**Manufacturing standard ;ISO 5167, AGA -3 , B16.5, B16.36, B16.20, B 16.34, PTC 19.3
(temperature compensation averaging pitot tube), vibration analysis as per ASME PTC 19.3**

Spraytech Systems manufactured Averaging Pitot Tubes are another type of differential pressure flowmeters. Averaging Pitot tubes are basically used to detect flow velocity of fluids, gasses, steam, steam water and absolutely all those medias which atmost with 3-5ppm of solids as the max size. Spraytech Systems make averaging Pitot tubes have the potential to measure two pressures at the same time

i.e. impact (dynamic) and static. The static pressure is the operating pressure in the pipe, duct, or the environment, upstream to the Pitot tube. It is measured at right angles to the flow direction, In a averaging Spraytech Systems make Pitot-static tube, the kinetic energy of the flowing fluid is transformed into potential energy for measurement of fluid flow velocity.

Advantages in using Spraytech Systems make Averaging Pitot tube

1. Hexagonal sensor in forged construction, enables, perfect velocity and flow distribution, no erossion on the material with media thus

2. With aerodynamic design, enabling, perfect pressure distribution to enable most workable solution against cavitation and flashing conditions of the liquid media and against choking of the gas / vapour media

3. Cost effective measurement against orifice assembly, ventury and flow nozzle as the free length space involved with Spraytech Systems make, is only 2D in upstream and 1D in downstream as compared to higher lengths defined as per beta ratio in ventury, orifice and nozzle

4. No moving parts

5. Type tested to radiography level - 1

6. MTBF is 10^6

7. Guranteed life cycles to 5,00,000

8. Helium lead test to $10^{(-6)}$ mbarltr/sec

9. Simple to use and install

10. Low pressure drop, resulting into most free accurate reading of flow measurement compared to other device

11. 90% flow recovery coefficient achieved with 4, 8, 12, 16, 24 averagers

12. Accuracy of flow measurement upto 0.05% of the max span of flow at min 75-80% consumption of flow

13. Temperature compensation device available with averagers enabling it to be used for perfect mass flow measurements in especially hydrogen and superheated steam line

14. Also applicable for bidirectional flow, especially used in gas lines

Spraytech Systems Averaging Pitot Tube

With the advent of averaging pitot tubes, the difficulty of determining the average velocity point has almost been sorted out. Our averaging pitot tube is designed with manifold impact and static pressure ports. Besides, it is constructed in such a manner that it extends across the whole pipe diameter. Averaging pitot tubes offer better accuracy as

compared to single port pitot tubes, particularly in cases where the flow is not entirely formed. It enables a flow recovery of 90% as compared to only 55% with single port pitot tube.

Averaging the application considers the following to have the best results in flow and pressure recovery of the system against which it has to measure.

Table 10.1

Line size	Consumption rate for steam and gas and liquids	Flow recovery coefficient results	Free length at upstream in mm	Free length at down stream in mm	Hysterisis	Accuracy	No of Averagers
X line size max upto 12"	Min 80%	90%	2D	1D	0.10%	0.05%	4
X line size max upto 12"	60% for liquids	70%	5D	2D	0.10%	0.25%	4
X line size max upto 12"	60% for gas and steam	80%	3.5D	1.5D	0.10%	0.15%	8
X line size max upto 12"	50%	70%	5.5D	2.5D	0.10%	0.25%	4
X line size max upto 12"	30%	60%	7.5D	4D	0.10%	0.50%	4
156"	80%	90%	2D	1D	0.10%	0.05%	24
156"	80%	70%	3.5D	2D	0.10%	0.20%	8
156'	30%	60%	7.5D	4D	0.10%	2.50%	4

For other combination, kindly contact the design cell of Spraytech Systems.

The above is the indicative table as to how the accuracy matters with respect to line size, flow rate consumption, no of averagers in the averaging pitot tube.

The free space indicated in upstream and downstream informs us that more the free space, beyond what is indicated does make the averaging pitot tube more accurate.

Principle of operation

Averaging pitot tube is nothing but an element which is suppose to measure the flow rate and offer the differential pressure to the flow meter mounted on top. The averaging pitot tube works on the 80% velocity of the media rate at the top of the centre line in a velocity gradient in a pipe line or duct and 70% velocity of the media in the below portion of the centre line. it does not work on the centre line velocity which is 100% for the media as what a orifice, a ventury and nozzle, and many more flow meter works. Thus the velocity of the media is perfectly averaged out and offered for DP measurement in the flow meter.

An averager on the inlet side measures the velocity at :

Table 10.2

No of averagers	Holes at the inlet part, % of the total length of sensor bulb	Holes at the outlet, % of the total length of sensor bulb	Flow rate consumption	Free length at the inlet	Free length at the out let	Direction of flow	Line size
4	At 70%, 60%, 30% and 20%	50%	80%	2D	1D	unidirectional	Max upto 12"
8	At 80%,73%,66%, 60%, 40%, 33%, 26% and 20%	50%	80%	2D	1D	unidirectional	Max upto 24"
12	At 85%,80%, 75%, 70%, 65%, 60%, 40%, 35%, 30%, 25%, 20%, 15%	50%	80%	2D	1D	unidirectional	Max upto 48"
16	At 90%, 86%,81%, 77%, 73%, 69%, 65%, 60%, 40%, 36%, 31%, 27%, 23%, 19%, 15%, 10%	50%	80%	2D	1D	unidirectional	Max upto 156"

The differential pressure created by the dynamic force at the inlet and static force at the output, creates the average at the out put to enable the flow rate measurement more accurately with lesser free length

For bidirectional measurement, the concept is completed by holes at the other side for measurement, at 1.5% lesser than the length at the dynamic side of the unidirectional flow measurement device.

The 4, 8, 12,....24 averagers works to enable the perfect flow recovery based on the consumption of the media in the pipe.

The choice of the non retract and retract mechanism is based on the activities of choosing the device under velocity considerations.

The following is to be considered accordingly

Table 10.3

Design options available at conditions	Non retract without end support	Retract with end support	Retract without end support	Non retract with end support
Velocity of media at max upto 70% of the max applicable on pipe size upto 16"	Yes	No	No	No
Velocity of media at max upto 70% of the max applicable on pipe size above 20"	No	No	No	Yes
Velocity of media at max above 70% and below 100% of the max applicable on pipe size upto 16"	No	No	Yes	Yes
Velocity of media at max above 70% and below 100% of the max applicable on pipe size above 20"	No	Yes	Yes	Yes
Velocity of media at max above 100% and upto 150% of the max applicable on pipe size upto 16"	No	Yes	Yes	Yes
Velocity of media at max above 100% and upto 150% of the max applicable on pipe size above 20"	No	Yes	No	No
Velocity recorded anything above 150% shud be analysed only for retract mechanism with end support	-	Yes	-	-

Spraytech Systems Pitot-static tube can measure the fluid flow velocity by converting the kinetic energy in the fluid flow into potential energy.

The principle is based on the Bernoulli Equation where each term can be interpreted as a form of pressure

$p + 1/2\,\rho v^2 + \gamma h$ = constant along a streamline   (1)

where

p = static pressure (relative to the moving fluid) (Pa)

ρ = density (kg/m^3)

γ = specific weight (kN/m^3)

v = flow velocity (m/s)

g = acceleration of gravity (m/s^2)

h = elevation height (m)

Each term of this equation has the dimension force per unit area - N/m^2 or in imperial units psi, lb/ft.^{2}

Static Pressure

The first term - p - is the static pressure. It is static relative to the moving fluid and can be measured through an flat opening in parallel to the flow.

Dynamic Pressure

The second term - $1/2\rho v^2$ - is called the dynamic pressure.

Hydrostatic Pressure

The third term - γh - is called the hydrostatic pressure. It represent the pressure due to change in elevation.

Stagnation Pressure

Since the Bernoulli Equation states that the energy along the streamline is constant, (1) can be modified to

$p1 + 1/2\rho v1^2 + \gamma h1$

   $= p2 + 1/2\,\rho v2^2 + \gamma h2$

   = constant along the streamline   (2)

where

suffix 1 is a point the free flow upstream

suffix 2 is the stagnation point where the velocity in the flow is zero

Flow Velocity

In a measuring point we regard the hydrostatic pressure as a constant, h1 = h2 and this part can be eliminated. Since v2 is zero, (2) can be modified to:

$p1 + 1/2\rho v1^2 = p2$ (3)

or

$v1 = [\, 2\,(p2 - p1)\,/\rho\,]\,1/2$ (4)

where

p2 - p1 = DP (Differential Pressure)

With (4) it's possible to calculate the flow velocity in point 1 - the free flow upstream - if we know the differential pressure difference dp = p2 - p1 and the density of the fluid.

The averaging pitot tube is a simple and convenient instrument to measure the difference between static, total and dynamic pressure (or head).

The difference of pressure recorded is the minimum applicable depending on the flow consumption per pipe size and the inlet pressure.

As per the ISO 5167 std and also IEC 60534 for flow conditins and all internationally acclaimed conditions the flow rate recorded in averaging pitot tube and the one manufactured by Spraytech Systems records DP at the following conditions

Table 10.4

Flow rate at the pipe size	Inlet pressure	DP recorded	At the free length of in the upstream	No of averagers
20% and less	X pressure range	X*0.8	7.5D	4
30%	X pressure range	X*0.6	7D	4
50%	X pressure range	X*0.4	4D	4
70%	X pressure range	X*0.25	2.5D	4
90%	X pressure range	X*0.15	2D	4
100%	X pressure range	X*0.05	2D	4
150%	X pressure range	X*0.05	2D	4
Flow rate at the pipe size for media for gas and steam for eg	Inlet pressure	DP recorded	At the free length of in the upstream	No of averagers
20% and less	X pressure range	X*0.6	5.5D	8
30%	X pressure range	X*0.4	5D	8
50%	X pressure range	X*0.25	3.5D	8
70%	X pressure range	X*0.15	2.0D	8
90%	X pressure range	X*0.08	2D	8
100%	X pressure range	X*0.03	2D	8
150%	X pressure range	X*0.02	2D	8

The above is the briefing on how much it matters for DP keeping the flow rate and pressure in mind.

Retract Versus Non Retract Mechanism

Table 10.5

Type	Non retract mechanism	Retract mechanism
Selection	Velocity within 10 m/sec for liquids	Exceeds 10m/sec for liquids
selection	Velocity within 40m/sec for gas	Exceeds 40m/sec for gas
selection	Velocity within 60 m/sec for steam	Exceeds 60m/sec for steam
Suctionability and hold of characteristics	Within the above velocity control, the averaging pitot tube characteristics does not change thus the inherent characteristics is not affected while before and after maintenance	While velocity exceeds as above, non retract easily loses its characteristics before and after maintenance, and hence a retract mechanism, holds the suctionability and thus helps in maintaining the inherent control characteristics, since the retract mechanism maintains suctionability thru the ball valve and the mounting mechanism
Temperature compensation	Yes available	Yes available

For steam, air, and gas applications, considering unidirectional flow, internal IDs and port Size applicable for avaerajing pitot tube

Table 10.6

Consumption of fluid in pipe	Tube ID required (internal tube)	No of ports required for 2D and 1D upstream and downstream free length	Port dimensions at dynamic end, min size in mm	Port dimensions at static end in mm	Internal tube lengths
10%	0.8 mm	4 nos till 3", 8 nos till 16" and 12 nos till 32" and 16 nos till 56"	Till 4", port shall be of 8 mm ID, after 14 mm for all sizes	6 mm till 4" and after shall be 8-12 mm for all other sizes	Static port length is till 45% from the bottom end and dynamic port length is till 30% from bottom port end
20%	0.8 mm	4 nos till 3", 8 nos till 16" and 12 nos till 32" and 16 nos till 56"	Till 4", port shall be of 8 mm ID, after 14 mm for all sizes	6 mm till 4" and after shall be 8-12 mm for all other sizes	Static port length is till 45% from the bottom end and dynamic port length is till 30% from bottom port end
30%	1 mm	4 nos till 3", 8 nos till 16" and 12 nos till 32" and 16 nos till 56"	Till 4", port shall be of 8 mm ID, after 14 mm for all sizes	6 mm till 4" and after shall be 8-12 mm for all other sizes	Static port length is till 45% from the bottom end and dynamic port length is till 30% from bottom port end
40%	1.6 mm	4 nos till 3", 8 nos till 16" and 12 nos till 32" and 16 nos till 56"	Till 4", port shall be of 8 mm ID, after 14 mm for all sizes	6 mm till 4" and after shall be 8-12 mm for all other sizes	Static port length is till 45% from the bottom end and dynamic port length is till 30% from bottom port end
50%	1.6 mm	4 nos till 3", 8 nos till 16" and 12 nos till 32" and 16 nos till 56"	Till 4", port shall be of 8 mm ID, after 14 mm for all sizes	6 mm till 4" and after shall be 8-12 mm for all other sizes	Static port length is till 45% from the bottom end and dynamic port length is till 45% from bottom port end
60%	3 mm	4 nos till 6", 8 nos till 24" and 12 nos till 40" and 16 nos till 64"	Till 4", port shall be of 8 mm ID, after 14 mm for all sizes	6 mm till 4" and after shall be 8-12 mm for all other sizes	Static port length is till 45% from the bottom end and dynamic port length is till 45% from bottom port end
70%	3 mm	4 nos till 6", 8 nos till 24" and 12 nos till 40" and 16 nos till 64"	Till 4", port shall be of 8 mm ID, after 14 mm for all sizes	6 mm till 4" and after shall be 8-12 mm for all other sizes	Static port length is till 45% from the bottom end and dynamic port length is till 45% from bottom port end
80%	5 mm	4 nos till 12", 8 nos till 36" and 12 nos till 56" and 16 nos till 82"	Till 4", port shall be of 8 mm ID, after 14 mm for all sizes	6 mm till 4" and after shall be 8-12 mm for all other sizes	Static port length is till 45% from the bottom end and dynamic port length is till 45% from bottom port end
90%	5 mm	4 nos till 12", 8 nos till 36" and 12 nos till 56" and 16 nos till 82"	Till 4", port shall be of 8 mm ID, after 14 mm for all sizes	6 mm till 4" and after shall be 8-12 mm for all other sizes	Static port length is till 45% from the bottom end and dynamic port length is till 45% from bottom port end
100%	5 mm	4 nos till 12", 8 nos till 36" and 12 nos till 56" and 16 nos till 82"	Till 4", port shall be of 8 mm ID, after 14 mm for all sizes	6 mm till 4" and after shall be 8-12 mm for all other sizes	Static port length is till 45% from the bottom end and dynamic port length is till 45% from bottom port end
150%	5 mm	4 nos till 12", 8 nos till 36" and 12 nos till 56" and 16 nos till 82"	Till 4", port shall be of 8 mm ID, after 14 mm for all sizes	6 mm till 4" and after shall be 8-12 mm for all other sizes	Static port length is till 45% from the bottom end and dynamic port length is till 45% from bottom port end
200%	5 mm	4 nos till 12", 8 nos till 36" and 12 nos till 56" and 16 nos till 82"	Till 4", port shall be of 8 mm ID, after 14 mm for all sizes	6 mm till 4" and after shall be 8-12 mm for all other sizes	Static port length is till 45% from the bottom end and dynamic port length is till 45% from bottom port end

The above is to ensure that the flow is sensed for each changing phases in flow consumption of steam, air, or any gasses. This enables no choking or no noise applicable for the design considerations

Similarly for flow of water the following is the considerations

Table 10.6 cont.

Consumption of fluid in pipe	Tube ID required (internal tube)	No of ports required for 2D and 1D upstream and downstream free length	Port dimensions at dynamic end, min size in mm	Port dimensions at static end in mm	Internal tube lengths
10%	0.6 mm	4 nos till 3", 8 nos till 16" and 12 nos till 32" and 16 nos till 56"	Till 4" port shall be of 12 mm ID, after 16 mm for all sizes	8 mm till 4" and after shall be 10-14 mm for all other sizes	Static port length is till 45% of consumption, from the bottom end and dynamic port length is till 10% from bottom port end
20%	0.6mm	4 nos till 3", 8 nos till 16" and 12 nos till 32" and 16 nos till 56"	Till 4", port shall be of 12mm ID, after 16 mm for all sizes	6 mm till 4" and after shall be 8-12 mm for all other sizes	Static port length is till 45% of consumption, from the bottom end and dynamic port length is till 10% from bottom port end
30%	0.6 mm	4 nos till 3", 8 nos till 16" and 12 nos till 32" and 16 nos till 56"	Till 4" , port shall be of 12 mm ID, after 16 mm for all sizes	8 mm till 4" and after shall be 10-14 mm for all other sizes	Static port length is till 45% of consumption, from the bottom end and dynamic port length is till 10% from bottom port end
40%	1.25 mm	4 nos till 3", 8 nos till 16" and 12 nos till 32" and 16 nos till 56"	Till 4", port shall be of 12 mm ID, after 16 mm for all sizes	8 mm till 4" and after shall be 10-14 mm for all other sizes	Static port length is till 45% of consumption, from the bottom end and dynamic port length is till 10% from bottom port end
50%	1.4mm	4 nos till 3", 8 nos till 16" and 12 nos till 32" and 16 nos till 56"	Till 4", port shall be of 12 mm ID, after 16 mm for all sizes	8 mm till 4" and after shall be 10-14 mm for all other sizes	Static port length is till 45% from the bottom end and dynamic port length is till 10% from bottom port end
60%	2.25 mm	4 nos till 6", 8 nos till 24" and 12 nos till 40" and 16 nos till 64"	Till 4", port shall be of 12 mm ID, after 16 mm for all sizes	8 mm till 4" and after shall be 10-14 mm for all other sizes	Static port length is till 45% from the bottom end and dynamic port length is till 10% from bottom port end
70%	2.25 mm	4 nos till 6", 8 nos till 24" and 12 nos till 40" and 16 nos till 64"	Till 4", port shall be of 12 mm ID, after 16mm for all sizes	8 mm till 4" and after shall be 10-14 mm for all other sizes	Static port length is till 45% from the bottom end and dynamic port length is till 10% from bottom port end
80%	3 mm	4 nos till 12", 8 nos till 36" and 12 nos till 56" and 16 nos till 82"	Till 4", port shall be of 12 mm ID, after 16 mm for all sizes	8 mm till 4" and after shall be 10-14 mm for all other sizes	Static port length is till 45% from the bottom end and dynamic port length is till 10% from bottom port end
90%	3 mm	4 nos till 12", 8 nos till 36" and 12 nos till 56" and 16 nos till 82"	Till 4", port shall be of 12 mm ID, after 16 mm for all sizes	8 mm till 4" and after shall be 10-16 mm for all other sizes	Static port length is till 45% from the bottom end and dynamic port length is till 10% from bottom port end
100%	3 mm	4 nos till 12", 8 nos till 36" and 12 nos till 56" and 16 nos till 82"	Till 4", port shall be of 12 mm ID, after 16 mm for all sizes	8 mm till 4" and after shall be 10-14 mm for all other sizes	Static port length is till 45% from the bottom end and dynamic port length is till 10% from bottom port end
150%	3 mm	4 nos till 12", 8 nos till 36" and 12 nos till 56" and 16 nos till 82"	Till 4", port shall be of 12 mm ID, after 16 mm for all sizes	8 mm till 4" and after shall be 10-14 mm for all other sizes	Static port length is till 45% from the bottom end and dynamic port length is till 10% from bottom port end
200%	3 mm	4 nos till 12", 8 nos till 36" and 12 nos till 56" and 16 nos till 82"	Till 4", port shall be of 12 mm ID, after 16 mm for all sizes	8mm till 4" and after shall be 10-14 mm for all other sizes	Static port length is till 45% from the bottom end and dynamic port length is till 10% from bottom port end

Averaging pitot tube takes the concept of upper and lower band of flow velocity in a pipe flow system and thus defines the averager of the upper and the lower band of the velocities, highlighting the best possible flow recovery in this type element as compared to nozzles, ventury and aerofoils and even in orifices, vortex, magnetic type flow meters and measurement technique.

Table 10.7

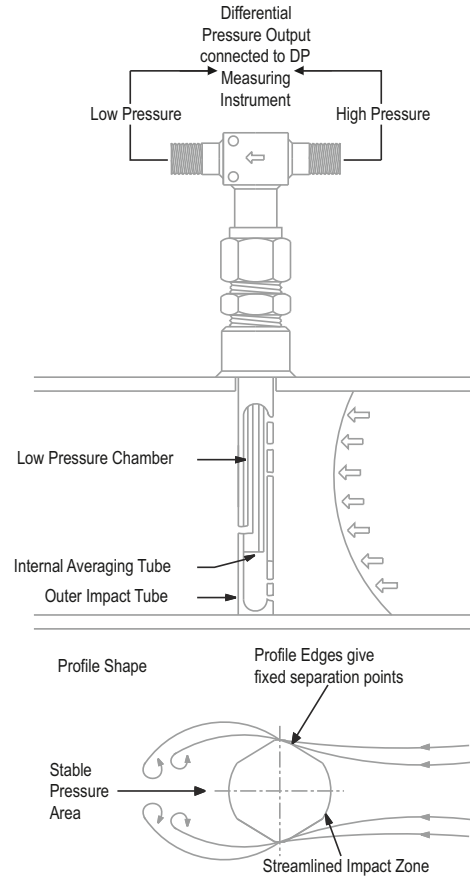| Type	Non retract mechanism	Retract mechanism
Material of Construction		
Sensor flange	SS316, SS316L, SS304, SS304L, PTFE, PP, Monel, Hastealloy	SS316, SS316L, SS304, SS304L, PTFE, PP, Monel, Hastealloy
Sensor	SS316, SS316L, SS304, SS304L, PTFE, PP, Monel, Hastealloy	SS316, SS316L, SS304, SS304L, PTFE, PP, Monel, Hastealloy
Mounting needle valves	SS316, SS316L, SS304, SS304L, PTFE, PP, Monel, Hastealloy A105	SS316, SS316L, Ss304, SS304L, PTFE, PP, Monel, Hastealloy A105
Mounting ball valves		SS316, SS316L, Ss304, SS304L, PTFE, PP, Monel, Hastealloy, A105
Mounting rods with pads		SS316, SS304, SS316L, Mild steel with anticorossion powder coat, MS, SS with PTFE coating
Mounting pipe chamber		MS, Carbon steel, Stainless steel, PTFE, PP
Tubes for differential pressure	Stainless steel, monel, hastealloy, SS304L, SS316L, SS304, PTFE, PP	Stainless steel, monel, hastealloy, SS304L, SS316L, SS304, PTFE, PP
Weld couple	SS316, SS316L, SS304, SS304L, PTFE, PP, Monel, Hastealloy, carbon steel	SS316, SS316L, SS304, SS304L, PTFE, PP, Monel, Hastealloy, carbon steel
Bonnet flange connection	SS316, SS316L, SS304, SS304L, PTFE, PP, Monel, Hastealloy, carbon steel	SS316, SS316L, SS304, SS304L, PTFE, PP, Monel, Hastealloy, carbon steel
Ball valves		11/2", 3", 4", 6 " ANSI 150#, 300#, 600#, 900#, 1500#, 2500#
Needle valves	1 1/2", 3", 4", 6 " ANSI 150#, 300#, 600#, 900#, 1500#, 2500#	11/2", 3", 4", 6 " ANSI 150#, 300#, 600#, 900#, 1500#, 2500#
Averaging pitot tubes	½" to 156"	4" to 156"
Sensor sizes	25.4mm, 57.3mm, 85mm, 115mm, 165mm	25.4mm, 57.3mm, 85mm, 115mm, 165mm

Fig 10.1

Table 10.7 contd

Type	Non retract mechanism	Retract mechanism
No of ports (averagers)	2, 4, 8, 12, 16, 24	2, 4, 8, 12, 16, 24
End support	SS316, SS304L, A105, SS316L, Hastealloy, Monel, PTFE, PP	SS316, SS304L, A105, SS316L, Hastealloy, Monel, PTFE, PP
End support	Flanged ends, screwed, welded	Flanged ends, screwed, welded
Temperature compensation	Yes with element upto 1200 deg cent compensation	Yes with element upto 1200 deg cent compensation
Temperature element	RTD, Thermocouple, graphite expansion technique	RTD, Thermocouple, graphite expansion technique
HART protocol based transmitter, single or multivariable transmitter	Yes available with mounting accessories	Yes available with mounting accessories
Mounting hardware with transmitter	Manifold valve and valves and nipples with various MOC as per sensor MOC	Manifold valve and valves and nipples with various MOC as per sensor MOC

Installing an averaging pitot tube is a simple process. However, problems can result that are difficult to correct later if a few basic factors are not considered during the mounting process. The first three steps to successful mounting are location, orientation and installation.

Some pitot tubes have hardware to support its far end. Tack weld such hardware with the pitot tube in place before performing final welds.

Step one: Location

First, determine if adequate straight run is available. Straight run refers to the amount of obstruction-free piping upstream and downstream of the averaging pitot tube. Elbows, control valves, changes in pipe size and other obstructions create flow disturbances that affect accuracy. Because the averaging pitot tube measures and averages the readings from multiple points along the flow profile **(see Figure 10.1)**, its straight run requirements are less stringent than most other devices, but upstream and downstream disturbances must still be taken into consideration.
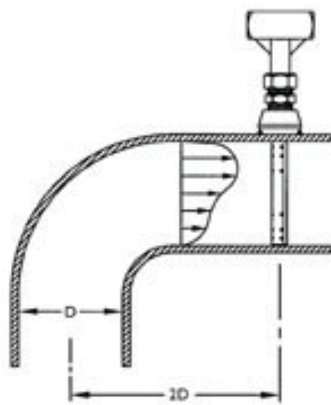
Elbow Mount Installation

Fig 10.2

Most flow meter manufacturers publish straight run charts. However, the charts don't tell where to locate the pitot tube when adequate straight run is not available. Intuition may not always be correct when deciding. For example, when the only option is to install it immediately downstream of an elbow, one may be tempted to install it as far away from the elbow as possible. While it's true that upstream disturbances influence accuracy more than downstream disturbances, this is one case where installing the averaging pitot tube two diameters from the centerline of the elbow is best **(see Figure 10.2)**.

The velocity profile hugs the outside radius of the pipe immediately after an elbow in a predictable manner. At two pipe diameters from the centerline of a short-radius elbow, reasonable accuracy can be achieved if the instrument is mounted to the outside radius of the elbow and the flow coefficient is properly adjusted.

Notice how the pitot tube traverses the skew of the flow profile in Figure 10.2. If it were rotated 90 degrees from the position shown, it would not average the flow correctly. Another example of traversing the skew occurs downstream of a butterfly valve, with the instrument oriented 90 degrees from the valve axis.

Not all straight run rules are chiseled in stone. For example, the chart may require 24 pipe diameters after a valve. However, a fully open, full-throat gate or ball valve induces only a small flow disturbance. A modulating control valve or butterfly valve causes a much greater flow disturbance. Because there are so many combinations possible, consult the instrument manufacturer for a recommendation on where it should be installed and for an estimated accuracy. One pointer: always provide a sketch or diagram. Verbal descriptions are not always conveyed or interpreted accurately. In addition, there may be something in the diagram that seems irrelevant, such as a temperature sensor or pressure tap, but may affect the accuracy of the device.

Step two: Orientation

Consider horizontal piping runs first. For gas applications, mount the pitot tube in the upper 160-degree portion of the pipe to prevent condensate from collecting in the instrument lines or transmitter **(see Figure 10.3)**. This is especially critical when the gas is saturated or operating at a temperature above ambient.

For liquid applications, the pitot tube should be mounted in the lower 160-degree portion to prevent air from collecting in the instrument lines or transmitter. Because steam applications require liquid legs to isolate the transmitter, the same consideration applies.
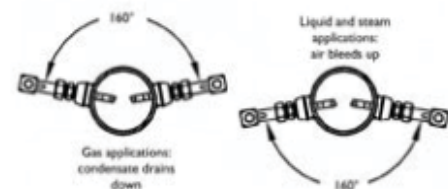
Horizontal pipe orientation

Fig 10.3
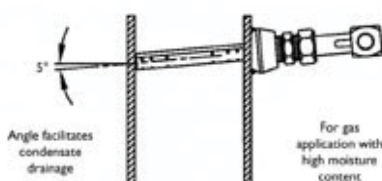
Vertical pipe orientation

Fig 10.4

For vertical piping, mount the pitot tube in any location around the circumference of the pipe. For gas with a high moisture content, mount the instrument at a five-degree angle to allow drainage **(see Figure 10. 4)**.

Indicate if the line is vertical when you order the device. The manufacturer will orient the connections parallel to the ground to eliminate low points for condensation build-up.
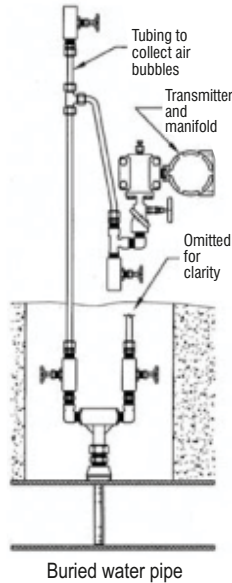
Buried water pipe

Fig 10.5

Non-standard orientation

Occasionally, it's not practical to mount the pitot tube in the recommended orientation. For example, a buried water line does not allow access to the lower portion of the pipe; therefore, the instrument must be mounted to the top. In such cases, special mounting considerations prevent entrained air from collecting in the instrument lines or transmitter **(see Figure 10.5)**.

Step three: Installation

An averaging pitot tube can be installed through various connections. The two most common methods are flanged and threaded. Regardless of the connection size or type, the size of the hole drilled in the pipe is critical to measurement accuracy.

Hole size

The averaging pitot tube is designed to pass through a specific hole size. For example, if the pitot tube diameter is 7/8", the manufacturer will probably recommend a 1" hole. In short, the hole should be just large enough to allow the instrument to pass and be de-burred whenever possible. Drilling an oversized hole or using a cutting torch affects accuracy. A large or jagged hole produces a disturbance that can wash out the signal from the sensing ports located closest to the pipe wall **(see Figure 10.6)**.

In smaller line sizes, the sensing ports are located closer to the pipe wall. The smaller the pipe and the larger hole, the greater effect on accuracy. To quantify the error, for example, a 1-3/8" hole in a 6" pipe to pass a 7/8" pitot tube will generate a potential error of 8 to 10 percent.
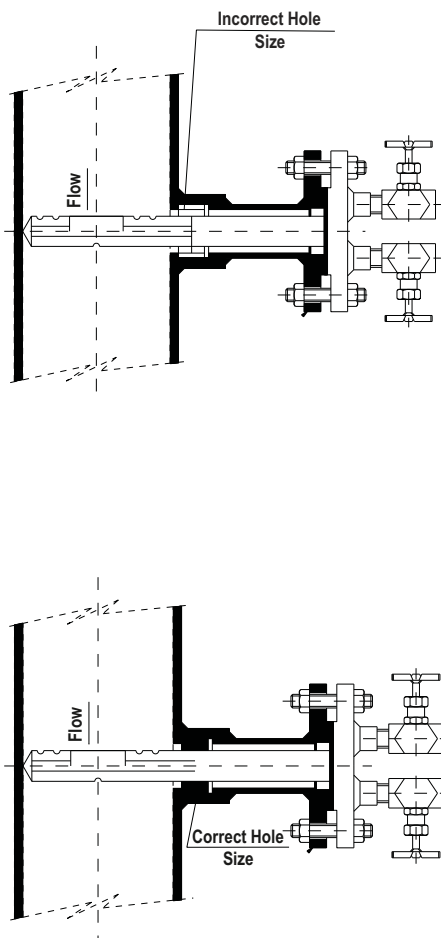
If there is an existing oversized hole in the pipe but no alternate mounting location, it is better to have the manufacturer refrain from drilling the sensing ports closest to the pipe wall. While this sacrifices some averaging capabilities, the effect on accuracy is far less than having sensing ports in the swirl zone. As the pipe gets larger and the sensing ports move farther away from the pipe wall, the effect of a large hole diminishes.

Too often, the hole size is ignored, especially when the fitting is welded to the pipe by a contractor working without installation instructions. A common mistake is burning out the hole to match the

inside diameter of the fitting. For example, a 1" FNPT 3000# threaded weld coupling actually has an inside diameter of 1-5/16" Burning out this hole instead of drilling the manufacturer's recommended 1" hole can introduce a significant error.

Simply specifying the connection size for the pitot tube is not enough. The specification sheet and submittal and certified drawings should identify the hole size as well. It's imperative that this information be passed to the relevant pipe fitters and subcontractors.

Another common error is overlooking the pipe schedule. For example, a 6" Sch 40 pipe has an inside diameter five percent greater than a 6" Sch 80 pipe. Not only would specifying the wrong schedule cause the averaging pitot tube's sensing ports to be positioned incorrectly in the pipe, there would be a flow rate error of 11% from the differences in flow area. For pipe sizes 12" and larger, the inside diameter of schedule standard pipe is different than Sch 40 pipe. Because Sch 40 and schedule standard are identical up to 12", it is commonly (and mistakenly) assumed that they are identical in larger lines. Verify pipe size and schedule before ordering the averaging pitot tube.


Hole size effect

Fig 10.6

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Averaging Pitot Tube
Technical Information

Threaded Connections

An averaging pitot tube mounted through a threaded connection should be bottomed firmly against the opposite wall of the pipe. This ensures the sensing ports are aligned properly in the flow stream and the pitot tube has structural support. **Figure 10.7** shows why an averaging pitot tube that is not bottomed against the opposite wall has sensing ports "lost" in the pipe wall.

In addition, an averaging pitot tube that merely is cantilevered in the flow stream is structurally weak. A cantilevered pitot tube withstands approximately one-half the velocity of a firmly bottomed pitot tube. The leading cause of pitot tube breakage is leaving it cantilevered in the flow stream. Some manufacturers offer a spring-lock mechanism to ensure the pitot tube is firmly bottomed.

Some pitot tubes have hardware to support its far end. Tack weld such hardware with the pitot tube in place before performing final welds.
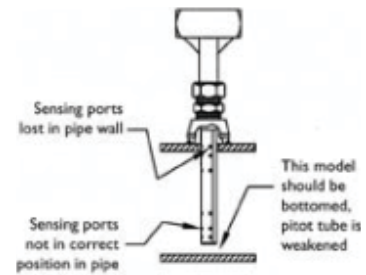
Improper installation
Fig 10.7
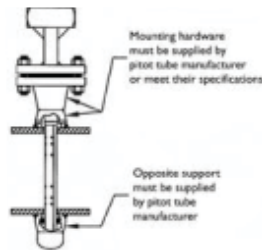
Flanged connection with opposite support
Fig 10.8

Flanged connections

Severe service applications, such as high-pressure steam and explosive gases, usually require flanged connections. Some companies, especially refineries and power plants, require flanged connections throughout, regardless of service.

Most averaging pitot tube manufacturers supply the necessary flanged mounting hardware with the instrument **(see Figure 10.8)**. This is desirable because the hardware height determines how the sensing ports align in the flow stream. Pitot tube manufacturers have set dimensions for 150#, 300# and 600# hardware and the pitot tube is located accordingly. For this reason, specify "mounting flange to be supplied by manufacturer."

If the mounting flanges are provided by others or if the pitot tube is to be mounted through an existing flange, it's important that the flange installation match the manufacturer's installation instructions. For example, mounting a 7/8" pitot tube through an existing, unused 2" 150# flange results in loss of accuracy.
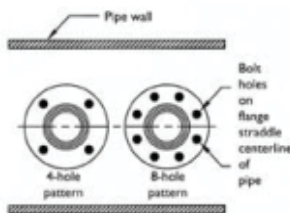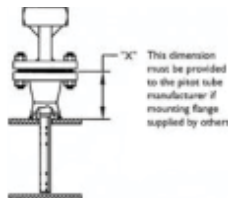
Figure 9. Bolt-hole patterns
Fig 10.9

Another consideration when mounting a pitot tube to an existing flange is whether the flange bolt holes are properly aligned. Bolt holes should straddle the pipe centerline, an industry standard orientation **(see Figure 10.9)**.

Customer supplied mounting flange
Fig 10.10

The pitot tube flange locates off the bolt hole pattern to ensure it lines up properly in the flow stream. Provide the flange height dimension so the pitot tube can be manufactured according to the specific installation **(see Figure 10.10)**.
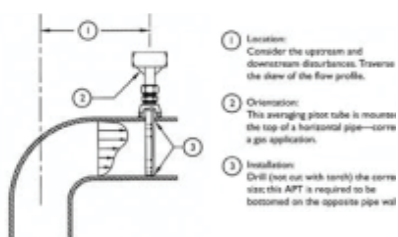
Correct installation summary (side view)
Fig 10.11

For certain applications, the sensor may be strong enough to be cantilevered rather than with the support hardware. The manufacturer determines the adequacy of the cantilever style based on the flow conditions.

Figure 10.11 summarizes the most important points of a good installation. If you follow the basics of location, orientation and installation, you can ensure accurate long-term performance.

Technical comparison between averaging pitot tube with other direct acting / contact flow elements

Table 10.8

Item	Orifice assembly, manufactured by Spraytech	Averaging pitot tube manufactured by Spraytech	Flow nozzles, ventury	Aerofoil
Media service	conductive and non conductive with 15ppm at most solid particles	conductive and non but with 5ppm of solids atmost max	conductive and non conductive with 500ppm at most of solid particles	non conductive and conductive, gases and only liquids
Flow recovery coefficient	60-85% depending on accuracy of the beveling ad the free length available on Beta value	Strictly 90% flow recovery and independent of flow free length	strictly 70% but will depend on free length	60% flow recovery
Pressure recovery coefficient	75% pressure recovery co-efficient depending on bevelling	strictly 95% pressure recovery and is independent of free length	strictly 80% but will depend on free length	55 % flow recovery
Free length upstream and downstream	depends on beta value and varies between 7D to 44D in upstream and between 2D and 8D in the downstream	max 2D and 1D and that too for accuracy to be maintained at 0.1% and if not then no requirement of free length	depends on beta value and varies between 15D till 2D in upstream and 6D till 1D in downstream	15D upstream and 8D downstream
Accuracy	0.25% provided the free length is maintained, depending on beta value	0.1% at 2D and 1D free length forupstream an downstream or at 0.2% at no available free length	0.5% at the available free length	2% and is dependent on free length both up-stream and down stream
Repeatability	0.15%	0.05%	0.1%	1%
Hysterisis	0.1%	0.005%	0.1%	2%
Pressure loss for the device	10% to 60% of the input pr depending on requirements	strictly 0.1% to 5% at any conditions applicable	5% to 30% of the input pr depending on requirements	5% to 20% of the input pr depending on requirement
Size of manufacture	upto 64"	upto 132"	upto 104"	Upto 36"
Guaranteed cycles of operation	70,000	1,00,000	70,000	25,000
MTBF	10^5	10^8	10^6	10^2
Dynamic response test	most linear stable reading at upto 30 decibels reading and then at 0.25 fall at upto 100 decibels	most linear stable reading at upto 70decibels reading and then at 0.15 fall at upto 100 decibels	most linear stable reading at upto 40 decibels reading and then at 0.25 fall at upto 100 decibels	most linear stable reading at upto 40 decibels reading and then at 0.5 fall at upto 100 decibels
Conservation of energy	plant usage energy is limited to 17% to drive in beveled related flow elements	plant energy is limited to only 6% todrive averaging pitot tube, flow elements, since it has got 90% flow and pressure recovery coefficient	plant usage energy is limited to 20-22% to drive in beveled related flow elements	plant usage energy is limited to 20-22% to drive in beveled related flow elements
Differential pressure	average differential pressure, lowest possible is 100mmwc but applicable accuracy will be upto 2%, with 70% flow recovery	lowest possible with special holes designed at the input to keep the highest possible flow recovery coefficient and highest value of accuracy with vortices being averaged out at all flows thus maintaining min differential pressure even for sizes beyond 100", lowest possible diff pressure is 1mmwc at 0.2% accuracy and 90% flow recovery	average differential pressure, lowest possible is 70mmwc but applicable accuracy will be upto 1.5%, with 80% flow recovery	average differential pressure, lowest possible is 90mmwc but applicable accuracy will be upto 2.5%, with 80% flow recovery
Applicability in thermal power sector	yes with available free length but for rating till 4000#	for steam water application and for rating till 2500#, since pressure recovery an flow recovery is very high, this helps in perfect application of flow measuring element and also in maintaining most economical cost solution for plant	yes with available free length but for rating till 4000#	yes with available free length but for rating till 4000#
Exclusive boiler application	yes	yes	yes	yes