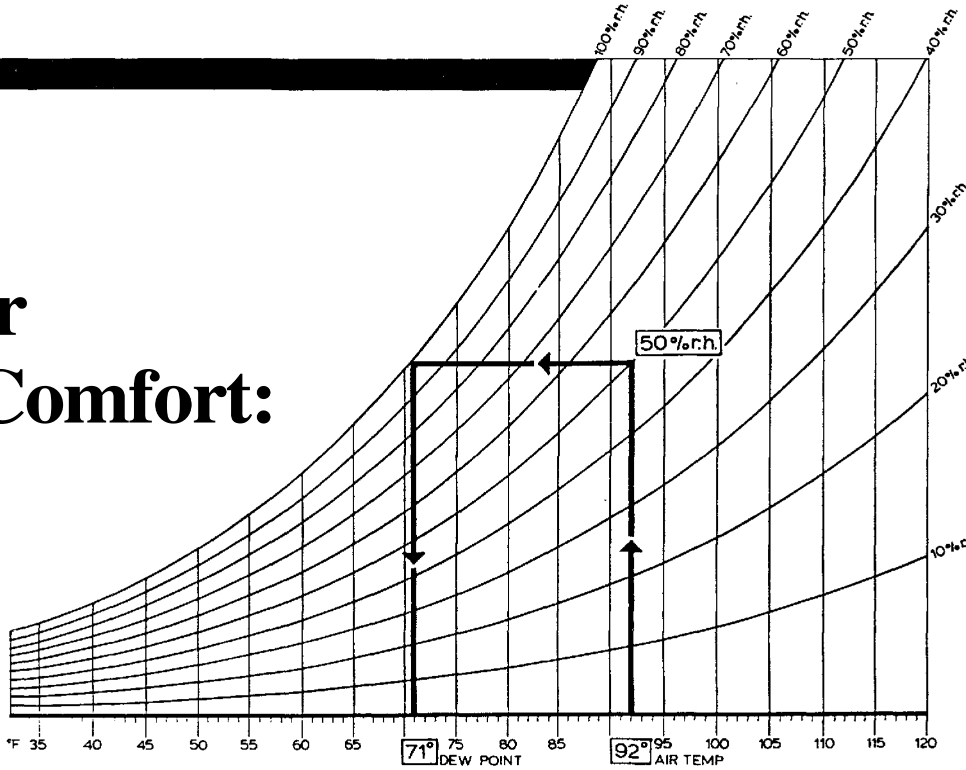
Recipe for Heating Comfort:

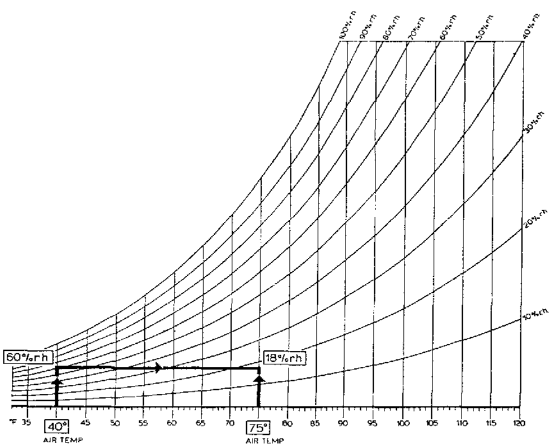
Mix It Well Over a Low Flame



A *psychrometric chart. This one shows how to find the dew-point temperature of air at 92 degrees Fahrenheit and 50 percent relative humidity.*

by Jon Eakes

I constantly am hearing the popular myth that electric baseboard heaters "burn off the oxygen" and dry out houses, and that an overall relative-humidity level of 40 percent (a reasonable figure for a cold climate) can have entirely different readings of health and comfort. This is because hot-water radiators seem to give off comfortable humidity. Meanwhile, many new houses heated with electric baseboards are soaking wet, and people often put pans of water on their old, hydronic radiators to humidify the air.



Finding the relative humidity of air at 40 degrees Fahrenheit and 60 percent relative humidity when heated to 75 degrees.

Without necessarily understanding the mechanisms, home owners and contractors alike realize that even though different systems might be able to heat a house to the same temperature, they don't all have the same effect on comfort and health. In fact, the two main factors that determine whether a heating system is comfortable or a health hazard are the temperature of the reheated air and its means of mixing into the house.

Relative Humidity

When a system heats or cools the air, it does not add or subtract water vapor from it. That being said, two different houses maintained at 70 degrees Fahrenheit with of the elusive, complex animal we call "relative humidity." Without changing the quantity of water in the air, different heating systems will create zones with different relative humidities throughout the house that will fluctuate radically from minute to minute.

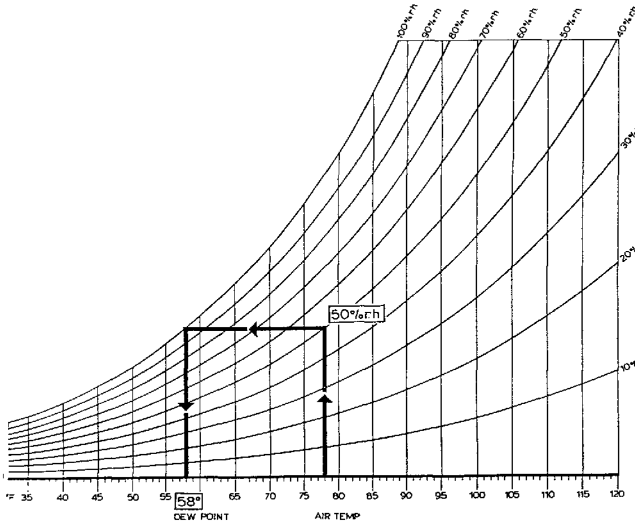
Relative humidity is defined as the amount of water vapor in a given volume of air compared to the maximum amount of water vapor that same volume of air could possibly hold, and it is expressed as a percentage. Unlike a measuring cup, which always is 75 percent full when it contains six ounces of water, the amount of water vapor that can fit into a given block of air depends greatly on the temperature—because the air's "measuring cup" expands when it gets hot.

If room air at 50 percent relative humidity and 70 degrees is heated to 100 degrees, for example, the relative humidity will fall to 19 percent. The quantity of water remains the same, but the measuring cup gets bigger. The relationships between temperature, water vapor and relative humidity are plotted on a graph called the psychrometric chart—a chart so complex it could drive you to the psychiatrist, although I don't think that's how it got its name.

A block of air is much like a sponge. If you put it into contact with water, it will soak up water only to a certain point. If you keep adding water until you saturate the sponge, the water will drip out as quickly as you pour it in. If you change the size of the sponge, it will be able to hold more or less water—less if you squeeze the sponge smaller, and more if you start with a small, compacted sponge that is able to expand a great deal.

So it is with our block of air. If you heat the air, it becomes a larger sponge—able to soak up and hold more water. If you cool the block of air, the sponge will shrink and therefore be able to hold less water—so the water already in the sponge represents a larger percentage of its total water-holding potential. If you shrink the block of air enough, it will rain or snow.

When warm, moist air comes into contact with a cold window, the sponge shrinks. And if the window is cold enough, the air will shrink to the point that it will deposit its excess water on the window—bingo: condensation. When warm air at less than 100 percent relative humidity (that is, with some space still left in the sponge) blows over the window, it will soak up the condensation and leave you



Finding the dew-point temperature of air at 78 degrees Fahrenheit and 50 percent relative humidity.

The charts accompanying this article are reprinted with permission from the February 1985 issue of Energy Design Update, *published in Arlington, Mass. For more information, refer to the article "Psychrometrics for Builders and Designers" in that issue of* EDU.

with a dry window, which is a major reason why heaters are placed under windows.

In the winter, then, cold, humid air

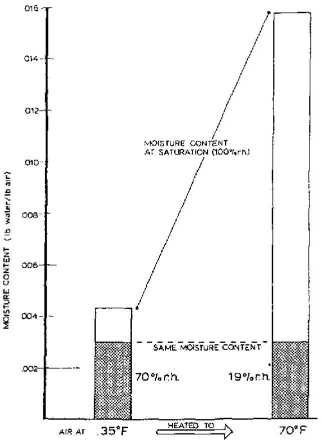
Bursts of heat wouldn't be so bad were it not for the fact that human mucous tissue does not follow the same cycles as our heating systems.

from the outside drifts into our houses, where it is warmed and soaks up water. It then drifts out the other end, leaving us with a dry, drafty house.

Temperature & Drying Capacity

How does all of this affect our heating systems?

Heating systems warm the room air several degrees higher than the room temperature. This warm air mixes with the room air until the thermostat finally tells the heater to shut off and wait for everything to cool down. Some systems



Graph showing the change in relative humidity of air at 35 degrees Fahrenheit and 70 percent relative humidity when heated to 70 degrees with no moisture added or removed.

tend to create cycles that get quite hot, then quite cool, and so on. Others manage to maintain a less exaggerated cycle, keeping much closer to the desired room temperature.

Air comes out of a forced-air floor grill at about 100 degrees. Because of the fan, it mixes rapidly with the rest of the air in the house. Air heated by a radiator doesn't mix throughout the house as well (it has no fan), but it tends to be at lower temperatures for longer periods of time. Air from an ordinary baseboard heater, on the other hand, pours out at 130 degrees and up. Because of the absence of a fan, it circulates slowly throughout the room, meaning that the space near the heater will be significantly warmer than the rest of the room for a certain time.

Now, let's go back to our sponges. When the room air is heated up, its "sponge" gets bigger—and as long as it remains significantly warmer than the room air, it will slurp up as much moisture as it can get hold of. Room air at 60 degrees and 50 percent relative humidity will be at 14 percent relative humidity when it comes out of the forced-air floor duct or off of the hot-water radiator, but it will be at less than 7 percent relative humidity coming out of the baseboard heater.

In fact, if you calculate how much moisture this heated air can absorb before reaching the overall room humidity (what is called its "drying capacity"), you will find that air coming out of a baseboard heater at 120 degrees has *twice* the drying capacity of air from a forced-air furnace or a radiator at 100 degrees. At 130 degrees, it jumps nonlinearly to *three* times the drying capacity. (Actually, my thermometer topped off at more than 140 degrees two inches above the baseboard heater, but that falls off the end of my psychrometric chart. So I'll simply say that if you take a reading close to the heater for a few minutes of each heating cycle, an ordinary baseboard heater has two to three times

It's not water or electricity or gas or oil or wood that makes the health difference—it's controlling the heat delivery so that you don't create extremely hot drying zones for any length of time.

the drying capacity of other common heating systems.)

So now we have a temporary situation in which air near any heater has just as much water as the rest of the house, but it has a greater "drying capacity." The higher the temperature, the worse the situation gets—and rapidly. And, of course, the poorer the circulation, the longer the air stays there.

Drying Cycles & Health

This wouldn't be so bad were it not for the fact that human mucous tissue does not follow the same cycles as our heating systems. If our throats are subjected to five minutes of extremely dry heat, they not only dry out a little, but they also become slightly irritated. When the humidity returns to a comfortable level, the tissue regains its moisture rather quickly, but the irritation goes away more slowly. Unfortunately, the heater usually comes back on before all is well, so our throats dry out again, and the irritation is compounded.

Most people's throat and nasal passages are not significantly irritated by occasional bursts of air at 100 degrees, but when you double and triple the drying effect with 130-degree air, they often end up in pretty bad shape. A psychological factor enters into this, too. We always remember when something bothers us, and we tend to forget when it does not. We may spend only a few minutes of each hour under irritating conditions, but we'll remember it as being a bad day all day long.

Solutions

There are three keys to healthy heating systems: lower delivery temperatures, fewer extreme temperature cycles, and good air circulation.

At the same time they are being modified to make them more energy-efficient, old, forced-air heating systems are becoming more comfortable as well: they give off less heat at the burners and run the fans for longer periods, thereby extending the heating time. The end result is lower and more constant temperatures at the floor grill.

New hydronic baseboard heaters now use high-temperature electric resistance to heat a pipeful of water, which in turn releases that heat at a much lower temperature for a longer period of time—acting almost like a water radiator. And new solid- state controls are in the works that will vary the heat output of electric systems so as to maintain a constant output of a lower temperature. [See accompanying article.]

For existing systems, minimizing temperature swings will help. Old, in-line thermostats mounted on baseboard heaters, which are very slow to react to temperature changes and create wide temperature swings, can be replaced by ordinary, low-voltage wall thermostats that are much more efficient. (It could cost $100 a unit to make the conversion, however, since you'd need a 220-volt relay, a 24-volt transformer, a wall thermostat and an electrician.) Some newer baseboard heaters have more efficient temperature controls built right in.

Finally, good air circulation can help to minimize the size of the "extreme drying zone" and more rapidly mix the air to an acceptable room average.

The thing to remember is that it's not water or electricity or gas or oil or wood that makes the health difference—it's controlling the heat delivery so that you don't create extremely hot drying zones for any period of time within a living space. ■

Jon Eakes is a home renovator, author and instructor specializing in energy and Canadian construction practices. His latest television venture, the 26-part "Renovation Zone" (the Canadian version of "This Old House"), will begin airing in September.