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PRACTICAL APPLICATIONS FOR INNOVATIVE HVACR MECHANICAL SYSTEMS ENGINEERS

CONDENSATE CONTROL

HUMIDITY, TEMPERATURE IN AIR SUPPLY DUCTS

High relative humidity and low temperature in the air supply system can have serious, direct affects on IAQ and can cause equipment damage. Here is what to watch out for.

BY WARREN TRENT, P.E., AND CURTIS TRENT, Ph.D.

EDITOR'S NOTE: *This is the fourth of a six-part series of articles devoted to the design of hvac systems that are free of health-threatening and property-damaging problems. This article is adapted from "Condensate Control," by authors Warren and Curtis Trent, in the* HVAC Systems and Components Handbook, *Second Edition, published by The McGraw-Hill Companies (Copyright 1998). This is being reprinted with permission of The McGraw-Hill Companies.*

High relative humidity (rh) and low temperature in the hvac air supply system can result in serious degradation in indoor air quality (IAQ), and considerable damage to exposed hardware components.

Good design practices dictate that these factors be considered carefully in hvac system design.

CRITICAL DESIGN FACTORS

The conventional hvac unit provides air cooling and moisture removal by reducing the drybulb temperature (dbt) of the air it handles. Passing through the cooling coil, the temperature is reduced to a dewpoint equal to or below that of the indoor air.

This process reduces the humidity ratio (moisture in the air) but the average rh is increased typically to about 95%.

Figure 1 illustrates the cooling process where the cooling load on the system is 25% latent heat and 75% sensible heat: a sensible heat ratio (SHR) of 0.75. Point A represents the indoor conditions. Point B represents the condition of the air entering the supply system where the rh is 95% and the dbt is 55.2°F.

In a tightly sealed and well-insulated air supply system, the rh and dbt of the air remain essentially constant as it passes through the supply system.

Humidity conditions:

High rh conditions, as shown in Figure 2, are conducive to and support the growth of contaminating organisms, including bacteria, viruses, fungi, etc.

The relatively low air temperature may suppress rapid growth of organisms and air movement may prevent accumulation of contaminates. However, this condition can degrade IAQ, and it represents a potential health hazard which must be carefully considered in hvac system design.

One simple, but often expensive, way to reduce rh in the supply air is to provide reheat. As illustrated in Figure 1, an increase of about 9°F in the air supply temperature, path B to C, decreases rh to 70%. At this lower rh, the growth of bacteria, viruses, and fungi is greatly reduced (see Figure 2, page 52).

Temperature conditions:

Inside the air supply system, low-temperature air has no particular

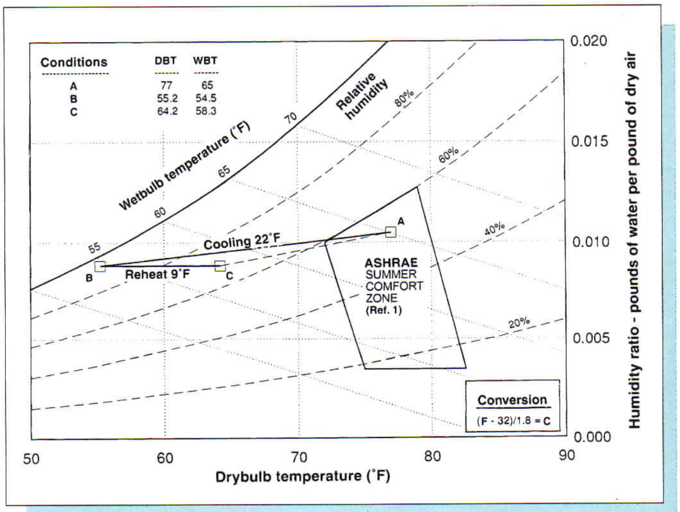

FIGURE 1: Psychrometric chart showing cooling reheat process and paths.

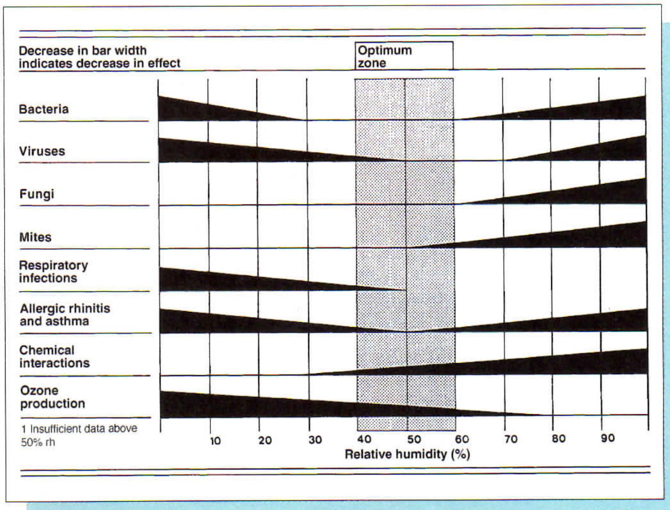

FIGURE 2: Optimum relative humidity ranges for health. *(Reprinted with permission from ASHRAE Transactions, 1985, Vol. 91, Part 1B).*

adverse affect on IAQ. Its effect occurs inside the conditioned space, at the air supply grille. Cold supply air often reduces the temperature of the grille below the dewpoint of the indoor air.

When this happens, condensate can form on exposed surfaces of the grille. There, it promotes the growth of contaminating organisms, including mold, mildew, and other fungi. The discoloration frequently observed on supply grilles is often caused by these conditions and not always by dirty air filters, as is sometimes suggested.

To minimize this problem, consideration must be given to both supply air temperature and grille design. The factors that affect air supply temperature are indicated in Figure 3, for a typical design condition. Here, the supply air temperature is shown as a function of the SHR of the system, at various values of indoor wetbulb temperature (wbt), and rh. Also shown, for the various conditions, is how much the supply air temperature is below the dewpoint of the indoor air.

The difference between the indoor air and dewpoint temperatures, shown in Figure 3, varies with indoor operating conditions. Lower indoor drybulb temperatures reduce the differences. Higher indoor drybulb temperatures and lower wetbulb temperatures increase the differences. For any specific design, these differences can be determined through the use of the psychometric charts in Appendix A, of the Handbook of HVAC Design.

Grille design:

Low-temperature air does not always cause condensate to form on air supply grilles. At any particular temperature level, condensate formation depends upon specific features of the grille design. Some of the most significant features include the following: thermal conductivity of the grille materal; jet velocity of the supply air; and amount of grille surface area exposed to the indoor air and not washed by the supply air.

Materials applicable to grille fabrication with the lowest and most desirable thermal conductivity characteristic are listed in order as follows: plastics, steel, aluminum, and copper.

High jet velocity causes air supply grilles to cool to a low temperature, which increases the potential for condensate formation. Flush-mounted ceiling grilles that provide long throw distances usually operate with high jet velocities. Ceiling-mounted concentric supply grilles, with short throw distances, often operate with low jet velocities.

Large grille surface areas exposed to indoor air increases the potential for the formation of condensate. Large unwashed surfaces usually accompany flush-mounted ceiling grilles that discharge in one direction only. Ceiling-mounted concentric grilles usually exhibit small areas of unwashed surfaces.

The condensate formation characteristics of the various types of air supply grilles are generally not available. However, grille manufacturers are cognizant of this problem. They realize that certain designs are superior to others, and they can aid designers in coping with the subtleties of this problem.

In the meantime, designers should take advantage of the grille design fundamentals reviewed above when selecting supply air grilles from production units.

ECONOMICS, SUMMARY

The costs associated with high rh and low temperature inside the air supply system can be appreciable.

The cost of degraded IAQ is difficult to establish. In most cases, it cannot be determined with any degree of accuracy. It is real, however, and could result in costly health care and other health-related problems.

The cost of equipment damaged by high humidity and low temperature is much more tangible. The effects of high humidity will become evident in damage to air-handling equipment and other downstream hardware. The cost of grille maintenance and damage caused by low air temperature will be both visible and definable.

Remedies to the air supply problem may not be expensive. There may be little or no hardware costs associated with selecting a supply grille of superior design.

Reheat, if provided with electricity or fossil

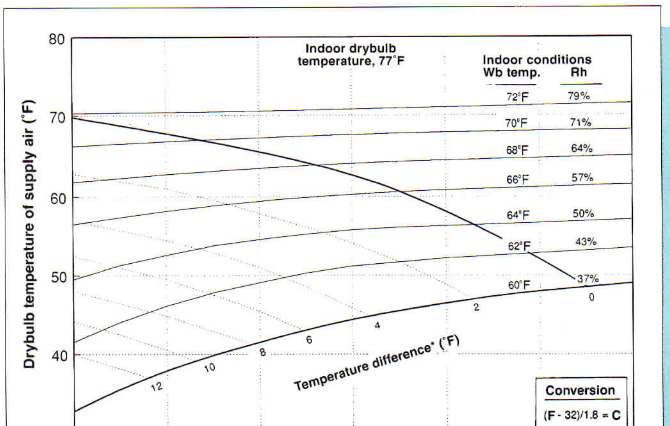

FIGURE 3: Effects of system sensible heat ratio and indoor wetbulb temperature on temperature of supply air.

fuel, involves appreciable initial costs plus significant and continuing operating costs. For this type application a heat pipe system may be attractive. The technology is mature. The initial costs are not exorbitant, about 30% of the cost of the basic air handler. There is no significant continuing operating cost, and maintenance costs are minimal.

With the above in mind, here is the suggested statement for specifications:

The hvac system shall provide conditioned air to the air supply system, at an rh no greater than 70%, and the dbt shall be sufficiently high to prevent condensate formation on supply grille surfaces during all operating conditions.

Next month: *The position of the fan in an air handler system can directly affect internal airflow conditions, and can seriously degrade air handler performance.* **ES**

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The IAQ Report

Continued from page 47

mance becomes paramount to protect the liability of building owners and all those in the hvac-related fields. **ES**

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