Technical Note
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Rosemount DP Flow Terminology (Part 1)

THE DP FLOW EQUATION

$$Q_m = NC_dEY_1d^2\sqrt{DP\rho}$$

To better understand DP flow, there are a number of different terms to become familiar with.

N, Numerical Conversion Factor

N is a conversion factor to convert all the different units in the mass flow equation to like term.

β, Beta Ratio

This is the ratio of orifice bore (d), to pipe internal diameter (D), d/D=β . Note, β is not constant. It will change with temperature due to thermal expansion.

R_D, Reynolds Number

R_D is a dimension-less number used to predict the behavior of fluids under flowing conditions. It does not show up directly in the mass flow equation, but is a function of C_d. It is a function of density, velocity, pipe ID and viscosity.

$$R_D = \frac{(PipeID)(velocity)(density)}{viscosity}$$

C_D, Discharge Coefficient

The discharge coefficient is a correction factor for describing the amount of flow that actually passes through the primary element. It corrects the theoretical flow equation for effects of frictional energy loss, placement of the pressure taps and velocity profile. C_d has been studied extensively with equations being developed to accurately fit test data. ASME, ISO and AGA all use slightly different equations for C_d. These equations are all a function of Beta (β) and Reynolds Number (R_D). For most primary elements, C_d changes with flow rate.

E, Velocity of Approach Factor

E is simply a substitution for a messy term in the theoretical equation to relate the velocity of the fluid in the throat of an orifice plate to that in the pipe. Beta ratio is the only variable in this term.

$$E = \frac{1}{\sqrt{1-B^4}}$$

Y_1, Gas Expansion Factor

The density of a gas changes as it passes through a primary element. In the theoretical equation, density is assumed constant before and after a primary element. Y_1 corrects for the change in density of the fluid as it passes through the primary element. It is a function of Beta, the ratio of DP to line pressure, and fluid properties.

ρ, Density

Density is mass per unit volume. Typically lb/ft^3 or kg/m^3. Density of gases is dependent on pressure and temperature. Generally only temperature affects the density of liquids.

Z, Compressibility Factor

By knowing pressure, temperature, and molecular weight (MW), gas density can be calculated using the Ideal Gas Law. The Compressibility Factor (Z) is used in the Ideal Gas Law to compensate for deviations from ideal behavior.

$$PV = ZnRT$$

Where, P= absolute pressure, V= volume, n= mass/MW, R = Gas constant, and T= absolute temperature.

Z is required to accurately calculate real gas density. It is important to note that Z actually changes with pressure and temperature for any given gas.

μ, Viscosity

Viscosity is a measure of a fluids resistance to flow. A greater force is required to shear a higher viscosity fluid than a lower viscosity fluid. Generally, viscosity decreases with temperature for liquids, and increases with temperature for gases.

All of these terms with the exception of N, change with flow, pressure, and/or temperature. The 3051S MultiVariable™ transmitter compensates for these variables by dynamically calculating all of the DP flow coefficients using real time measurements of differential pressure, static pressure and temperature.

Emerson Process Management
Rosemount Measurement
8200 Market Boulevard
Chanhassen MN 55317 USA
Tel (USA) 1 800 999 9307
Tel (International) +1 952 906 8888
Fax +1 952 949 7001

Emerson Process Management
Blegistrasse 23
P.O. Box 1046
CH 6341 Baar
Switzerland
Tel +41 (0) 41 768 6111
Fax +41 (0) 41 768 6300

Emerson FZE
P.O. Box 17033
Jebel Ali Free Zone
Dubai UAE
Tel +971 4 811 8100
Fax +971 4 886 5465

Emerson Process Management Asia Pacific Pte Ltd
1 Pandan Crescent
Singapore 128461
Tel +65 6777 8211
Fax +65 6777 0947
Service Support Hotline : +65 6770 8711
Email : Enquiries@AP.EmersonProcess.com

EMERSON™
Process Management