

PITOT TUBE SELECTION AND SIZING GUIDE

Sizing Equations

1. Any Liquid:

$$\Delta P \text{ (in. H}_2\text{O)} = \frac{Q^2(\text{GPM}) \times S_f}{K^2 \times D_1^4 \times 32.14}$$

2. Steam or Any Gas (steam requires min ΔP of 10" H₂O):

$$\Delta P \text{ (in. H}_2\text{O)} = \frac{Q^2(\text{lb/hr})}{K^2 \times D^4 \times \rho \times 128,900}$$

3. Any Gas:

$$\Delta P \text{ (in. H}_2\text{O)} = \frac{Q^2(\text{scfm}) \times S_s \times (T + 460)}{K^2 \times D_1^4 \times P \times 16,590}$$

Where:

ΔP = differential pressure (in in H₂O)

Q = flowrate

K = flow coefficient (see "how to order")

D₁ = inside diameter of line size (in inches for square and rectangular ducts use):

$$D_1 = \sqrt{\frac{4 \times \text{height} \times \text{width}}{\pi}}$$

P = static line pressure (psia)

T = temperature (in °F)

ρ = density of medium (in pounds per cubic foot)

S_f = Sp. Gr. at flowing conditions

S_s = Sp. Gr. at 15°C (60°F)

NOTE: Use of these equations for liquids yields an accuracy of $\pm 2\%$ of rate. When used for steam, accuracy is $\pm 10\%$ of rate (when steam tables are used). Gas equation yields $\pm 2\%$ of rate accuracy from 21 to 204°C (70 to 400°F) and 0 to 150 psig (when gas is not near its critical point). A $\pm 1\%$ of rate accuracy requires the use of more precise equations which account for shift in K with change in flowrate, gas compressibility, etc. Request a precision flow calibration sheet and please supply the following data: name of fluid, specific gravity, pressure, temperature, inside pipe diameter, viscosity, steam quality, degrees superheat, and ratio of specific heat at constant pressure to that at constant volume (for gas velocities approaching 500 fps).

VIBRATION CALCULATIONS

Natural frequency or resonant vibrations can inhibit performance. Checks should be made during sizing. The checks will guide you to the proper probe with a resonant

vibration range outside your anticipated operating flow range.

FOR ALL APPLICATIONS, VIBRATION CHECKS MUST BE MADE.

Natural frequency vibration is caused by the force created as vortices are shed by a pitot tube. At a critical point (which is a function of probe geometry, probe material and the velocity of the flowing fluid), a destructive natural frequency vibration is created which can lead to probe failure.

To an extent, we can adjust the point at which this destructive vibration occurs by using varying probe diameters or by improving the probe's resistance to vibration by providing a second mounting support. Ideally, the destructive vibration range should be above the maximum anticipated flowrate. This removes the vibration concern from the flow application. A pitot tube can also be used if the vibration range is well below the anticipated operating flow range. The process flowrate can pass through the vibration range, but the flow should not be allowed to remain within the vibration range continuously.

The equations below yield the flowrate range **which must be avoided** when selecting a pitot tube. The calculated flow range is representative of the point of natural frequency vibration for the probe including a $\pm 20\%$ safety factor. If operated continuously within the calculated danger range, probe failure may result.

AVOID VELOCITY RANGE from:

$$\text{Vel (lower limit)} = \frac{5252.7 \times M \times \text{Pr} \times \text{DIA}}{L^2}$$

where:

Vel = fluid velocity, feet per second

M = mounting factor (3.52 for single mount)

Pr = probe factor, (see TABLE 1 below)

DIA = probe diameter, (in inches)

L = unsupported probe length (in inches; see TABLE 1 below)

TO

$$\text{Vel (upper limit)} = \frac{7879.0 \times M \times \text{Pr} \times \text{DIA}}{L^2}$$

The upper and lower limit velocities obtained define the destructive vibration range. Convert velocity into Actual Cubic Feet per Minute (ACFM) or Standard Cubic Feet per

Minute (SCFM) using the equations below. Then compare the calculated vibration range to your anticipated operating flow range and refer to the last column on this page to interpret your results.

$$\text{ACFM} = \text{Vel} \times \text{I.D.}^2 \times 0.3272$$

$$\text{SCFM} = \text{ACFM} \times 35.37 \times P/T$$

$$\text{PPH} = \text{ACFM} \times \rho \times 60$$

where:

ACFM = Actual Cubic Feet per Minute at flowing conditions

SCFM = Standard Cubic Feet per Minute at 14.7 psi and 15°C (60°F)

PPH = Pounds Per Hour

Vel = Velocity, (feet per second)

I.D. = pipe Inside Diameter, (inches)

P = inlet Pressure, (psia)

T = inlet Temperature, °R (°R = 460°F)

ρ = density, (pounds per cubic foot)

COMPARISON OF VIBRATION RANGE TO OPERATING FLOWRATE RANGE

- Vibration range calculated above is greater than operating flow range; selection is OK.
- Vibration range falls within operating flow range. Rerun vibration check using double mount, larger probe diameter or both, as necessary.
 - If check is OK, then the new selection is OK.
 - If vibration range is still within 70% of the minimum operating flow, try a smaller probe and see "C" below.
- Vibration range is less than 30% of minimum operating flow range. Selection is OK, provided: (1) flowrate is not allowed to remain within calculated vibration range; and (2) requirements of pressure differential are satisfied.

TABLE 1

Probe Diameter	Probe Factor (Pr)	Unsupported Probe Length L (inches)
3/8"	0.185	I.D.+ Wall + 1.25*
1/2"	0.269	I.D.+ Wall + 1.50*
3/4"	0.372	I.D.+ Wall + 1.56
1"	0.552	I.D.+ Wall + 1.94

* For FPT-6300 Series, see page G-10



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