

# TECH TIP # 26



One of a series of dealer contractor technical advisories prepared by HARDI wholesalers as a customer service.

## THE “PEOPLE LOAD”

One of the many contributions to internal heat gains is the “people load.” When a contractor designs an air conditioning system he usually adds about 400 Btu’s for each person scheduled to reside in the building. Hence, a family of three sitting in a living room imposes a load of nearly 1200 Btuh on a conditioning unit. Thirty people could impose a one ton cooling load --- or even more, as we shall see.

Setting aside the medical aspects of the human body, let’s consider how and why people can impose such heat loads. In our weight conscious society we often refer to the “number of calories” a certain food may contain. The word calorie is derived from the French word *calor* which means heat. Food, therefore, is energy. The energy is released when the food is oxidized (in a sense burned) in the body. In terms of heat units, one calorie equals about 4 Btu’s. This process of internal heat generation is called metabolism.

At the outset, we stated that the people load was usually taken to be about 400 Btu’s per person, but this is only true for a person sitting at rest. (In fact, it really is an average value, applicable to male adults -- females and children average less. The average female metabolism is about 85 percent of a male’s and a child’s is about 75 percent.)

A person sleeping generates about 260 Btu’s, when walking about 800 Btuh, and for heavy work, such as swimming, a person could generate more than 2000 Btuh. Thus, a person’s size, weight, age and sex, plus the degree of physical activity, all affect the metabolic or heat generation rate. As a result, in design work all these facts should be considered and applicable heat gain values used.

Figure 1 lists the heat gain attributes to people for various activities. The values have been adjusted to account for a normal percentage of women and children as part of the total number of occupants.

The heat energy which is generated internally must be dissipated -- otherwise body temperature will rise and people will become ill. Some of the energy is released as mechanical work, i.e., moving about, but most of the energy is transferred as heat to the surroundings.

To carry off this heat, three modes of energy transfer are involved -- radiation, convection and evaporation. A heat balance shows that metabolism equals the sum of heat lost by these three modes, plus or minus any heat storage in the body.

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Figure 1

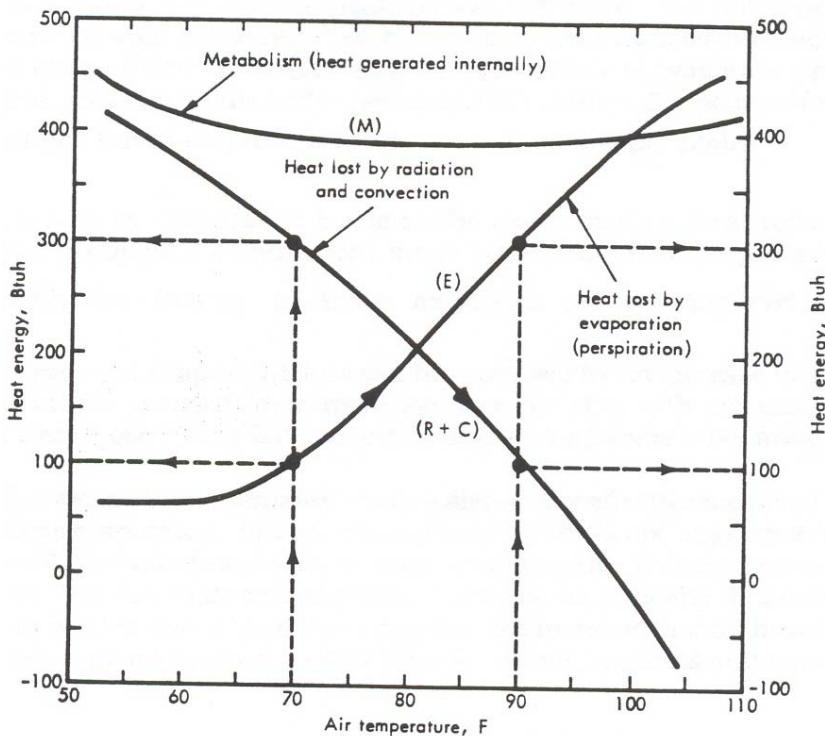
Application	Heat generated per person		
	Sensible	Latent	Total
Home & theaters	195	155	350
Hotel & apartments	195	205	400
Offices & department stores	200	250	450
Drug stores & banks	200	300	500
Restaurants	220	330	550
Light factory work	220	530	750
Dance hall	245	605	850
Moderate factory work	300	700	1000
Bowling & heavy factory work	465	985	1450

Hence:  $M = E + R + C \pm S$

**Where:**  
**M** = metabolic rate, Btuh  
**E** = evaporative heat loss, Btuh  
**R** = radiation heat loss, Btuh  
**C** = convection heat loss, Btuh  
**S** = heat storage (reflected as a rise or fall in body temperature)

This relationship is illustrated graphically in Figure 2 for a person sitting at rest in an atmosphere with 45 percent relative humidity, such as is normally encountered in residential air conditioning.

Figure 2



The upper curve, labeled "M," is the metabolism or heat generation rate: the other curves represent the heat loss by evaporation (E) and the combined losses due to radiation and convection heat transfer (R + C).

It can be seen from curve M that, except for extremes of heat or cold, a person's metabolism when sitting down is very

nearly constant at a value of 400 Btuh. In a cold environment a person loses more heat than is generated and shivering may result in an attempt to increase metabolism. Conversely, in an extremely hot environment, heat is not lost fast enough and heat exhaustion could occur.

Note as the ambient air temperature increases (horizontal scale), body heat lost by evaporation increases, and logically the heat lost by perspiration (evaporation), and 300 Btuh is lost by radiation to cold wall and window surfaces, including convection losses to room air moving over the body. At 90° F, the situation is just reversed. Since room air, wall and window surfaces are now warmer, less heat (only about 100 Btuh) is carried away by radiation and convection and the loss due to moisture evaporation from the skin is larger --- about 300 Btuh.

In both these cases the sum of the total heat lost was 400 Btuh. Any difference between the metabolic rate and the sum of the heat lost by the three transfer methods, means heat storage is taking place. (Note: since it takes about 1000 Btu's to evaporate a pound of water at room conditions, this means the body loses only 100/1000 or 0.1 pounds of moisture at 70° F and 45 percent RH, but at 90° F this increases to 0.3 pounds per hour.)

Because the heat loss by evaporation becomes the major mode of heat rejection at higher temperatures, the occupant's environment must be "conditioned" to promote evaporative losses --- specifically this refers to two factors, air motion and humidity level.

The rate of perspiration or evaporative loss can be increased by an increase in air velocity over the body. The increase in moisture evaporation from the skin with increased air motion is precisely why a simple oscillating fan is effective in providing some relief from the heat.

Dry air, or in other words, a low humidity level, is also a very effective means of improving the amount of moisture evaporated. In fact, where humidity levels are high, moisture will not be evaporated, but will accumulate as beads of sweat upon the skin. This also happens when there is a rise in metabolism due to increased physical activity, as is clearly illustrated in Figure 1 under the column headed latent heat. For example: the increase in total heat from 400 Btuh for people in hotels and apartments, to 450 Btuh for people in offices and stores is all due to an increase in latent heat -- from 250 to 300 Btuh for the more active situation.

Earlier we stated that 30 people could impose a one ton cooling load. Now we know that if these same people were dancing they could impose a two ton load.

It's a little strange to think of heat flowing from a person to a room --- especially during winter heating. But let's look at the facts; normal body temperature is 98.6° F. And since heat only flows from a higher to a lower temperature, heat must flow from a person to his surroundings. Therefore, a heating plant does not warm a person, but rather, it warms the room and allows the occupants to lose heat at a proper rate. In air conditioning as well, the environment is maintained so that body heat can be rejected at the required rate.

Comfort really means --- letting people lose heat in proportion to the rate at which they are generating it. And with this --- the underlying premise for all comfort air conditioning --- clearly understood the contractor can more judiciously select design indoor conditions, estimate the total load on the equipment, and finally install and adjust a proper system.