ORIFICE MTERE

BASIC SELECTION & DESIGN CONSIDERATIONS

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METER SELECTION PHILOSOPHY

- ⌘Reliability/ Repeatability
- ⌘Rangeability
- ⌘Versatility
- ⌘Economics
  - ⌘Installation Cost
  - ⌘Maintenance cost
- ⌘Easily Replaceable
- ⌘Range modification
- ⌘Space Occupation

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Why Orifice Meter

- Least Expensive.
- Easiest to Change.
- Locally Resizable.

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Why Orifice Meter (Continued)

METER	ERROR
•Single Orifice Meter	2%
•Dual Orifice Meter	0.75%
•Mag Flow meters	1%
•Positive displacement meter	0.25%

Therefore it is by far the most common sensing element used.

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What is an Orifice Meter?

An orifice Meter is a conduit and a restriction to create pressure drop.

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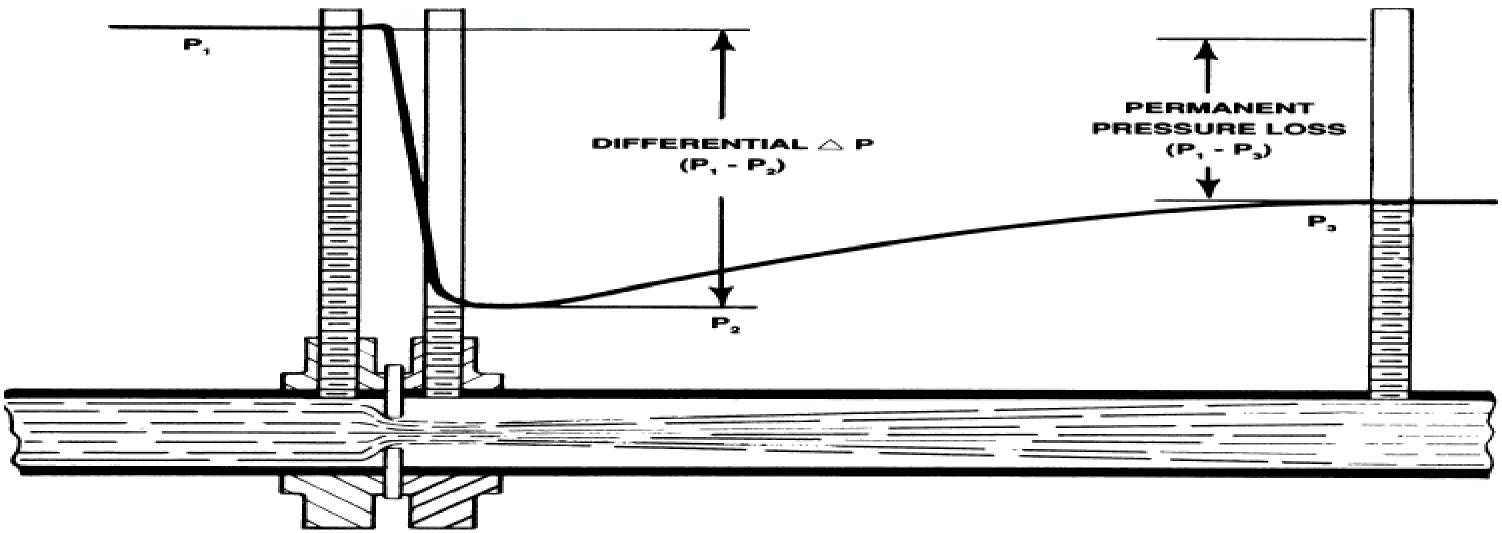
How does it work?

As the fluid approaches the orifice plate, the pressure increases slightly and then drops suddenly as the orifice plate is passed.



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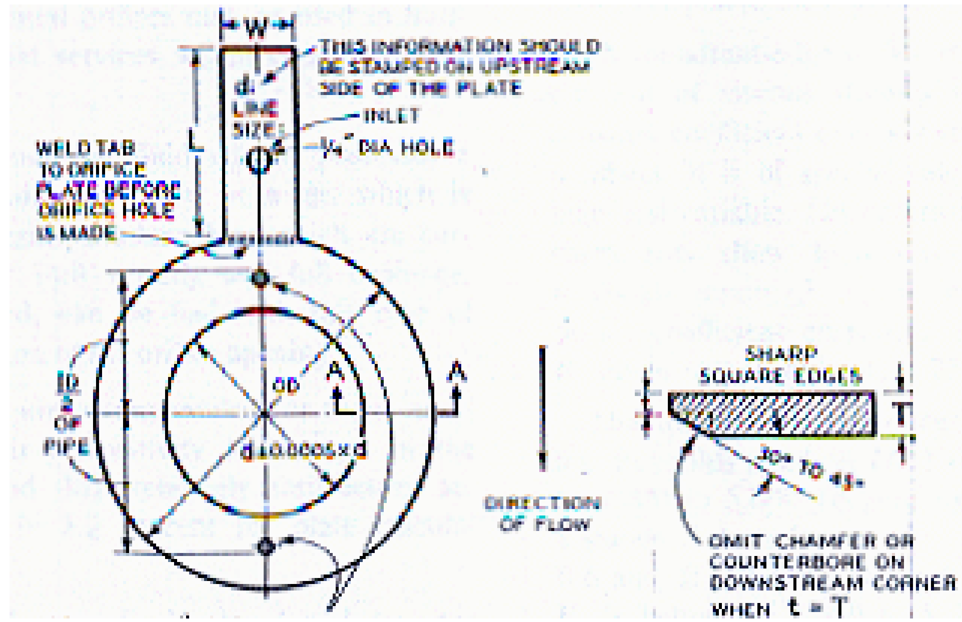
CONCENTRIC ORIFICE PLATE SPECIFICATIONS

- **Material of construction**

SS-304, SS-316, or some special material



- **Orifice plate Edge Thickness**

D/50, d/8, (D-d)/8

- **The Upstream edge of Orifice**

Square & Sharp

- **Weep holes Provision**

To remove moisture from wet steam, wet gas, or to remove non-condensables from liquid stream

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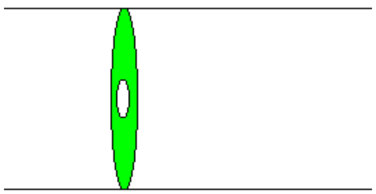
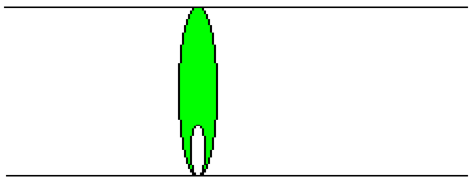
TYPES OF ORIFICE PLATE

A. The Thin Plate, Concentric Orifice



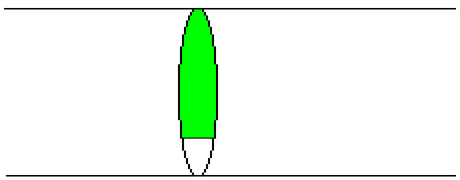
- Reliable measurement.
- The upstream edge of the orifice must be sharp and square.
- Minimum plate thickness based on pipe I.D., orifice bore, etc. is standardized.

B. Eccentric Orifice Plates



⌘Round opening (bore) tangent to the inside wall of the pipe.
⌘Used to measure fluids which carry a small amount of non-abrasive solids, or gases with small amounts of liquid.

C. Segmental Orifice Plates



⌘Used for measuring liquids or gases which carry non-abrasive impurities such as light slurries or exceptionally dirty gases.
⌘Efficiency not as good as that of Concentric Plate.

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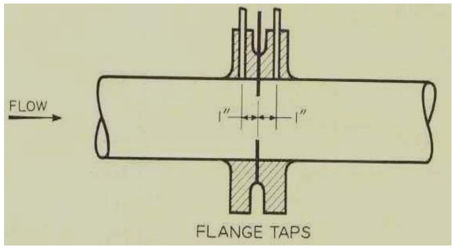
METER TAP TYPE / LOCATION

a. Flange Taps

• 1” from the U/S face

•1” from the D/S face with a + 1/64 to +1/32 tolerance.

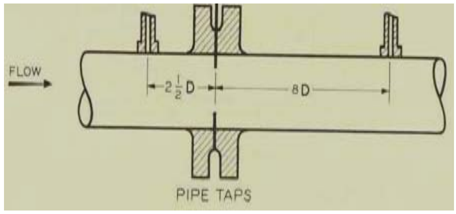


b. Pipe Taps

•2½ pipe diameters U/S

• 8 pipe diameters downstream

(point of maximum pressure recovery).

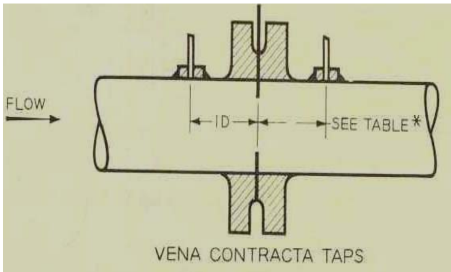


c. Vena-Contracta Taps

•One pipe diameter U/S

•The point of minimum pressure downstream

(vena-contracta 0.3~0.8 PD).



d. Corner Taps

•Immediately adjacent to the plate faces, U/S and D/S.

•Used in line sizes less than 2 inches

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TAP LOCATION / FLOW DIRECTION

- ⌘Hold Impulse Leads to Min. Length
- ⌘1in/ ft positive slop to avoid possible pocketing & to provide venting / drainage.
- ⌘In Vertical lines Up flow for liquids to avoid vap or Trash build up
- ⌘Install meter Below the tap for liquids and condensable vapors
- ⌘For gases install meter above the taps for avoiding the accumulation of condensable

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DESIGN COSIDERATION OF ORIFICE METER

•Design Flow rate and Meter Capacity

Design flow should be above 30% and below 90% of maximum Flow.

• ß Ratio (d/D) (Range varies between 0.7 to 0.25)

•Meter dP (<1/25th of the line pressure)

•Line Size (Minimum line size of 2" is standard because of pipe roughness considerations)

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Orifice Plate Coefficient of Discharge - Cd

The coefficient of discharge depends on

- ⌘Reynolds number
- ⌘Sensing tap location
- ⌘Meter tube diameter

&

- ⌘Orifice diameter etc.

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SIZING ORIFICES

Orifice Plates are sized to provide the differential of 100~200 in H2O Column at maximum Flow Rate.

Advantage:

This sizing allows to change the meter range without changing the orifice plate.

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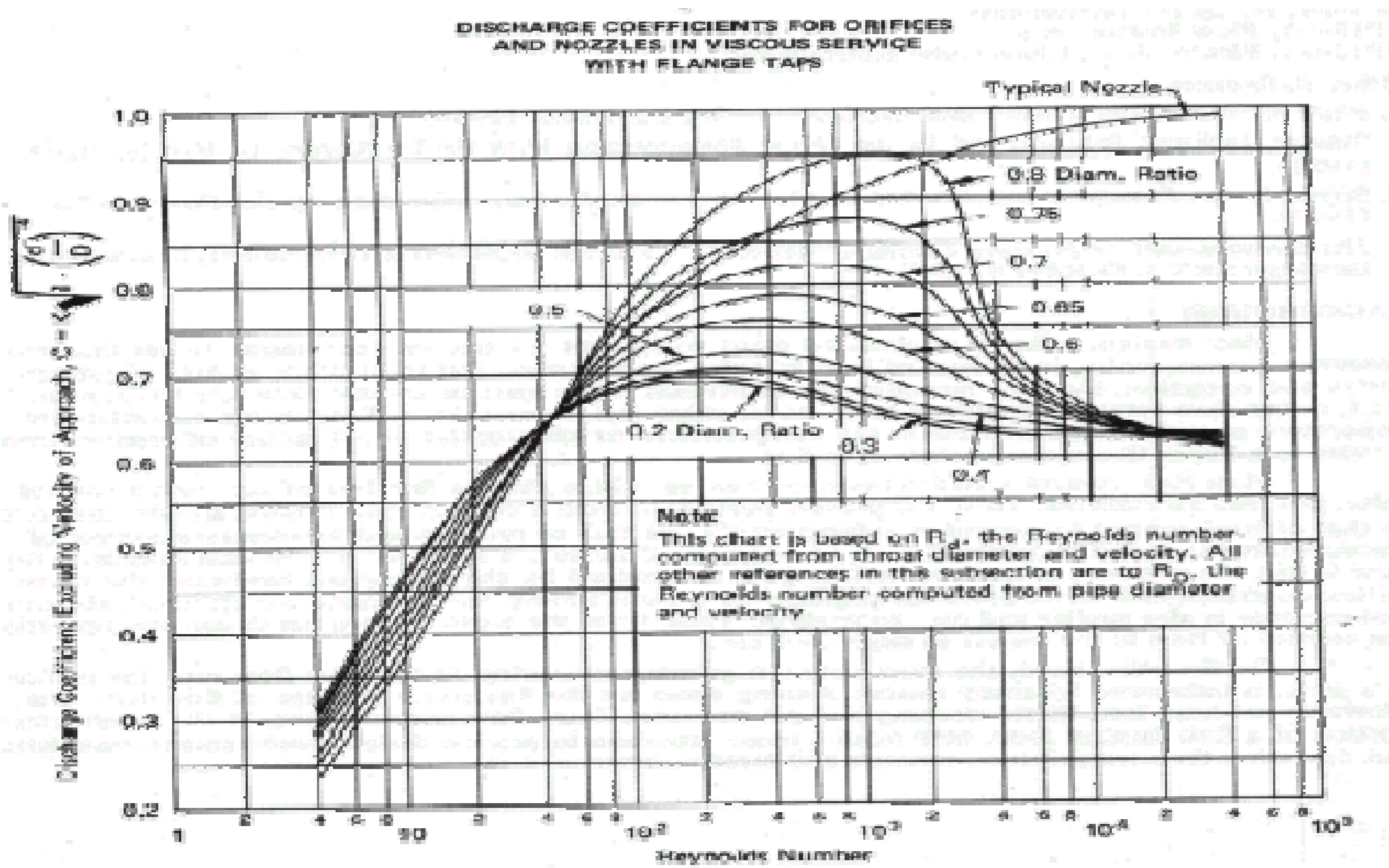
Discharge Coefficient



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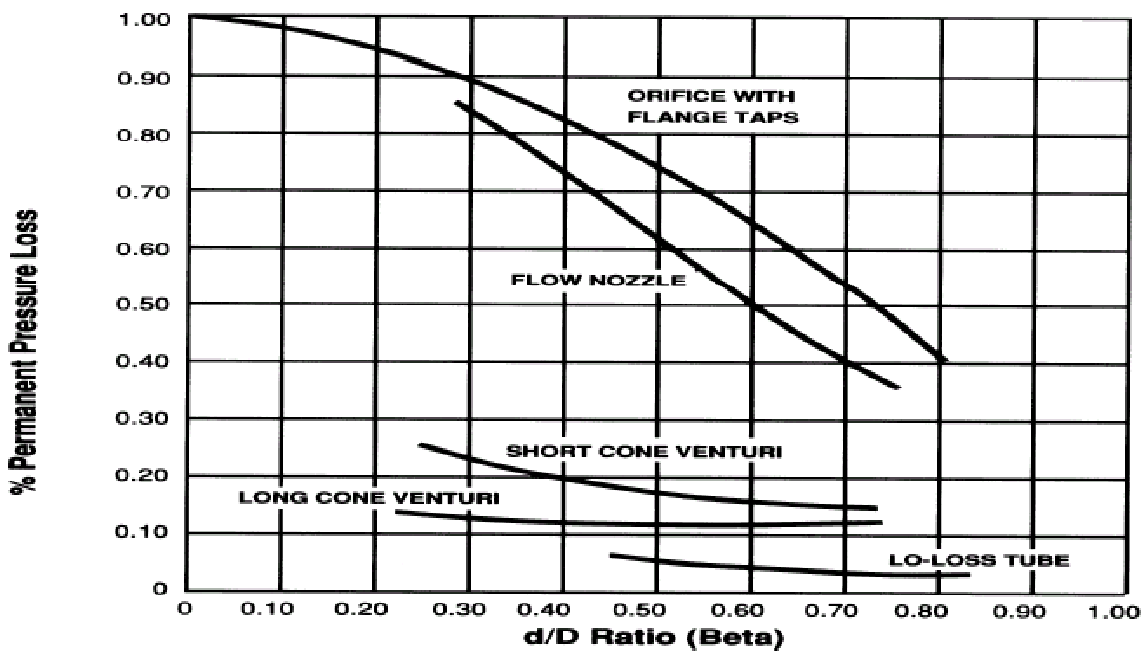
Pressure Recovery

The fraction of the orifice differential that is lost permanently depends upon **β** ratio.



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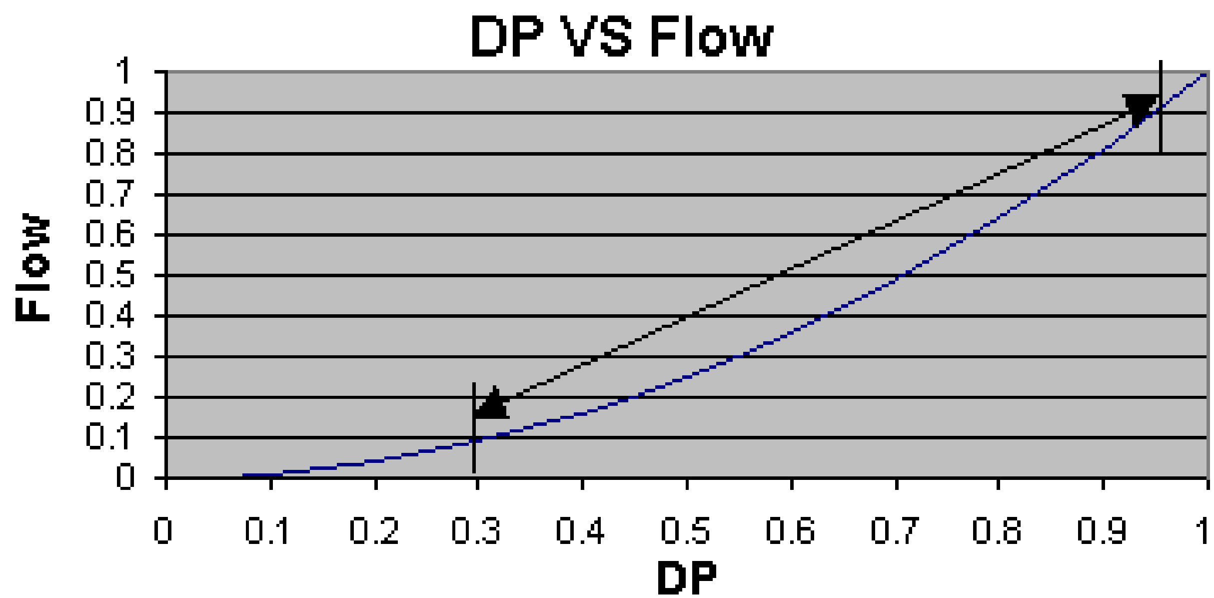
Orifice Meter Limitations

RANGEABILITY:



Because of Sq. Root Relationship accuracy and readability become worse at decreased flow rates.

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Orifice Meter Limitations CONTINUED

RANGEABILITY :

Solution:

To decrease this rangeability without loss in accuracy, two differential pressure transmitters with different ranges can be connected across Orifice Plate.

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Orifice Meter Limitations CONTINUED

VARYING DISCHARGE COEFFICIENT AT LOW R_D

Below a Pipe R_D of about 20,000, the basic discharge coefficient changes markedly with R_D and hence with flow rate.

Solution:

For this reason Either

- It is not used below R_D 20,000. Or
- Specially designed to operate on flat portion of the curve (C_D VS R_D) with the realization that accuracy would somewhat reduced.

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Orifice Meter Limitations CONTINUED

VARYING PROCESS CONDITIONS

As the Process flow conditions deviate from the design conditions, flow indications become inaccurate.

Solution:

To compensate this inaccuracy in the indication the correction factors are introduced into the flow measuring relation.

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Correction Factors for Compressible Fluids

Pressure correction

$$Q_2 = \sqrt{\frac{P_2}{P_1}} \times Q_1$$

Temperature correction

$$Q_2 = \sqrt{\frac{T_1}{T_2}} \times Q_1$$

Molecular weight Correction

$$Q_2 = \sqrt{\frac{M_2}{M_1}} \times Q_1$$

Overall Correction

$$Q_2 = \sqrt{\frac{P_2 M_2 T_1}{P_1 M_1 T_2}} \times Q_1$$

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Correction Factors for Compressible Fluids

EXAMPLES

CO2 Flow to UR-1

Parameter	Design	Operating
Temp	95 F	95 F
Press	5 Psig	7 Psig
MW	44	43.65
Flow	510 KSCFH	533 KSCFH

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Correction Factors for Compressible Fluids

EXAMPLES

CO2 Flow to UR-2

Parameter	Design	Operating
MW	44	43.427
Flow	1280	1272

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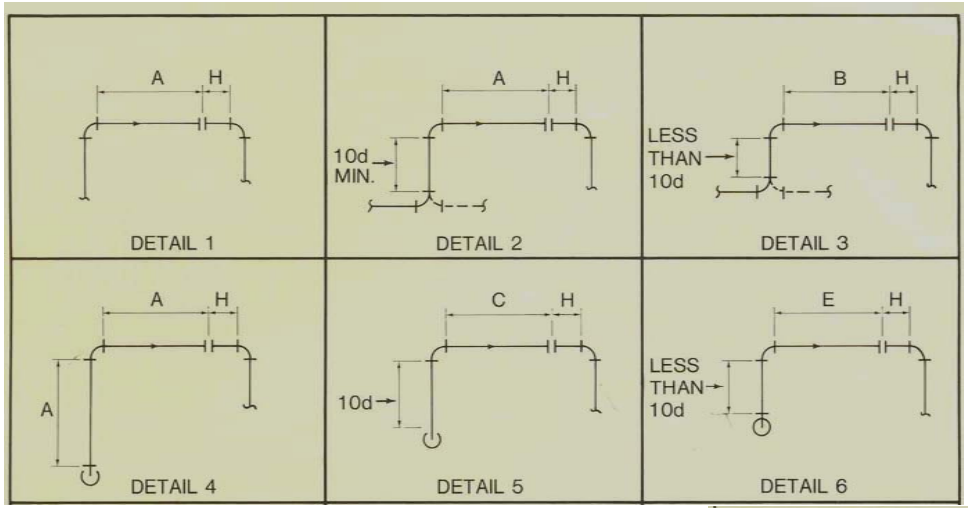
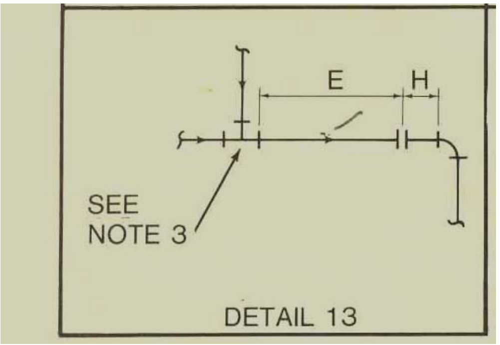
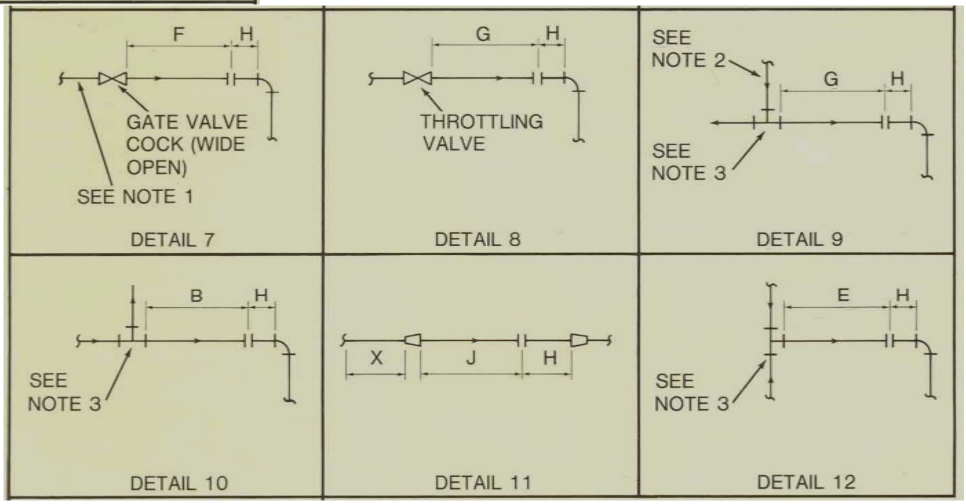
Straight Run Vs Fittings







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Straight Run Vs Fittings

Table 1-2—d/D vs. Straight Run Required

d/D = Orifice ID / Actual Pipe ID (See Note 4)	Straight Run Required (Nominal Pipe Diameters)							
	A	B	C	E	F	G	H	J
.8	20	25	33	40	14	50	5	15
.75	17	21	27	35	11	44	5	14
.7	14	19	23	31	9	39	5	13
.65	12	15	21	28	8	34	5	11
.6	10	14	19	25	8	31	5	10
.55	9	12	18	22	7	28	5	9
.5	8	10	17	21	7	25	5	8
.45	7	9	16	20	5	24	5	7
.4	7	9	15	18	5	22	5	7
.35	6	9	14	17	5	21	5	6
.3	6	9	14	16	5	20	5	6
.25	6	9	14	16	5	19	5	6

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ORIFICE MTERE
CALCULATIONS

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BASIC EQUATIONS

Liquid Flow>M_L=2834.53*D^2* β^2*C_d*F_a*$(Sp.g*H)^{1/2}$

Gas Flow>M_G=2834.53*D^2* β^2*C_d*F_a*Y_1*$(\rho*H)^{1/2}$

- C_d = Orifice plate coefficient of discharge
- D = Pipe ID calculated at Standard Conditions
- ρ = Density of Gas at reference conditions (Lb/Cu ft)
- H = Orifice differential pressure in inches of water at 60 degF
- $Q_{L,G}$ = Mass flow rate - Lb/hr.
- Y_1 = Expansion factor (upstream tap)
- F_a = Ratio of the Orifice bore area at operating conditions to those at 60 ^{o}F
- β =Ratio of Orifice Bore Dia to Pipe ID

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