

in terms of the flowing fluid, to h_{aw} , the actual head in inches of water, using the equation

$$h_f = \frac{h_{aw} \rho_w}{12 \rho} \quad (56)$$

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 56 in Equation 48 gives

$$Q_f = 359.15 K D_2^2 \sqrt{\frac{h_{aw}}{\rho}} \quad (57)$$

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

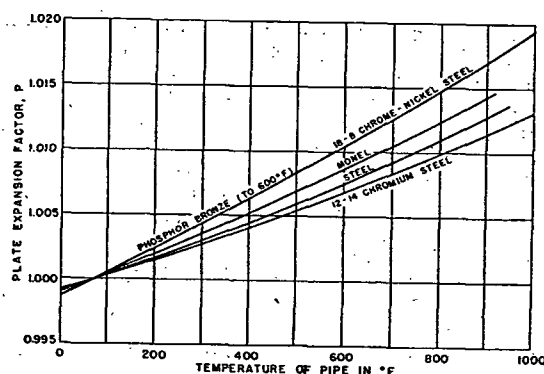


FIG. 13. VARIATION OF ORIFICE PLATE EXPANSION FACTOR, P , WITH TEMPERATURE AND MATERIAL

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

$$h_{aw} = h_w \frac{12.557}{13.557} \quad (58)$$

is applied to Equation 57. The denominator in Equation 58 is the specific gravity of mercury; and the numerator is the difference in specific gravity between mercury and water. Equation 57, hence, becomes

$$Q_f = 345.65 K D_2^2 \sqrt{\frac{h_w}{\rho}} \quad (59)$$

Steam is commonly measured in terms of weight, and since

$$W = \rho Q_f \quad (60)$$

where

W = the rate of flow in pounds per hour.

$$W = 345.65 K D_2^2 \sqrt{h_w \rho} \quad (61)$$

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

$$W = 345.65 K Y P D_2^2 \sqrt{h_w \rho} \quad (62)$$

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 pressure taps used. Y may be computed from Equation 55. 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 Keyes⁴, which are widely used.

METERING LIQUIDS

Orifices are also used for metering liquids, and Equation 48 serves again as a starting point for developing the working formula. Again,

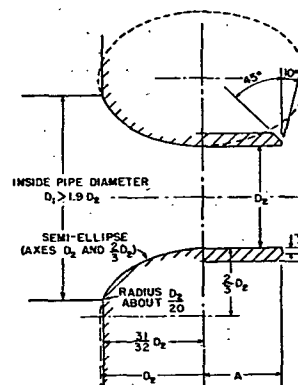


FIG. 14. SHAPE OF ASME LONG RADIUS NOZZLE WHEN RATIO OF THROAT TO PIPE DIAMETER IS 0.53 OR LESS

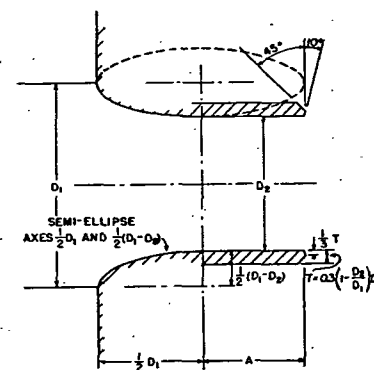


FIG. 15. SHAPE OF ASME LONG RADIUS NOZZLE WHEN RATIO OF THROAT TO PIPE DIAMETER IS 0.4 TO 0.7

too, it is necessary to convert h_f to h_{aw} , the actual head in inches of water, by substituting Equation 56. 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 58:

$$h_{aw} = h_w \frac{13.557 - \frac{\rho_f}{\rho_w}}{13.557} \quad (63)$$

where

ρ_f = the density of the fluid over the mercury in the manometer.

ρ_w = the density of water at 60 F.

Substituting Equations 56 and 63 in Equation 48 gives

$$Q_f = 44.764 K D_2^2 \sqrt{h_w \left(\frac{1}{\rho_f} - 0.00118 \right)} \quad (64)$$