Power Calculations

Conduction and Convection Heating

Total Heat Losses

The total conduction, convection and radiation heat losses are summed together to allow for all losses in the power equations. Depending on the application, heat losses may make up only a small fraction of total power required or it may be the largest portion of the total. Therefore, do not ignore heat losses unless previous experience tells you it is alright to do.

Equation 3E—Total Losses

$Q_L = Q_{L1} + Q_{L2} + Q_{L3}$ If convection and radiation losses are calculated separately. (Surfaces are not uniformly insulated and losses must be calculated separately.)

OR

$Q_L = Q_{L1} + Q_{L4}$ If combined radiation and convection curves are used. (Pipes, ducts, uniformly insulated bodies.)

Start-Up and Operating Power Required

Both of these equations estimate required energy and convert it to power. Since power (watts) specifies an energy rate, we can use power to select electric heater requirements. Both the start-up power and the operating power must be analyzed before heater selection can take place.

Equation 4—Start-Up Power (Watts)

$$P_S = \left[\frac{Q_A + Q_C}{t_S} \frac{2}{3} (Q_L)\right] \times (1 + S.F.)$$

Q_A = heat absorbed by materials during heat-up (Wh)

Q_C = latent heat absorbed during heat-up (Wh)

Q_L = conduction, convection, radiation losses (Wh)

S.F. = safety factor

t_S = start-up (heat-up) time required (hr)

During start up of a system the losses are zero, and rise to 100 percent at process temperature. A good approximation of actual losses is obtained when heat losses (Q_L) are multiplied by $^2/_3$.

Equation 5—Operating Power (Watts)

$$P_O = \left[\frac{Q_B + Q_D}{t_C} + (Q_L)\right] \times (1 + S.F.)$$

Q_B = heat absorbed by processed materials in working cycle (Wh)

Q_D = latent heat absorbed by materials heated in working cycle (Wh)

Q_L = conduction, convection, radiation losses (Wh)

S.F. = safety factor

t_C = cycle time required (hr)