



The Comfort Factor in Building Performance

by Alex Wilson

Picture this for a minute: a man standing with one foot in a bucket of ice water and the other in a bucket of scalding water heated to 130 degrees Fahrenheit. Would he be comfortable? An engineer operating by the book might say yes, because the average temperature of those buckets is a balmy 80 degrees. Btu in equal Btu out. The "net heat loss" or "net heat gain" by the man is zero. Thermal equilibrium.

Scott Lewis of the Energy Design Collaborative in New York used this example at a recent conference of the Northeast Solar Energy Association to illustrate the frequent inconsistency between quantitative energy performance and performance in terms of comfort. You and I know that the man standing in the water isn't comfortable, and certainly *he* knows it. But it is numbers that usually reflect how well our buildings perform, and these often don't tell the whole story.

To better understand comfort, we need to back up a few steps and look at some human physiology.

Our bodies constantly produce heat through metabolic processes. To maintain thermal equilibrium, the average adult needs to dissipate about 400 Btu per hour to the surroundings. And we do this through four mechanisms: conduction, convection, radiation and evaporation.

Conduction

Conduction is familiar to anyone who has dealt with R-values and heat loss through building skins. It is the transfer of heat from a warmer object in physical contact with a cooler one; heat flows from molecule to molecule.

From the standpoint of heat loss from our bodies, conduction usually plays a fairly minor role. Unless we are sitting on metal bleachers during a ball game on a cold afternoon, or standing in thin-soled shoes on a cold, concrete floor all day, the only role conduction plays is in carrying heat through our clothing, where it is lost to the environment by other means.

Convection

We constantly lose heat by convection, which is the transfer of heat by a moving fluid such as air. In typical conditions (an adult at rest with light clothing in 74-degree air with 50 percent relative humidity), convection accounts for about 25 percent of the body's heat loss. Convective heat loss increases as the wind speed increases.

Radiation

Radiation is the transfer of heat from a warmer to a cooler body through the emission of heat waves or thermal radiation. Many people are surprised to learn that radiation accounts for the majority—about 50 percent—of the heat lost from our bodies in typical conditions.

Radiant heat loss occurs whenever there are surfaces in our surroundings that are cooler than our bodies. Areas with a lot of glass often are tremendous sinks for radiant heat loss. For example, if you're standing in an all-glass sunspace without window insulation at nighttime and the outside temperature is 10 degrees, the inside surface of the glass

Mean Radiant & Air Temperature Comfort Table								
Air & Mean Radiant Temperature (MRT) Combinations Required to Achieve a Thermal Comfort Level of 70° F								
MRT	65	66	67	68	69	70	71	72
Air Temp.	77	75.6	74.2	72.8	71.4	70	68.6	67.2
MRT	73	74	75	76	77	78	79	80
Air Temp.	65.8	64.4	63	61.6	60.2	58.8	57.4	56

Source: *The Passive Solar Energy Book*, by Edward Mazria, 1979, Rodale Press, Emmaus, Pa.

will be 50 degrees (assuming it is insulated, but not low-emissivity, glass). Because such a large surrounding surface area is so cold, you will radiate a tremendous amount of heat to these surfaces—and you won't be comfortable even if the air temperature is as high as 90 degrees.

The average temperature of the surfaces that our bodies can feel is called the mean radiant temperature (MRT). As illustrated by the accompanying table, the MRT has a more significant impact on our level of comfort than the air temperature. A decrease in the MRT of one degree increases the heat loss from our bodies 40 percent more than a one-degree drop in air temperature.

Evaporation

The final mechanism by which we lose heat from our bodies is evaporation. Moisture constantly evaporates from our skin surfaces, and the process of evaporation (the change in phase from a liquid to a gas) robs a lot of heat. Evaporation is the reason a breeze feels so good on a hot, summer day. In the typical situation described earlier (74 degrees

comfortable, but for a different reason: When cold air contains more moisture, it increases the rate of *convective* heat loss from our skin and cools us off.

Designing for Comfort

If we understand what makes a person comfortable or uncomfortable, we can begin to incorporate features into the houses we build that maximize comfort and minimize discomfort. Here are a few examples:

- In areas with lots of glass, use low-emissivity (low-E) glass and/or provide some type of curtain or blind to minimize radiant heat loss to the glass surface.
- Allow for natural breezes that can provide summer cooling (both by convective and evaporative mechanisms).
- Take pains to avoid drafts in the winter. This means tight construction and the careful placement of any convective heating elements.
- Install a heating system that closely matches the heating load of the building so that hot and cold cycling will be less of a problem.
- Consider in-floor radiant heating or passive-solar design for the most comfortable low-temperature heat delivery. Avoid hot-air heating systems if at all possible.

This by no means is a complete list, of course. Think of it as a starting point. With a little conscious effort, you should be able to come up with a lot of other comfort features as well—and your clients will be grateful. ■

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The rate of evaporative heat loss is determined by the relative humidity, the temperature and the air movement. On humid days in the summer, the high relative humidity makes it more difficult for moisture to evaporate from our skin, so we don't cool off as readily. Humid days in winter also make us feel less