Convection Transfer

Convection values of heat transfer are not easily established. Convection in a panel heated space is usually considered to be of the *natural* type, that is, air motion is generated by the warming (by conduction) of the boundary layer of air which starts moving as soon as its temperature exceeds that of the surrounding air. In practice, however, there are many factors interfering with *natural* convection. Infiltration, localized drafts, ventilation, and movement of persons are all likely to disturb this process so that it becomes difficult to determine the exact convection effect. Until results from current research become available, an interim evaluation of convection heat exchange can be determined for ordinary panel heating applications from available theoretical relationships.

As investigated[3, 4, 5] by Nusselt and Henky, Griffiths and Davis, Wilkes and Peterson, McAdams and others, natural convection is found to be affected by only two factors:

a. Temperature difference between the heat emitting surface and the surrounding air.
b. The position of the surface.

The basic general equation for natural convection from a flat surface is of the following form:

$$q_c = f_c(t_s - t_a)^n \tag{4}$$

where

- q_c = heat transfer by convection, Btu per (square foot) (hour).
- f_c = a coefficient (surface conductance) representing the heat transfer from a unit area per unit difference in temperature, Btu per (square foot) (hour) (Fahrenheit degree temperature difference between surface and air).
- n = an exponent depending on surface position and temperature difference between the surface and the surrounding air.
- t_s = temperature of the surface, F.
- t_a = temperature of the air, F.

The value of n is usually taken as 1.25 regardless of the magnitude of the temperature difference and the position of the surface. However, Wilkes and Peterson state that a value of 1.12 for n is more appropriate for *low temperature differences*, with heat flow upward from horizontal surfaces, and that a value of 1.00 is best in the case of heat flow downward from horizontal surfaces. The various investigators mentioned also indicate that values of f_c vary from 0.2 to 0.38 for downward heat flow from ceilings, and from 0.38 to 0.81 for upward heat flow from floors. The variation in the value of f_c, as reported by the various investigators, is dependent upon the temperature difference and the value of the exponent n.

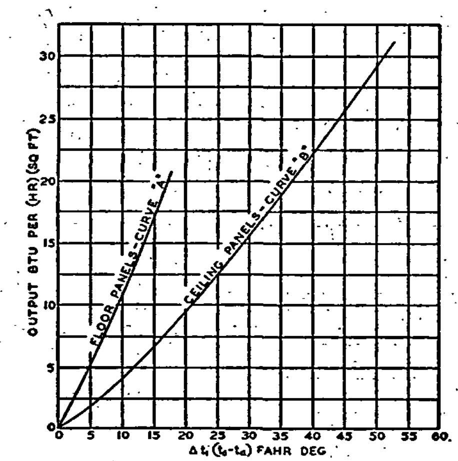
More recent experimental work indicates a provisional correlation between measured convection outputs in actual floor panel heated rooms and the laboratory values obtained by the previous investigators. This correlation indicates that the values obtained from Wilkes and Peterson's equation

$$q_c = 0.81\ (t_s - t_a)^{1.12} \tag{5}$$

for heat flow upward from horizontal surfaces and small temperature differences, give results that check within reasonable precision the convection output from floor panels, with temperature differences as recommended. Curve A in Fig. 10 is based on the equation of Wilkes and Peterson, and gives values which may be used for convection outputs from floor panels.

More experimental data are required on convection outputs of ceiling panels. The warming of the air by a ceiling panel does not in itself create convection currents. Instead, it is the action of cooling along the outside wall or walls which causes the air movement. In lieu of actual test data which would take this factor into account, it is recommended that the values obtained from Curve B in Fig. 10, based on the Nusselt and Henky equation

$$q_c = 0.22\ (t_s - t_a)^{1.25} \tag{6}$$



t_s = panel surface temperature
t_a = inside air temperature

FIG. 10. HEAT OUTPUT BY CONVECTION FROM FLOOR AND CEILING PANELS

should be used for determining convection outputs from ceiling panels for various surface temperatures.

Combined Heat Transfer

The *sum* of the *radiant* heat transfer from Fig. 9 and the *convective* transfer from curve A or B of Fig. 10, gives the combined useful heat transfer to the room for any combination of panel surface temperature, room air temperature, unheated mean radiant temperature (UMRT), and panel location.

Example 1: Find the combined total useful heat transfer from a square foot of floor panel having a surface temperature of 85 F, when the average room air temperature is 70 F and the mean radiant temperature UMRT of the unheated room surfaces is 60 F.

Solution:

	Btu/(hr)(sq ft)
Radiation	
(Fig. 9 for UMRT of 60 F and t_s of 85 F)	21.4
Convection	
(Fig. 10, Curve A for a temperature difference of 15 deg F)	16.9
Total useful heat transfer	**38.3**