this velocity to compute a corrected value of N_{Re} and repeating the process, a more nearly correct value of Q_f 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 52 serves as the starting point. Since it is usual to measure the differential

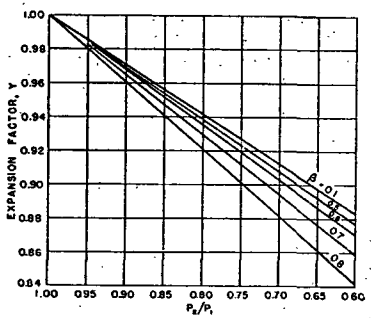


FIG. 12. EXPANSION FACTOR FOR AIR AND OTHER DIATOMIC GASES APPLICABLE TO FLANGE, RADIUS AND VENA CONTRACTA TAPS

pressure in inches of water, it is necessary to convert h_f, the head in feet in terms of the flowing fluid, to h_{aw}, the actual head in inches of water, using the equation:

$$h_f = \frac{h_{aw}}{12}\frac{\rho_w}{\rho} \tag{60}$$

where

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

Substituting Equation 60 in Equation 52 gives

$$Q_f = 359.15\,KD_2^2\sqrt{\frac{h_{aw}}{\rho}} \tag{61}$$

In steam measurement, a constant head of water is maintained over each leg of the manometer by means of condensing chambers, in order to keep the heat of the steam away from the meter. As the mercury level fluctuates, the difference in head as recorded on the chart, therefore, is not that due to mercury alone, but to mercury minus an equivalent head of water. To correct for this, the equation:

$$h_{aw} = h_w\frac{12.557}{13.557} \tag{62}$$

is applied to Equation 61. The denominator in Equation 62 is the specific

gravity of mercury; and the numerator is the difference in specific gravity between mercury and water. Hence, Equation 61 becomes

$$Q_f = 345.65\,KD_2^2\sqrt{\frac{h_w}{\rho}} \tag{63}$$

Steam is commonly measured in terms of weight, and since

$$w_h = \rho Q f \tag{64}$$

where

w_h = the rate of flow in pounds per hour.

$$w_h = 345.65\,KD_2^2\sqrt{h_w\rho} \tag{65}$$

The expansion factor Y, and the factor P, correcting for the expansion of the orifice plate with the temperature, must then be applied, so that

$$w_h = 345.65\,KYPD_2^2\sqrt{h_w\rho} \tag{66}$$

which is the *final form of the equation for the flow of steam through orifices.* Values of K may be obtained from Figs. 7, 8, and 9, according to the

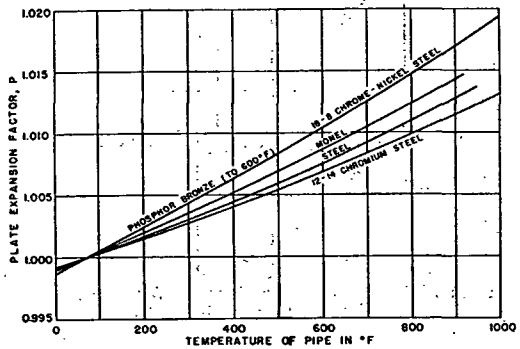


FIG. 13. VARIATION OF ORIFICE PLATE EXPANSION FACTOR, P, WITH TEMPERATURE AND MATERIAL

pressure taps used. Y may be computed from Equation 59. Fig. 13 gives values of the correction factor P, according to the temperature and the material of the orifice plate. Values of the density, ρ, may be obtained from steam tables, such as Keenan and Keyes[4], which are widely used.

METERING LIQUIDS

Orifices are also used for metering liquids, and Equation 52 serves again as a starting point for developing the working formula. Again, it is necessary to convert h_f to h_{aw}, the actual head in inches of water, by substituting Equation 60. It is also necessary to correct for the weight of the fluid above the manometer, and since this may be other than water, it is better to use an equation of more general form than Equation 62:

$$h_{aw} = h_w\frac{13.557 - \frac{\rho_f}{\rho_w}}{13.557} \tag{67}$$