load a starting resistor *NEMA* classification No. 15 may be used. For speed regulation resistor, classification No. 93 should be selected. On a compressor drive using an unloader, a constant torque resistor classification No. 15 should be used. If the compressor is started under load, *NEMA* classification No. 56 or 76 are used. For constant torque speed regulation, resistor No. 95 is used.

SINGLE PHASE MOTOR CONTROL

Where three phase current is not available or where single phase operation is preferred, then single phase repulsion induction, capacitor type or multispeed single phase motors may be used. Since the starting currents of all single phase motors are required to be within the starting-current limits established by the local power-supply company, a suitable type of starter may be chosen from the following selection:

1. Enclosed two pole manually operated motor starters with thermal overload protection.
2. Enclosed two pole automatic motor starter operated by a push button, thermostat or similar device, with thermal overload relay and low voltage protection.
3. A manual or magnetic resistance type starter with low voltage protection.
4. A manual or magnetic control for pole changing motors and for adjustable varying speed motors using an auto-transformer or resistance in the primary circuit to obtain line (or terminal) voltage drop.

In selecting across-the-line control for single phase capacitor type motors it is usually very desirable to use three pole across-the-line starters. Control for multispeed, single phase capacitor motors may be selected from tables on three phase rating when consideration is given to the increased current and the necessary switching of connections.

Chapter 40

PIPE AND DUCT INSULATION

Heat Transmission by Radiation and Convection, Heat Losses from Bare and Insulated Pipes, Heat Losses from Ducts, Low Temperature Insulation, Insulation of Pipes to Prevent Freezing, Economical Thickness of Pipe Insulation, Underground Pipe Insulation

HEAT is transmitted to or from pipes and ducts by radiation and convection. The radiant heat transfer per unit area is independent of the geometrical shape, whereas the convected heat depends to a considerable extent on the shape factor. In many cases, it is desirable to calculate the rate of heat transmission from a surface by radiation and convection, as the total rate of transfer is different, for instance, from a heating installation than from a cooling installation with an equal difference in temperature between the surface and the surrounding atmosphere.

HEAT TRANSMISSION BY RADIATION AND CONVECTION

The heat transmission by radiation from a surface to the surrounding surfaces can be calculated from the well-known Stefan-Boltzman formula:

$$q_r = 17.4 \times 10^{-10} \times p\,(T_1^4 - T_2^4) \qquad (1)$$

where

q_r = heat transmission by radiation, Btu per square foot per hour.
p = *effective* emissivity of surface and surroundings.
T_1 = temperature of hotter surface, degrees Fahrenheit absolute.
T_2 = temperature of cooler surface, degrees Fahrenheit absolute.

The heat transmission by free or natural convection can be determined from the formula:

$$q_c = C\left(\frac{1}{D}\right)^{0.2}\left(\frac{1}{T\,\text{av.}}\right)^{0.181} dt^{1.266} \qquad (2)$$

where

q_c = heat transmission by convection, Btu per square foot per hour.
C = a constant depending upon the surface shape.
D = diameter of pipe or circular duct or height of vertical wall, inches. (effect of diameter or height becomes constant at 24 in.)
T av. = average wall surface and surrounding air temperature, degrees Fahrenheit absolute.
dt = temperature excess between wall surface and surrounding air, degrees Fahrenheit.