

ORIFICE
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A Flowmeter Sizing Computation

by KYLE ENGINEERING, INC.

ORIFICE is a program meant to be used by the practicing engineer as an aid to the design of orifices for measurement of fluid flow. As such, it is intended to supplement rather than replace the engineer's skill and judgement. Numbers generated by this program may be meaningless or even incorrect for a given application if input data have not been wisely chosen. It is the user's responsibility to employ this program and its results in a sound and appropriate manner.

This program will provide computer aided sizing techniques for the most common industrial fluid flowmeter, the square edge orifice plate. This is generally considered the flowmeter of choice in 2-inch and larger pipe line sizes for clean liquids, gases, and low velocity vapor (including steam) flows. ORIFICE will calculate new orifice bores, recalculate range changes for existing orifice systems, and determine on-line flows from user-supplied process data.

The program uses methods found in two books. The first is the classic text "Principles and Practice of Flow Meter Engineering" by L. K. Spink (copyright by the Foxboro Company), edition 9. The other is a more recent work, "Flow Measurement Engineering Handbook", First Edition, by R. W. Miller, which describes the recently adopted ISO/ASME orifice equations and recommendations. The program user has the choice of either method.

HOW IT WORKS

Rigorous calculation of orifice performance is a complex procedure. The reader is advised to refer to the two books mentioned above for a complete description of calculation method. Basic equations for the calculation as used in this program are as follows:

ORIFICE - FUNDAMENTAL EQUATIONS

Specific to the spink universal equation:

$$W_m = 359 S D^2 F_a F_m F_c Y_1 (\text{Gamma} * h_m)^{0.5}$$

where --

$$S = (0.598 B^2) + (0.01 B^3) + (0.00001947 B^2 (10 B)^{4.425})$$

for flange taps

$$S = (0.58925 B^2) + (0.2725 B^3) - (0.825 B^4) + (1.75 B^5)$$

for pipe taps

$$F_m = 1.0 \text{ for "dry" transmitters}$$

$$F_c = K/K_1$$

$$K_1 = S/B^2$$

$$K = K_o (1 + (E_f B/RD)) \text{ for flange taps}$$

$$K = K_o (1 + (E_p B/RD)) \text{ for pipe taps}$$

- (See Buckingham equations # 119 - 129 in Spink, pages 527
- and 528 for additional information.)

$$\Gamma = \text{Flowing Specific Weight (lbs./cu. ft.)}$$

$$W_m = \text{Maximum Weight Flow Rate (lbs./hr.)}$$

$$W_n = \text{Normal Weight Flow Rate (lbs./hr.)}$$

$$RD = (6.32 W_n) / (\mu D) = \text{Pipe Reynolds Number}$$

Specific to ISO/ASME equations (Miller S_m method):

$$q_m = 358.9268 S_m F_a D^2 (\rho h_w)^{0.5}$$

where--

- $$S_m = \frac{C Y_1 B^2}{(1 - B^4)^{0.5}}$$
-

$$C = 0.5959 + (0.0312 B^{2.1}) - (0.184 B^8) + (0.09 B^4) / ((D_1 - B^4)) - (0.0337 B^3) / D + (91.71 B^{2.5}) / RD^{0.75}$$

for flange taps and $D > 2.3$ inches

$$C = 0.5959 + (0.0312 B^{2.1}) - (0.184 B^8 + (0.0399 B^4) / (1 - B^4) - (0.0337 B^3) / D + (91.71 B^{2.5}) / RD^{0.75}$$

for flange taps and $2 < D < 2.3$ inches

$$C = ((1-B^4)^{0.5} (0.598 + 0.468 (B^4 + 10 B^{12}) + (0.87 + 8.1 B^4) RD^{-0.5}$$

for flange taps and $D < 2$ inches

$$C = 0.5959 + 0.461 B^{2.1} + 0.48 B^8 + (0.039 B^4) / (1 - B^4) + (91.71 B^{2.5}) / RD^{0.75}$$

for pipe taps

Rho = Flowing Density (lbs./cu. ft.)

qm = Maximum Mass flow rate (lbs./hr.)

qn = Normal Flow Rate (lbs./hr.)

$RD = (6.32 qn) / (\text{Mu } D)$
(pipe reynolds number)

COMMON TO BOTH EQUATIONS

hw = Operating Differential Pressure (inches water column)

D = Pipe Inner Diameter (inches)

B = Orifice diameter / D (Beta Ratio)

Mu = Viscosity (centipoise)

Fa = Thermal Correction Factor

- (Fitted Equations Based on charts in Spink, page 156,
- and Miller, page 9-171.)

$k = \text{Specific Heat Ratio}$

$P_f = \text{Upstream Flowing Pressure (psig)}$

$p_f = P_f + 14.7 \text{ (psia)}$

$X = h_w / (27.7 p_f)$

$Y_1 = 1 - (0.41 + 0.35 B^4) X/k$

for flange taps

$Y_1 = 1 - (0.333 + 1.145 B^2 + 0.7 B^5 + 12 B^{13}) X/k$

for pipe taps

INSTRUCTIONS ON DISK

- This instruction set has been placed on the disk for the
 - convenience of the user. To print out the instructions on your
 - printer be in system mode, enter the instruction "TYPE
 - ORIFICE.DOC", and press ENTER. The instructions will be
 - displayed on your screen. To get a hard copy simultaneously
- press Ctrl and PrtSc prior to entering the TYPE command.

PROBLEMS

- If you experience any difficulty operating this software write or telephone Techdata at

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Houston, TX 77083
(713) 498-0797

- Even if you do not experience problems, we'd like to hear your
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