HEATING • COOLING • REFRIGERATION • CONTROLS

Engineered Systems®

Vol. 14 No.8 August 1997

BNP Business News Publishing Company

FIVE DOLLARS

Dehumidification At Work

- Industrial, manufacturing applications
- Sorting through different criteria, equipment configurations

Plus:

- Understanding pump curves
- Cooling towers have power
- Know your fans
- Condensate control series continues

See ES' enhanced website
www.bnp.com/engsys

PRACTICAL APPLICATIONS FOR INNOVATIVE HVACR MECHANICAL SYSTEMS ENGINEERS

CONDENSATE CONTROL

THE LOWDOWN ON DRAIN PANS

Because of the potential adverse side effects of stagnation in a drain pan, the type, position, and size of the drain port must be factored into its design, along with pan material, condensate flow rate, and drainage provisions.

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

EDITOR'S NOTE: *This is the second 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.*

Drain pans that allow condensate to stand and stagnate form an ideal growth haven for biological and microbial agents. When condensate stagnates, the hvac system becomes a source of air contamination and poses a threat to human health.

Just as condensate carryover and condensate drips can be avoided by proper system design, a properly designed drain pan is essential to the successful removal of condensate from an hvac system.

FOUR DESIGN FACTORS

The major considerations involved in designing a satisfactory drain pan include:

1. Condensate flow rate;
2. Drain ports (position, type, and size);
3. Condensate drainage provisions; and
4. Pan material.

Let's break each down.

1. Condensate flow rate:

The rate of condensate flow from an hvac unit is determined by the total cooling capacity, and how this capacity is divided between latent heat and sensible heat. Sensible heat ratio, at which an hvac system must operate, may vary from near 0% to 100% of the total cooling capacity, depending upon a number of variables, such as:

- The amount of internally generated moisture (human, animal, and equipment);
- The amount of infiltration;
- The amount of outdoor ventilation air; and
- The absolute humidity (humidity ratio) of the outdoor air.

Figure 1 shows how sensible and latent heat ratios affect the amount of condensate removed from cooling air. To determine the condensate flow rate for a given system, enter Figure 1 with the operating sensible heat ratio at the nominal-rate cooling capacity.

For example, a system rated at 60 tons, operating at a sensible heat ratio of 0.80, will remove about 0.3 gpm of condensate. The same system operating at a sensible heat ratio of 0.30 will remove about 1.05 gpm of condensate.

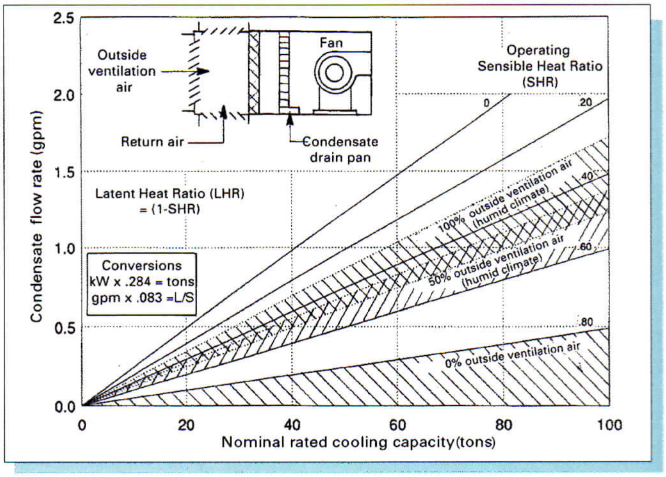

FIGURE 1: Condensate flow rate as a function of nominal ton rating and operating sensible heat ratio.

The shaded areas in Figure 1 indicate typical operating ranges of sensible heat ratio for various levels of outdoor ventilation air.

2. Drain ports:

Drain port position, type, and size all affect how deep condensate stands in the drain pan. Each of these factors affects the potential for stagnation. Even slight variations can have an appreciable effect on the minimum level at which condensate stands in the pan.

• Drain port position — Condensate drain ports may be positioned on a pan wall or in the bottom of the pan. For most effective drainage, ports must be flush with the bottom of the pan.

• Drain port type — Male drain connections are more desirable than female connections. A female connection requires an internal drain connection

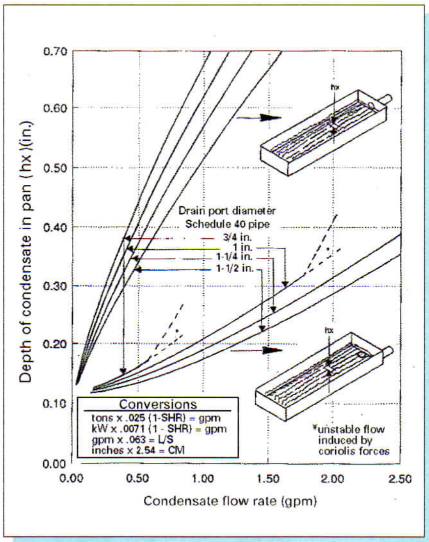

FIGURE 2: The effect of drain port size and position on condensate flow rate, under the force of gravity.

fitting, which reduces the flow area, blocking condensate flow and catching debris. In addition, in a pan wall drain port, this restriction raises the depth that condensate stands in the pan.

- Drain port size — This depends upon the condensate flow rate, whether the port is in a side wall or in the bottom of the pan, and what condensate depth can be tolerated in the pan.

3. Condensate drainage provisions:

In order for condensate to flow from a particular drain pan under the force of gravity, it must rise to a predetermined depth. This level depends upon the surface tension of the water, and the water level (head) necessary to provide the required flow rate.

Recent test data[1] indicate that about ⅛ in. (0.318 cm) of water is required to overcome surface tension and permit condensate flow. Thus, independent of the position, type, and size of the drain port, condensate will stand in the pan at some finite depth. The total depth, of course, increases in proportion to the condensate flow rate.

Figure 2 shows how condensate depth in a level pan varies with the condensate flow rate for different port sizes and positions. As shown, a bottom drain port provides better drainage than does a side wall port.

Neither drain port arrangement, however, allows for complete drainage from a level pan. Condensate will remain in the pan at some depth as long as moisture is being removed from the circulated air. If allowed to back up into the pan and stagnate, condensate, at any depth, promotes the growth of biological and microbial agents.

Although a bottom drain port affords better drainage than a wall drain port, either can be used successfully if properly integrated with the condensate pan design.

The importance of proper pan drainage and the avoidance of condensate stagnation is emphasized in ASHRAE Standard 62-1989: "Air-handling unit condensate pans shall be designed for self-drainage to preclude the buildup of microbial slime."[2]

One means of assisting self drainage is to slope the condensate drain pan in the direction of the drain port. However, it is generally not practical to add enough slope to prevent condensate from covering a large area of the drain pan during the cooling operation.

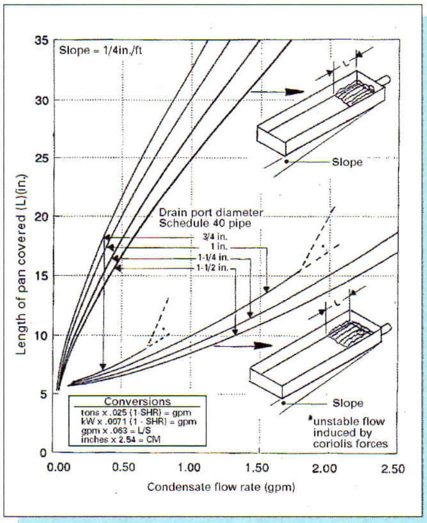

FIGURE 3: The effects of pan slope on the area covered by condensate.

Figure 3 shows how sloping the pan in one direction by ¼ in./ft, in combination with other pertinent variables, affects the amount of pan area covered with condensate. Doubling this slope, of course, reduces condensate coverage by half; reducing the slope by half doubles the area covered by condensate.

Although a sloped pan enhances flow, a portion of the pan will remain covered with condensate (see Figure 3). Under these circumstances, the pan width (the distance the pan extends downstream of the cooling coil) is critical.

Figure 4 illustrates the problems created by wide pans, often designed to catch condensate carryover from cooling coils. In such a pan, it is inevitable that a considerable amount of condensate will stagnate even if the pan is sloped (see Figure 5). The quantity of stagnant condensate in a wide pan can, of course, be reduced by sloping the pan in both directions.

But stagnant condensate is only one of the problems posed by wide pans. The primary purpose of a large pan is to catch condensate droplets blown off the cooling coil. Even if no condensate stands in the pan, condensate droplets deposited on the floor of the pan are held in place by surface tension.

Condensate carryover must be eliminated. In order to avoid condensate stagnation and droplet deposits, pan width must be limited to ensure that condensate leaving through the drain port flows continually over the total surface of the floor of the pan.

Figure 6 suggests pan widths suitable for units with various condensate flow rates, and for port sizes commonly used for side wall drain ports. These size relationships may also be used, conservatively, for selecting pans with

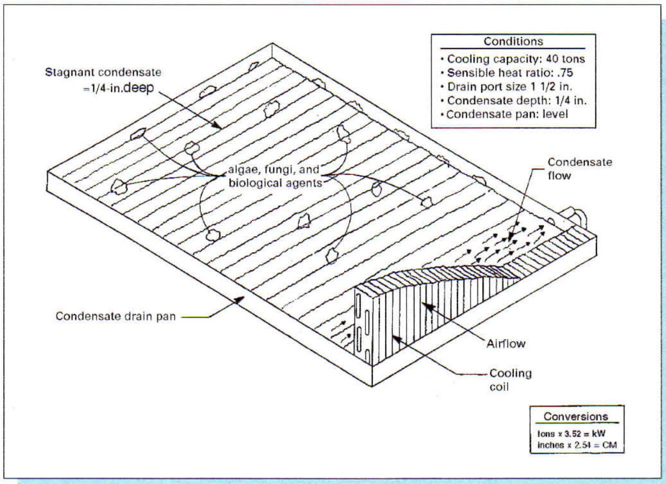

FIGURE 4: Contamination problems created by wide drain pans.

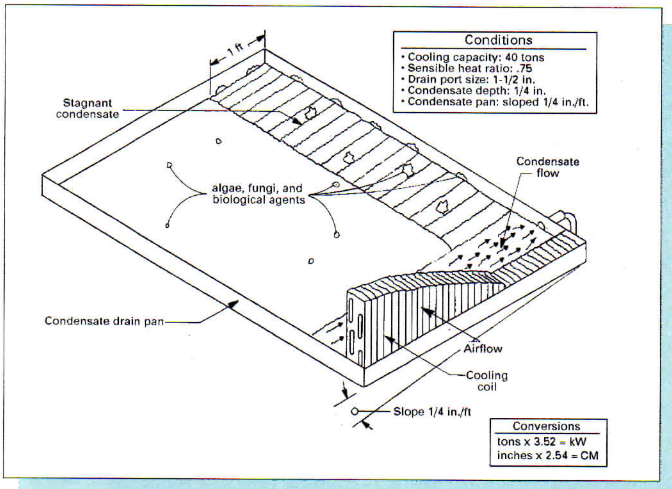

FIGURE 5: Effects of pan slope on condensed flow and contamination.

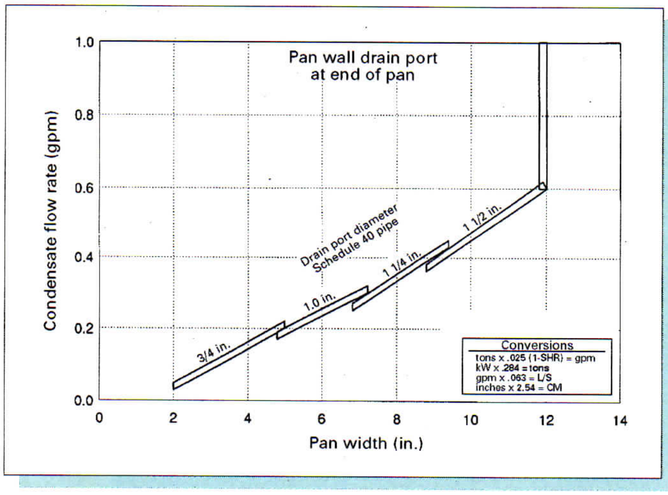

FIGURE 6: Pan widths suitable for units with various flow rates and for commonly used port sizes.

bottom floor drain ports. Greater pan widths and smaller drain port sizes increase the potential for condensate stagnation and system contamination.

4. Pan materials:

The condensate drain pan may be constructed of either metallic or nonmetallic materials. It is important to avoid iron-based materials, which are subject to rapid oxidation in the presence of water and humid air. Iron also is known to accelerate the growth of *Legionella pneumophilia,* the bacterium that causes Legionnaires' disease.

Although *Legionella pneumophilia* has been found in the condensate pans of some hvac units, no outbreak of Legionnaires' disease has been attributed, officially, to them. Investigators often give two questionable reasons why the hvac unit is not a threat to the generation and spread of this bacterium.

- First, it is argued that the condensate temperature is too low for sufficient multiplication of the bacteriump to occur.

Generally speaking, this may be the case. However, *Legionella pneumophilia* has been found in water temperatures from 42.3°F to 145°F (5.7°C to 63°C). Condensate temperatures typically around 55°F (13°C) are well within this range.

Moreover, in the presence of certain iron concentration levels, the multiplication rate of this bacterium increases more than 200 times.[3] In any case, this potential health threat dictates that if an iron-based material is to be used in construction of the condensate pan, it must be stainless steel.

- Second, it is contended that there is no mechanism for aerosolizing the condensate.

Contrary to this contention, an effective aerosolizing mechanism does exist and frequently operates inside the hvac unit (as will be discussed in Part 3 of this series of articles). This fact emphasizes the importance of using a pan material that avoids high iron concentrations in the condensate.

ECONOMICS, SUMMARY

Incorporating the above design features in the condensate pan has little effect on the initial cost of the hvac system. In fact, a smaller pan reduces material and fabrication costs.

An internally sloped drain pan necessitates a slightly higher enclosure for the pan and cooling coil; hence, some added cost will be incurred. However, in many systems, the desired pan slope may be achieved by tilting the hvac unit toward the condensate drain port. This can usually be done without compromising the performance of the system, and at little or no cost.

In any case, the added costs of a self-draining, stainless steel condensate pan are dwarfed by subsequent savings in terms of reduced maintenance, equipment damage, and fewer health problems.

In summation, here are suggestions for drain pan specifications:

- The condensate drain pan shall be constructed of 16-ga* stainless steel. It shall have a depth of no more than 2 in., enclose the base of the cooling coil, and extend no more than 10 in.* downstream.
- A 1-in.*, stainless steel drain pipe, with a male pipe thread, shall be connected to the end of the pan wall, flush with the bottom of the pan, and extended 2 in.* from the wall.
- The floor of the condensate pan shall be sloped ¼ in./ft toward the drain port. The slope may be effected by sloping the pan internally, or by externally tilting the entire hvac unit toward the drain port. External tilting, if employed, shall not affect the performance of the hvac unit nor the manufacturer's warranty.

(* = Typical values only.)

Next month: *See why the seal on a draw-through condensate drain line is essential for successful condensate removal, and for keeping the system dry inside.*

REFERENCES

[1] Unpublished test data from the Department of Mechanical Engineering, University of New Orleans and Trent Technologies, Inc., Laboratory, July, 1996.

[2] "Ventilation for Acceptable Indoor Air Quality," ASHRAE Standard 62-1989, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Atlanta, 1989, Section 5.12.

[3] G.W. Brundrett, Legionella and Building Services, Butterworth Heinemann Ltd., London, 1992, p. 4. **ES**

Warren C. Trent, P.E., is ceo of Trent Technologies, Inc., Tyler, TX. C. Curtis Trent, Ph.D., is president of Trent Technologies.