

PERSONAL COMFORT

By Norm Christopherson

Of all the uses for air conditioning systems, maintaining the comfort of people is the most common and the most obvious. Yet if we took a poll among air conditioning technicians and engineers, we would find that their knowledge of personal comfort and what it means to be comfortable is very limited. We would also find that these same air conditioning professionals spend many hours talking about equipment, controls, and other technical topics, and rarely if ever talk or think in terms of the comfort of the customers who own the equipment. We are poor observers of the conditions, which determine our comfort. Until we understand what these comfort conditions are, we will be at a disadvantage as we attempt to control them with an air conditioning or heating system. A basic understanding of how the human body controls its operating temperature and comfort is necessary before we attempt to design, install, adjust and service equipment which exists to aid the human body in the quest for that comfort. Unfortunately, a great deal of misunderstanding and misinformation about personal comfort exists and a careful reading and consideration of this chapter is a valuable tool for engineers and technicians.

You are a walking boiler!

The human body is continually producing heat. The body is always working to get rid of heat that it always has too much of. Yes, the body produces much more heat than it needs and is always doing so. The body is a heat engine and the fuel is food and drink. The body is a walking boiler, consuming food fuel and feeding an internal fire, which never goes out. Furthermore, the boiler is very inefficient, which is why so much extra heat is constantly being rejected to the air around it. For the body to feel comfortable and function properly it must maintain an optimum internal working temperature of 98.6 degrees F. Even a slight deviation from this normal internal temperature and we think about seeking out the help of a technician (medical doctor) to determine the cause of the control problem. The surface (skin) temperature is lower than the internal temperature and is usually about 93 to 94 degrees F.

A well-known principle of thermodynamics is that heat always flows from a higher temperature to a lower temperature. With the internal body temperature of 98.6 degrees and a surface temperature less than that, it is obvious that heat is flowing out of the body. Additionally, heat is moving from the surface of the body to the surrounding air. The body, this walking boiler, is always making more heat than it can use and is always having to get rid of the waste heat. Oh, you say, what about when the air temperature rises above that of the body temperature? Then the temperature difference is reversed and the heat flow should be reversed, right?

Well, if that were true, we would all have died of heat stroke long ago. So what really happens? The body kicks in another temperature control system, which takes over when the first is no longer thermodynamically possible. Perspiration or cooling by evaporation takes over. As we shall see, the body has a variety of cooling systems to work with to get rid of that excess heat. But, the body is always generating too much heat! Unless we understand and accept that one fact, we shall never understand comfort. This may go against everything you have been taught to believe, but that is the way it really is. Therefore, the human body is never in need of heating, but is always in need of cooling. This is not just a matter of semantics! This is true and useful if we are to understand how to make both air conditioning and heating systems work with the comfort system of the body.

In both summer and winter the body is generating more heat than it needs. In the summer we turn on an air conditioning system so the body can be cooled more easily. You see the problem is a matter of temperature difference. When the air temperature is too warm, the temperature difference between the body and the air is too close, and the rate of cooling for the body is reduced, making it difficult for the body to cool off as it needs. We become overheated because we cannot get rid of heat fast enough.

In the winter the problem is still one of getting rid of excess body heat. The problem now is that the body is losing too much heat too fast because the temperature difference is too great. The body needs to continue rejecting heat, but not at such a great rate. So we turn on the heating system in the house to lessen the temperature difference between the body and the air. The problem was the temperature difference was too great, and the body was losing heat too fast. The body still needs to lose heat but not too fast. To control comfort we need to control the cooling rate of the body, both summer and winter. It is always a matter of controlling cooling rate. It is never a matter of adding heat to the body. Both heating and cooling systems simply control the temperature differential between the body and the ambient, or surrounding, air. Understanding this is the beginning of a series of additional truths, which will help us understand how to correctly design, install, adjust and service air conditioning and heating systems for the most comfort.

The heat output of the human body depends upon what the activity level of the person is at the moment. A person sitting idle puts out about as much heat as does a 100-watt light bulb. An individual performing light work rejects about the same heat as a 200-watt bulb. Heavy activity like bowling or even running is in the range of 600 to perhaps more than 1000 watts of heat. Regardless of the level of activity, the body is rejecting heat. A special temperature control mechanism inside the body constantly works to keep the internal body temperature at exactly 98.6 degrees F. What an amazing system it is. An understanding of this system will give us a much better idea of how a climate control system can work with the human system rather than against.

How the walking boiler controls heat loss

The body is a walking boiler and is constantly generating more heat than it can use. There are several heat rejecting system's available for the purpose of getting rid of excess heat. At the central control point is the systems command center which determines how much heat is to be expelled and which heat rejecting subsystem or combination of heat rejecting methods is necessary for good control. The control point or command center is an organ in the brain called the hypothalamus. The hypothalamus works with nerves located at the skin. The nerves send signals to the hypothalamus which uses the relayed information to take the appropriate action to effect good temperature control both internally and at the surface. On a hot day when body cooling is impeded by the low temperature differential, the hypothalamus signals blood vessels to dilate or expand, causing blood to run closer to the skin's surface where heat is rejected. The hypothalamus also signals the skeletal muscles to relax. This results in less activity, so less heat is produced. If it is such a hot day that little or perhaps no temperature difference exists; or worse, if the temperature difference is reversed and the air is hotter than the body, then the hypothalamus kicks in another system. The hypothalamus sends a signal to special glands called the sudoriferous glands causing an increased production of perspiration. This amounts to a finely tuned evaporative cooling system. On a chilly day the hypothalamus signals blood vessels to constrict or narrow so as to make the blood run away from the skins surface thus losing less heat. Another signal increases muscular contractions (shivering), which increased activity produces, more heat. The hypothalamus can also stop the perspiration process so no heat is lost through this method. Once again, regardless of the conditions, the body is always controlling the rate of heat loss, but it is always a loss. It is the job of air conditioning and heating professionals to control the indoor climate so as to aid the body in its quest for comfort.

Perhaps you have already learned that there are three methods of heat transfer: conduction, convection and radiation. Where the human body is concerned we can add a fourth, evaporation. All four are of concern to air conditioning professionals. Control of these four factors will give us control over comfort. Most air conditioning and heating professionals only think of comfort in terms of the air temperature. A few others are a little better off because they include the humidity as a comfort factor. Yet, there is more to consider if we are to be complete. A careful look at conduction, convection, radiation, and evaporation with regard to the human body and the conditioned space is in order.

Conduction

Conduction is heat transfer by contact. The human body is always in contact with some other material substance. When standing it has feet in contact with the floor, when sitting it is in contact with the chair, and when sleeping, in contact with the bed. If a temperature difference exists, there will be a heat transfer. Occasionally, an individual comes in contact with something in a room, which is so different in temperature that it is uncomfortable (such as a hot teapot) and a natural reaction soon rectifies the problem. An individual standing on a cold concrete floor

will feel cold even though the room air temperature may be 80 degrees. Any object that is much hotter or much colder than the individual contributes to discomfort. The temperature of objects in the room not only affects conduction, (as we shall see later in the chapter) also affect radiation. Thus, we have two reasons for controlling the temperature of the solid objects in the room. Solid objects with large surface areas will be the more important, such as walls, ceilings, floors and windows.

Convection

As an individual resides in a room, air is in contact (conduction) with the individual, and heat is passed by conduction from the person to the ambient air. The air soaks up this heat and as a result of becoming heated begins to rise upwards. As you recall, heated air becomes less dense and thus lighter, causing its rise. This is a convection current. Every person creates a constant convection current as air around that individual is heated. This rising air causes cooler air to drift in to take its place, which in turn is heated, or shall we say, is used to cool the individual still more. Air conditioning and heating systems also move air through the room, which aids in the convection process; and if the air is properly conditioned, it is at the correct temperature and is moving at the proper rate. If the air is moving too fast, a draft is created and the individual is uncomfortable. If an air conditioning system is not moving air fast enough, the individual is unable to get rid of heat at a comfortable rate, and the perspiration system begins to function. So, a proper airflow rate is an important factor for individual comfort because it works in conjunction with the natural convection around the human body. Every 15 fpm the air speed increases over a base rate of 30 fpm is the equivalent to a one degree drop in temperature. What is the correct airflow rate? Well, that will depend upon the air temperature.

On a very hot day we can still feel comfortable as long as there is a good breeze. On a cold day a good breeze will make us feel even colder. The temperature of the air that an air conditioning system is providing will then have an effect upon what a comfortable airflow rate would be. In addition, the relative humidity of the air will determine how much air needs to move through a room for that room to be comfortable.

Radiation

We are already familiar with the radiant heat received from the sun. You have experienced it as it heated your face when on a cold day the air around you made you bundle up. It is radiant heat from the sun, which makes it possible for people to snow ski on a clear winter day while wearing swimming suits. What many people do not know is that radiation in the form of heat is present in every room at all times and has a direct effect upon our comfort and how well a particular air conditioning and heating system will be able to control comfort.

An individual sitting in an air-conditioned room may feel comfortable as long as he or she stays away from a window. The room air may be a nice 72 degrees, but the window is perhaps 98 degrees. The problem is that when near the window the body is unable to reject heat as well because the radiant heat from the warm window is blocking the body heat. The temperature difference in this case has reversed and the window is hotter than the individuals skin temperature. Remember heat flows from higher to lower temperatures. So, the hypothalamus kicks in the evaporative cooling system and the individual starts to sweat. If it is winter and the window is cold while the room is warm, the individual is still uncomfortable. Here the individual sitting near the window loses too much heat to the cold window and is uncomfortable even though the room air temperature is comfortable. This is radiation at work making people uncomfortable and driving some air conditioning technicians crazy because of their lack of knowledge of the radiation process.

The answer to this particular radiation problem is to temperature control the windows. A separate system may be used to cool the inside surfaces of the outside walls and windows. This is usually accomplished with perimeter heat, often consisting of warm air delivered over the inside surface of the windows. The system may be hydronic-heating coils installed at the floor and under windows or may be overhead air aimed at the windows. In the winter the walls and windows are heated and in the summer they are cooled, blocking the loss or gain of heat, whichever is necessary for the season.

Evaporation

When all else fails, the body seems to fall back upon evaporation or evaporative cooling to maintain its internal temperature. Actually, evaporation is working to some degree most of the time but we do not realize it until the sweat begins to accumulate and we wipe our brow. The main thing we need to consider with human comfort and evaporation is something you probably already know. We must control the relative humidity of the air. A high relative humidity will slow the ability of the body to lose heat by evaporation because the air is already holding a great deal of water vapor or moisture, and it is difficult for the air to absorb more. When the relative humidity is too low, the dry air absorbs moisture off the skin at a high rate and the skin is dried out. The skin cracks, flakes and in extreme cases bleeds. Dandruff and chapped lips become a problem. The correct humidity is important for good comfort control.

A well-designed comfort control system controls all of these factors.

A poorly designed, maintained, or operated system has its costs in the loss of the productivity, energy, vitality and health of the space occupants.

At the same time the operating costs are usually higher.

Often if the system is only out of adjustment, putting the system back into proper operating condition will increase occupant comfort and decrease operating costs.