

the static pressure is at a minimum. Its location, and the location of the downstream vena contracta tap, varies with the ratio of orifice to pipe diameter, and with rate of flow, as shown in Fig. 12; the tap is generally located in accordance with the mean curve in the figure.

Expansion Factor for Gases

The expansion factor, Y , for gases (for liquids, $Y = 1$) is found from the empirical formula

$$Y = 1 - (0.41 + 0.35\beta^4) \left(\frac{p_1 - p_2}{p_1} / k \right) \quad (55)$$

This is applicable to flange, radius, and vena contracta taps. For pipe taps, the formula is

$$Y = 1 - \left[0.333 + 1.145 (\beta^2 + 0.7\beta^5 + 12\beta^{10}) \right] \left[\frac{p_1 - p_2}{p_1} / k \right] \quad (56)$$

Values of Y for air, computed from these equations, are given in Fig. 13 and Fig. 14.

Computing Orifice Discharge

With this information it is possible to compute the discharge from an orifice if the Reynolds number is known. Here an odd complication is encountered—when the value of N_{Re} is computed, the rate of flow, which is the unknown quantity, must be used in the computation. However, it will be noted in Figs. 7, 8, 9, and 10 that the orifice coefficient does not change greatly as N_{Re} changes. If, then, an estimate is made of the velocity, using this in computing N_{Re} , and if the corresponding coefficient is used in Equation 54, a value for the rate of flow will be found. Using this velocity to compute a corrected value of N_{Re} and repeating the process, a more nearly correct value of Q_t is found. This cut-and-try method may be continued for several more cycles, but generally the first or second correction will be found sufficient.

Another method would be to use the value of K corresponding to $N_{Re} = \infty$, modifying this with a factor involving the rate of flow, determined from the temperature, and the differential and static pressures. This method is used by the *American Gas Association*.³

STEAM FLOW MEASUREMENT

While steam may be considered as a gas, its measurement differs from that of the usual gases because of a number of factors. Equation 48 serves as the starting point. Since it is usual to measure the differential pressure in inches of water, it is necessary to convert h_t , the head in feet in terms of the flowing fluid, to h_{aw} , the actual head in inches of water, using the equation

$$h_t = \frac{h_{aw}}{12} \frac{\rho_w}{\rho} \quad (57)$$

where

ρ_w = the density of water at 60 F (62.37 lb per cubic foot).
 ρ = the density of the flowing fluid.

Substituting Equation 57 in Equation 48 gives

$$Q_t = 359.15 K D_t^2 \sqrt{\frac{h_{aw}}{\rho}} \quad (58)$$

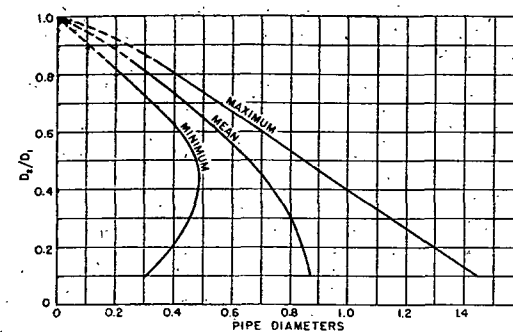


FIG. 12. LOCATION OF VENA CONTRACTA IN RELATION TO RATIO OF ORIFICE TO PIPE DIAMETER AND TO RATE OF FLOW

FIG. 13. EXPANSION FACTOR FOR AIR AND OTHER DIATOMIC GASES APPLICABLE TO FLANGE, RADIUS AND VENA CONTRACTA TAPS

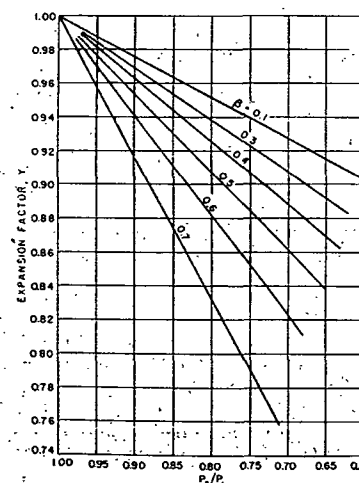
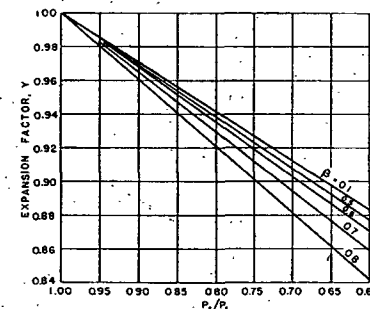


FIG. 14. EXPANSION FACTOR FOR AIR AND OTHER DIATOMIC GASES, APPLICABLE TO PIPE TAPS