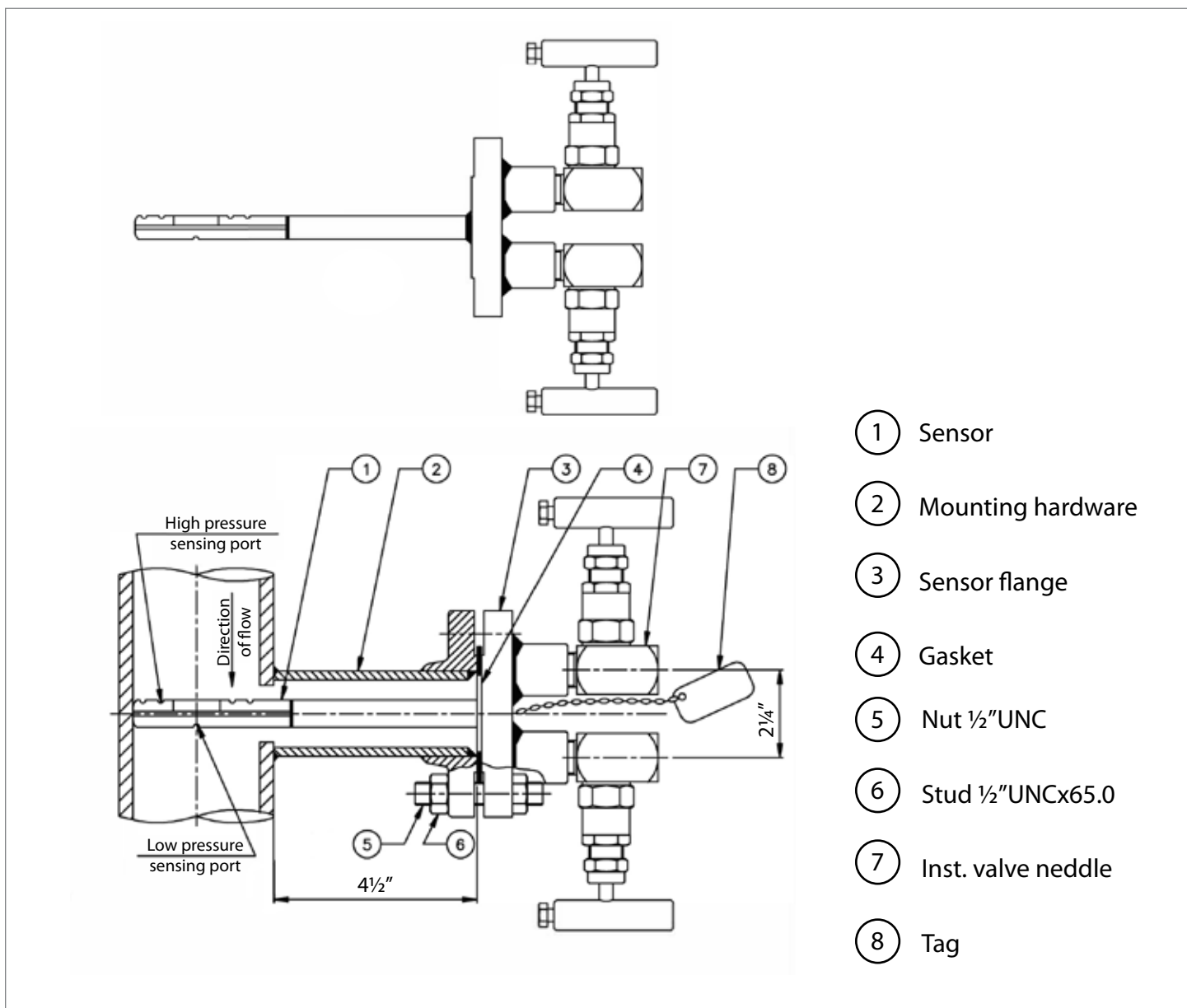
Fig 10: Averaging Pitot Tube (Flanged Options)

Type of the shape		
Pressure drop Δρ [Pa]/(*in. w. c.*)	96/0.385	206/0.827
Permanent pressure loss Δρ [Pa]/(*in. w. c.*)	33.13/0.133	66.5/0.267

Fig 11: (SAFM) Comparison of the detected value of pressure drop and permanent pressure loss.
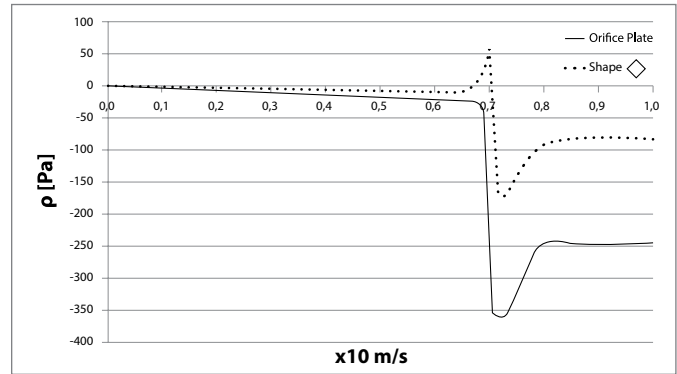
Fig 12: Static pressure distribution (typical) measured Upstream and Downstream of Multiport Averaging Pitot Tube and Orifice Plate

Benefits

- No Moving
- Velocity Sampled at several points to provide average flow rate.
- Accuracy up to ≤ 5 +/- 1.0% of the actual flow rate.
- Repeatability 0.1%.
- Unique diamond profile shape proven to offer good flow separation.
- High flow turndown.
- Easy to install and Cost Effective.
- Stable flow co-efficient (K).
- Highly durable and stable.
- Diamond Bar design ensures optimum strength.
- Low permanent pressure loss.
- Multiport Averaging: Improved performance with asymmetric flow profiles.
- Suitable for wide range of pipe sizes.
- Allows insertion into pressurized pipes (Via a full port valve and hot tap).
- Eliminates imposed piping between the primary element and DP transmitter.
- Available for all pipe sizes and in a wide range of materials.

Applications

Clean Fluids

- Steam.
- Air flow in ducts and pipes.
- Natural Gas.
- Water pipes.
- Hydrocarbon liquids and gases.
- Hazardous fluids.
- Power Generation

Installation

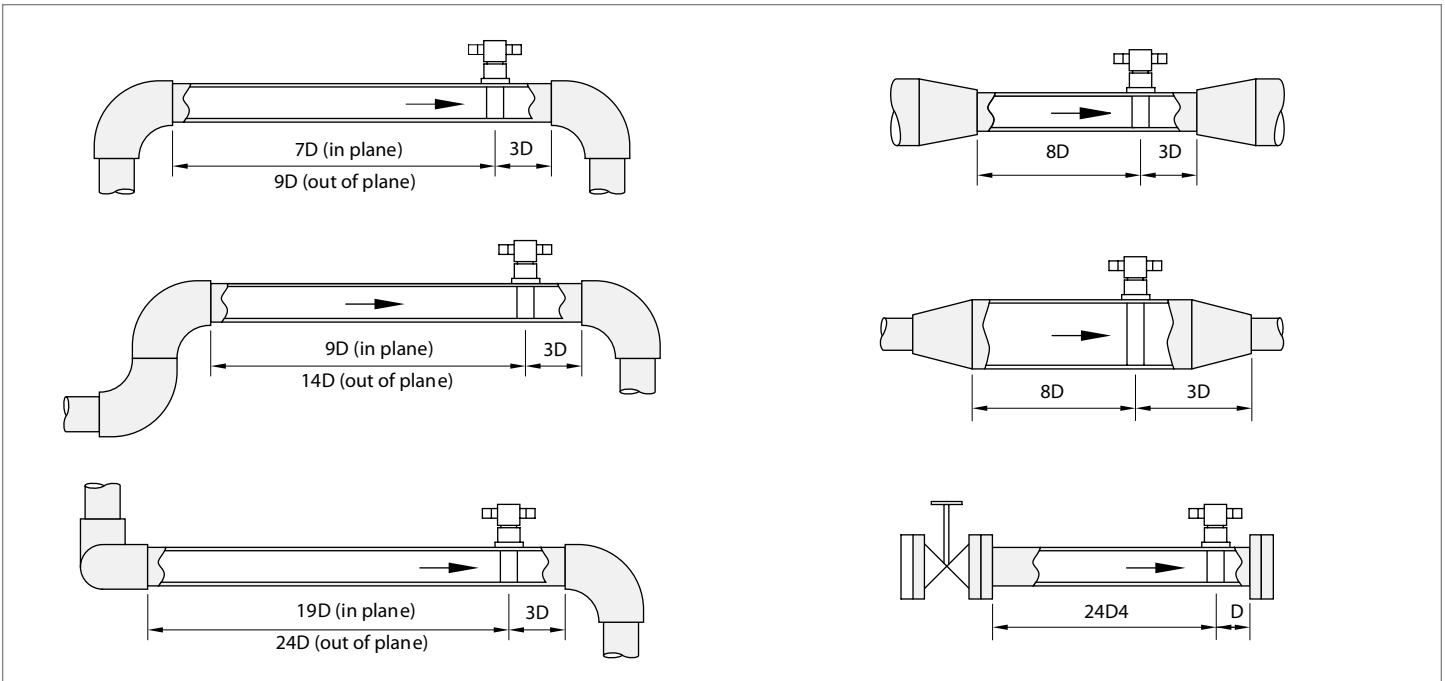- Recommended upstream and downstream lengths

Fig 13: Upstream and Downstream Installation
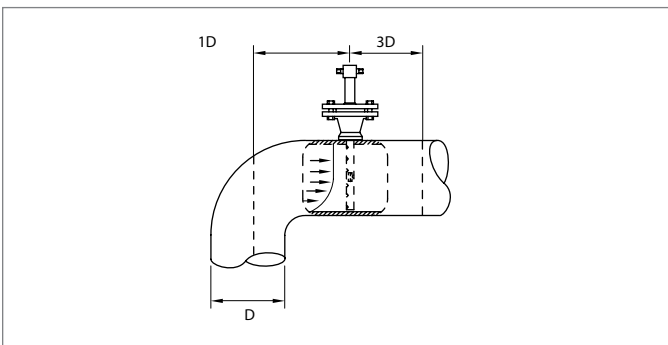
Fig 14: Elbow Installation
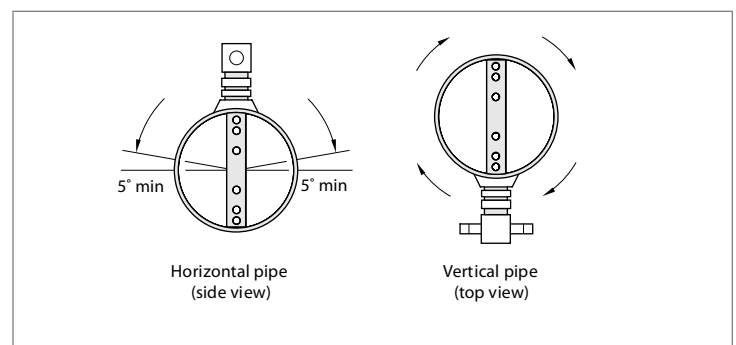
Fig 15: Side and Top view of DProbar for Gases
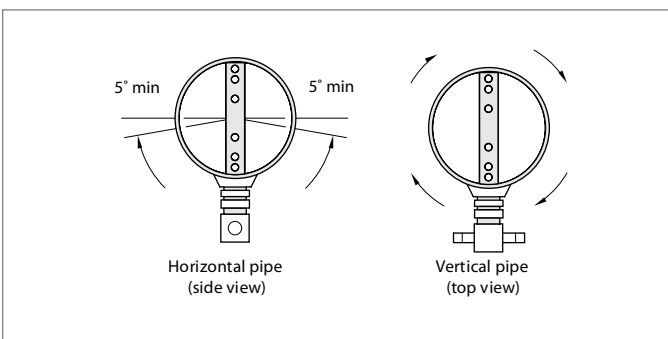
Fig 16: Side and Top view of DProbar for Liquid and Steam
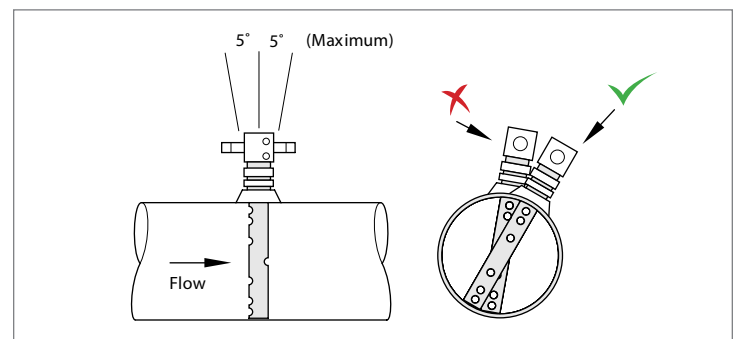
Fig 17: General Orientation

Specifications

Accuracy	±1% at 95% confidence level
Process Media	Liquid, Gas, and Steam
Line Sizes	2" to 72" diameter
Operating Temperature	Standard at -20°F to 100°F, optional -40°F to 1200°F
Body Material	316L SS
Isolating Valve Materials	316 SS or Carbon Steel
DProbar Material	All standard materials available including: Stainless Steels, Hastelloy and other Exotics.
Process Connections	Flanged Weld prepared ends Threaded NPT Others on request
Transmitter Mounting	Direct or Remote

DProbar Configuration

Permanently Installed Type

Fig 18: Fixed Dimensions

*Note: Dimensions are subject to vary at time of manufacturing based on final Beta selected. Dimensional drawing with a final engineering sizing sheet will be provided within 1-2 weeks of order acceptance.

Model Chart

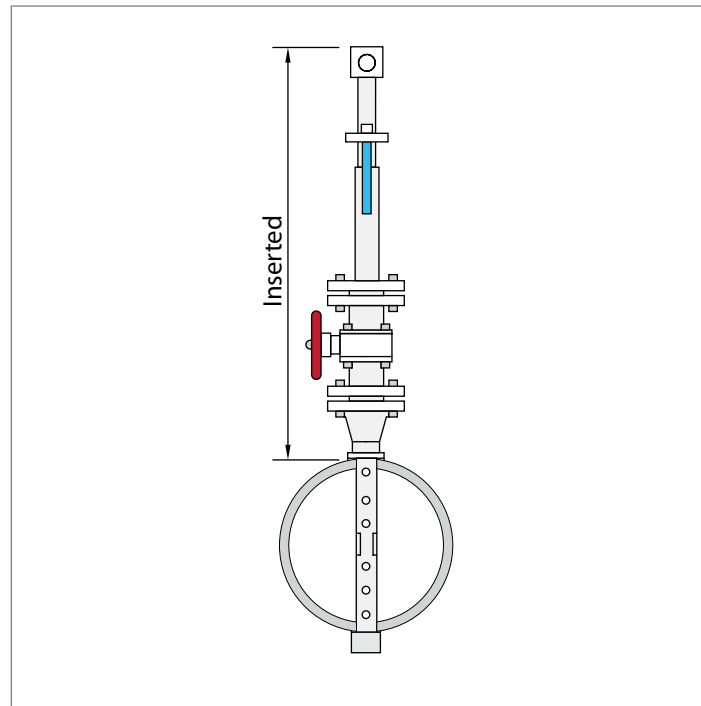| Example	Tek-DP 1650A	F	G	100	S	01	A	02	A	B	O	01	#	TEK-DP 1650A-F-G-100-S-01-A-02-A-B-O-01
Series	Tek-DP 1650A													DProbar Multiport Self-Averaging Flow Meter
Type		F												Fixed
Media			L											Liquid
			G											Gas
			S											Steam
Size				050										2″
				065										2 ½″
				080										3″
				085										3 ½″
				100										4″
				125										5″
				150										6″
				175										7″
				200										8″
				250										10″
				300										12″
				350										14″
				400										16″
				450										18″
				500										20″
				600										24″
				750										30″
Meter Body					S									316 SS
Pipe Schedule						01								STD (Standard Pipe SCH)
						02								10S
						03								10
						04								20
						05								30
						06								40S
						07								40
						08								80S
						09								80
						10								120
						11								160
						12								XS
						13								XXS
						XX								Special
Transmitter Connection							A							Remote mount; NPT connection
Pressure Rating								01						Threaded Connection (300psi)
								02						150# RF ANSI
								XX						Special
Pipe Fitting Material (Weld and Thread)									A					316SS
									X					Special

Category	Code	Description
Process Connections	A	1-½" mNPT
	B	1-½" 150# Flange
	C	1-½" weldolet
Temperature Measurement	0	No Temperature Sensor
	T	Integral RTD
	R	Remote thermowell and RTD
Flow Transmitters/Computers	01	None (Customer Supplied)
	02	Tek-Bar 3110 (Liquids) - Smart DP
	03	Tek-Bar 3800 (MVT Steam & Compressed Gases)
	04	Tek-FC 8000 (Natural Gas - Flow Computer)
	05	TekValsys DPRO (Flow Validation)
	06	TekValsys DPRO WFGM (Wet Gas)
	XX	Special
Options	MTR	Material Test Report EN3.1
	MC	Material Cert EN2.1
	COC	Certificate of Conformity
	O2C	O2 Cleaned
	TAG	SS TAG PLATE
	CDE	Certified Drawing Electronic (As Built)
	MRB	Manufacturing Record Book
	DFT	Dry Film Thickness - Custom Paint Spec
	CPC	Custom Product Code

Popular Models

Model Number	Description
1650A-F-G-100-S-01-A-02-A-B-O-01	4"
1650A-F-G-150-S-01-A-02-A-B-O-01	6"
1650A-F-G-200-S-01-A-02-A-B-O-01	8"
1650A-F-G-250-S-01-A-02-A-B-O-01	10"
1650A-F-G-300-S-01-A-02-A-B-O-01	12"
1650A-F-G-400-S-01-A-02-A-B-O-01	16"
1650A-F-G-450-S-01-A-02-A-B-O-01	18"
1650A-F-G-500-S-01-A-02-A-B-O-01	20"
1650A-F-G-600-S-01-A-02-A-B-O-01	24"
1650A-F-G-750-S-01-A-02-A-B-O-01	30"