Reference Data

Power Calculations

Conduction and Convection Heating

Conduction Heat Losses

Heat transfer by conduction is the contact exchange of heat from one body at a higher temperature to another body at a lower temperature, or between portions of the same body at different temperatures.

Equation 3A—Heat Required to Replace Conduction Losses

$$Q_{L1} = \frac{k \times A \times \Delta T \times t_E}{3.412 \times L}$$

Q_{L1} = conduction heat losses (Wh)

k = thermal conductivity (BTU x in./[ft² x °F x hour])

A = heat transfer surface area (ft²)

L = thickness of material (in.)

ΔT = temperature difference across material (T_2-T_1) °F

t_E = exposure time (hr)

This expression can be used to calculate losses through insulated walls of containers or other plane surfaces where the temperature of both surfaces can be determined or estimated.

Convection Heat Losses

Convection is a special case of conduction. Convection is defined as the transfer of heat from a high temperature region in a gas or liquid as a result of movement of the masses of the fluid.

Equation 3B—Convection Losses

$Q_{L2} = A \times F_{SL} \times C_F$

Q_{L2} = convection heat losses (Wh)

A = surface area (in²)

F_{SL} = vertical surface convection loss factor (W/in²) evaluated at surface temperature

C_F = surface orientation factor
heated surface faces up horizontally = 1.29
vertical = 1.00
heated surface faces down horizontally = 0.63

Radiation Heat Losses

Radiation losses are not dependent on orientation of the surface. Emissivity is used to adjust for a material's ability to radiate heat energy.

Equation 3C—Radiation Losses

$Q_{L3} = A \times F_{SL} \times e$

Q_{L3} = radiation heat losses (Wh)

A = surface area (in²)

F_{SL} = blackbody radiation loss factor at surface temperature (W/in²)

e = emissivity correction factor of material surface

Example:

We find that a blackbody radiator (perfect radiator) at 500°F, has heat losses of 2.5 W/in². Polished aluminum, in contrast, (e = 0.09) only has heat losses of 0.22 W/in² at the same temperature (2.5 W/in² · 0.09 = 0.22 W/in²).

Combined Convection and Radiation Heat Losses

Some curves combine both radiation and convection losses. This saves you from having to use both Equations 3B and 3C. If only the convection component is required, then the radiation component must be determined separately and subtracted from the combined curve.

Equation 3D—Combined Convection and Radiation Heat Losses

$Q_{L4} = A \times F_{SL}$

Q_{L4} = surface heat losses combined convection and radiation (Wh)

A = surface area (in²)

F_{SL} = combined surface loss factor at surface temperature (W/in²)

This equation assumes a constant surface temperature.