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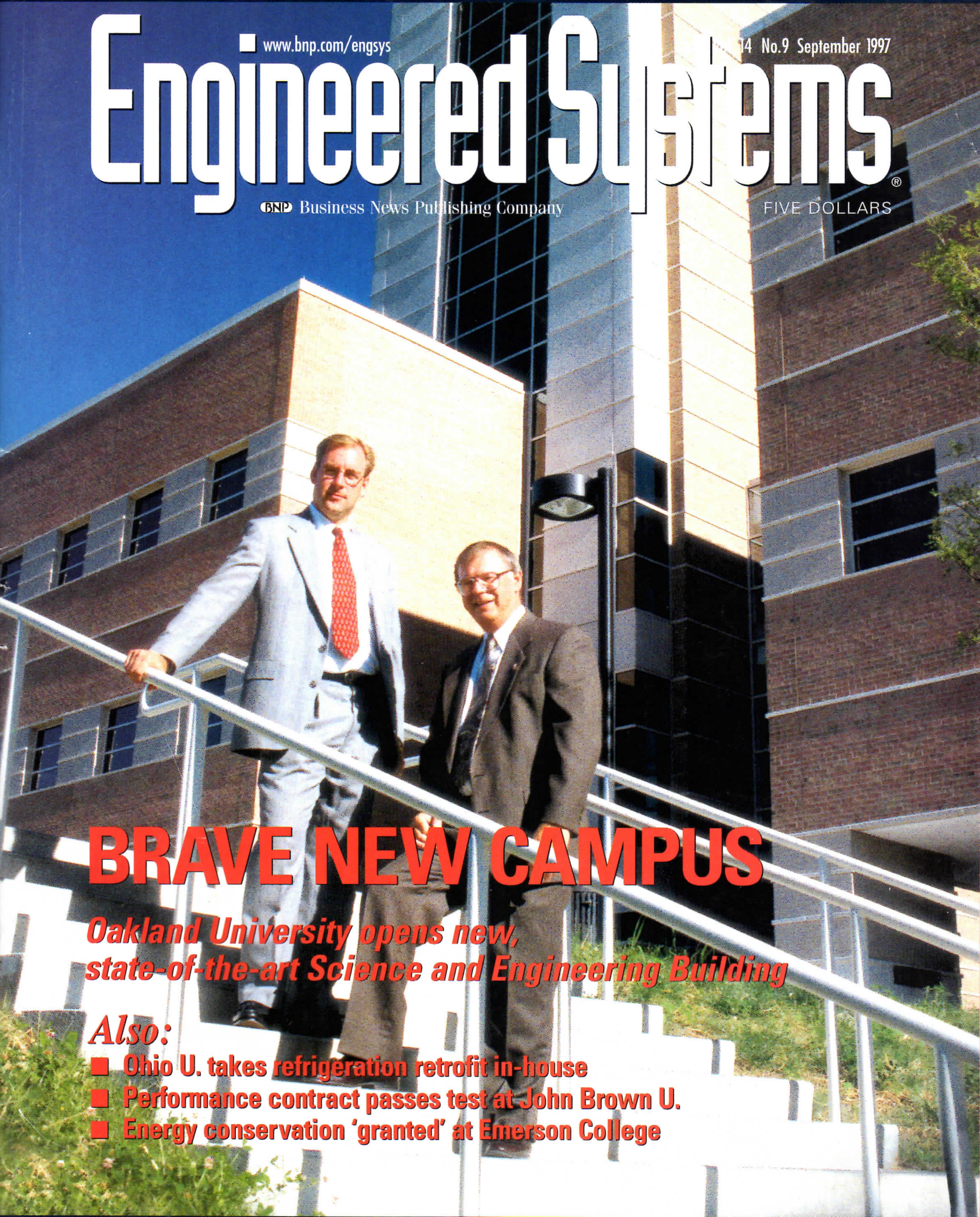

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PRACTICAL APPLICATIONS FOR INNOVATIVE HVACR MECHANICAL SYSTEMS ENGINEERS

CONDENSATE CONTROL

SEAL IT WITH MORE THAN A KISS

An effective and reliable seal on the condensate drain line of a draw-through hvac system is essential for successful condensate removal, and for keeping the system dry inside.

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

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

In a properly designed hvac system, all the water removed from the air collects in a pan below the cooling coil. From there, it is drained to a selected condensate disposal location. Achieving suitable drainage, however, can be difficult, depending upon the type of hvac unit involved.

There are two basic types of hvac units: "blow through" and "draw through." These names stem from the relative positions of the air-circulating fan and the cooling coil.

In the blow-through type, the unit is located upstream and blows air through the cooling coil. As a result, the air pressure surrounding the condensate drain pan is positive (above ambient). Under this condition, condensate drains readily to the outside.

In the draw-through type, the fan draws air through the cooling coil, creating a negative (below-ambient) pressure condition in the drain pan compartment. This can produce two adverse effects: It can impede, or may even prevent, the drainage of condensate; and it can affect ingestion of air and other gases from outside the unit.

To avoid the health problems and property damage caused by these conditions in a draw-through system, a seal should be provided in the condensate drain line, to permit condensate to flow freely and prevent the ingestion of outside air or other gases.

CRITICAL DESIGN FACTORS

Operating a draw-through hvac unit without an effective seal on the condensate drain line can cause serious problems, including the following:

- Negative pressure in the condensate drain pan area can impede the flow of condensate, causing flooding and overflowing that can damage the hvac unit and surrounding property.
- Inrushing air — which in some cases may exceed hurricane velocities — can create a geyser effect, propelling condensate from the drain pan into the system and keeping it wet. The results can be property damage and a growth haven for bacteria, mold, yeast, mildew, and fungi.
- The blowing of condensate can also create an aerosol mist, a known mechanism for spreading *Legionella pneumophila*, the Legionnaires' disease bacterium.
- Outside air, which may be polluted with carbon monoxide or other contaminants, can be drawn into the system and spread throughout the conditioned space.[1,2]

These possible consequences are unacceptable, and dictate that an effective and reliable seal be included on every draw-through hvac unit. In fact, the 1994 Standard Mechanical Code requires a seal on the condensate drain line of draw-through systems, designed

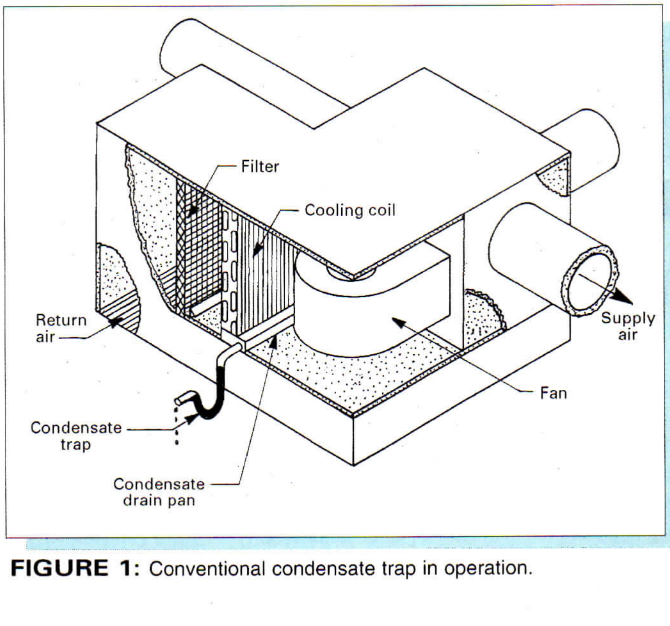
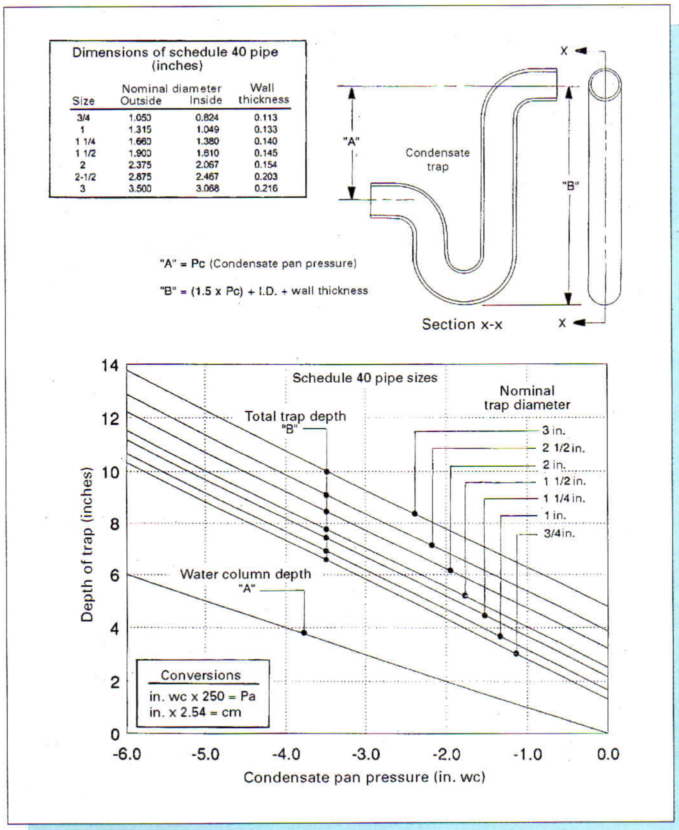


FIGURE 1: Conventional condensate trap in operation.



Size	Nominal diameter Outside	Nominal diameter Inside	Wall thickness
3/4	1.050	0.824	0.113
1	1.315	1.049	0.133
1 1/4	1.660	1.380	0.140
1 1/2	1.900	1.610	0.145
2	2.375	2.067	0.154
2-1/2	2.875	2.467	0.203
3	3.500	3.068	0.216

FIGURE 2: Dimensions of a properly designed condensate trap.

to prevent the ingestion of air through the drain line under all operating conditions.[3]

Within the industry, three types of devices are being used to form condensate drain seals for draw-through hvac systems:

1. Condensate (water) traps;
2. Condensate pumps; and
3. A fluid flow-control device, a more recent technological development.[4]

Each device exhibits unique physical and operating characteristics, and provides a different level of effectiveness and reliability.

THE POSSIBILITIES

Let's break down the different types of devices available.

1. Condensate trap:

The condensate trap is widely used as a seal in condensate drain lines. It is usually mounted outside the hvac unit (see Figure 1, page 52).

The seal is formed by gravitational forces acting on trapped water and a water column. The trap depth and water column depth necessary to form a seal depend upon the pressure inside the drain pan compartment. For any compartment pressure, the required depths remain fixed. However, the total depth varies with the diameter and thickness of the trap wall.

Trap geometry, established in accordance with Figure 2, ensures a positive seal when full of water, and prevents condensate from standing in the pan due to negative pressure. Designing the trap for a more negative pressure than required for system operation should be avoided. The resulting larger trap often poses unnecessary system design problems and installation costs.

Generally, condensate trap seals stocked by supply houses are unsuitable. Photographs of two such devices are shown in Figure 3. In this figure:

• Trap (a) provides a seal, but has no depth for water column. Thus, during system operation, it can allow water to stand in the drain pan at a depth at least equal to the pan pressure, in inches of water.

• Trap (b) provides a water column and a seal over a limited range of internal pressures, but its adaptability to a particular application must be assessed by the designer. (It is not recommended that trap selection be left to the installer.)

Effectiveness and reliability —

Under ideal conditions, the condensate trap can form an effective seal for the condensate drain line. However, because a conventional trap can exhibit many failure modes, its reliability is generally unacceptable for use as a drain line seal.

Some of the most critical failure modes of the condensate trap can be alleviated by incorporating the following design features and maintenance procedures.

• A water-replenishing system ensures that the trap provides a seal under all operating conditions.

• Heating provisions prevent water in the trap from freezing during winter operation in outside locations. (The use of freeze plugs for preventing trap damage should be avoided. The maintenance effort for replacing plugs after freeze-ups is impractical).

• Mandatory maintenance procedures ensure that traps are inspected frequently for flow blockage; filled with water prior to each cooling start-up; and thoroughly cleaned or replaced at least annually, then filled with water.

These design features and maintenance procedures should alleviate significant trap failures. Please be aware, however, that they can introduce others. Both the water replenishing and water heating systems are subject to failure.

And, even mandatory maintenance procedures are difficult to enforce. The designer must evaluate all these factors when considering the trap as a condensate drain seal.

2. Condensate pumps:

There are two basic types of condensate pumps — positive displacement and centrifugal. They require external power (usually electrical) to

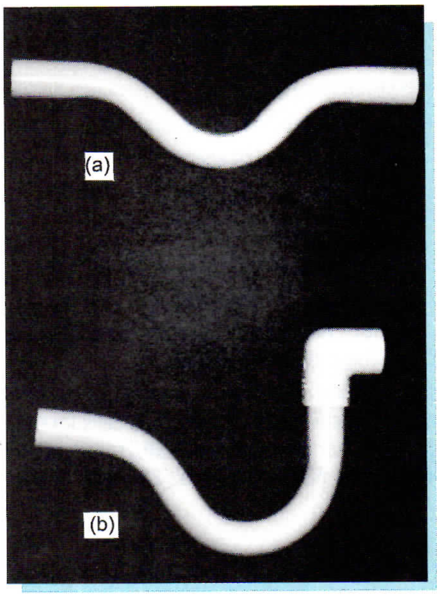


FIGURE 3: Condensate traps typically available at supply houses.

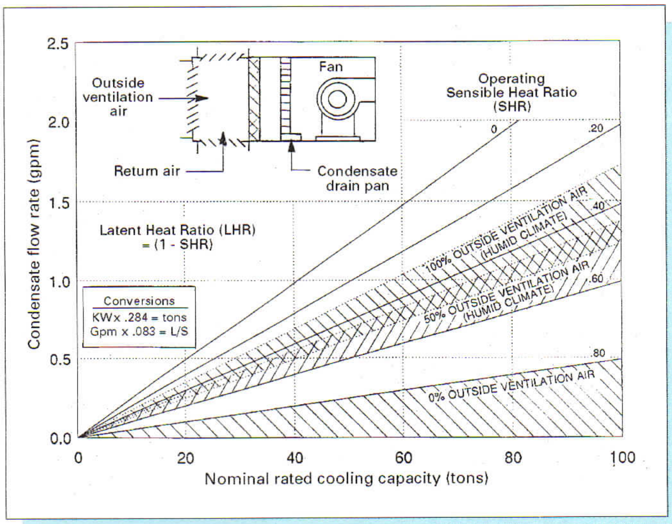


FIGURE 4: Condensate flow rate as a function of nominal ton rating and operating sensible heat ratio.

provide condensate removal.

Pumps are used primarily where there is insufficient depth for the installation of a gravity-dependent drain system, or where condensate must be discharged to a level above the drain pan. When used for condensate removal, pumps are usually placed inside the condensate drain pan.

The configuration of condensate pumps differs greatly among types and manufacturers. Some designs fit better into condensate drain pans than others. In most instances, however, the condensate pan must be equipped with a suitable water sump.

The physical dimensions of a particular pump, of course, depend primarily upon the volume of condensate it must handle. The maximum condensate flow from various-size hvac units, operating under specific cooling conditions, is shown in Figure 4.

In operation, the rate of condensate removed by an hvac unit varies from some maximum value to zero. To accommodate this variation, an on-off switch, which usually operates with a float, should be provided.

Effectiveness and reliability —

The condensate pump provides an effective and positive way to remove condensate from the drain pan.

The positive-displacement pump provides a firm seal, and prevents the ingestion of outside air under all operating conditions.

The centrifugal pump may not provide a firm seal when the pump is not operating. However, depending upon the particular design and installation, it may restrict air ingestion to an acceptably low level.

Condensate pumps are well developed and have been used successfully in certain applications. Their long-term reliability, however, is suspect. Keep in mind the following:

- They depend upon moving parts that must operate in a cold and humid environment.
- The pump must handle condensate that often carries significant quantities of debris, which can interrupt pumping action and block flow.
- The on-off switch is exposed to the same hostile environment, and is therefore subject to failure.

3. Fluid flow-control device:

The fluid flow-control device was developed specifically to provide a seal on the condensate drain line of draw-through hvac units.[4] It has no moving parts; the desired seal is formed by a combination of hydraulic and pneumatic forces readily available in the hvac unit.

One key feature is that it uses air, instead of water, as a seal. Thus, it avoids the problems associated with a water seal.[5]

The operating principles of the fluid flow-control device are illustrated in Figure 5. During both heating and cooling operation, this is how the air seal is designed to form.

1. Fresh air from the fan discharge is supplied to point (a) at a pressure slightly above atmospheric. Some of the air flows away from the hvac unit, thus preventing ingestion of outside air.
2. A portion of the fresh air returns to the hvac unit, passing through points (b) and (c). The quantity of air returning to the unit is minimized by the high pressure loss in the mitered elbows.

This pressure loss, plus the air flowing through the bypass connected at point (c), is designed to ensure that the air entering the condensate drip pan will not produce blowing, the geyser effect, or an aerosol mist.

In this case, condensate is designed to flow through the device without being trapped. At the same time, the counterflow of condensate and air is designed to create a pulsing action, which helps ensure free passage of debris. Hence, the potential for freeze-up and flow blockage — common problems with traps — is practically nil.

Effectiveness and reliability —

The fluid flow-control device can provide an effective and reliable seal for condensate drain lines during all cooling and heating conditions. Among its features, this device is designed to:

- Allow condensate to flow freely from the air conditioning unit;
- Prevent air (which may be contaminated) from being drawn into the system through the condensate drain pipe during heating and cooling start-up operations (when p-traps are usually

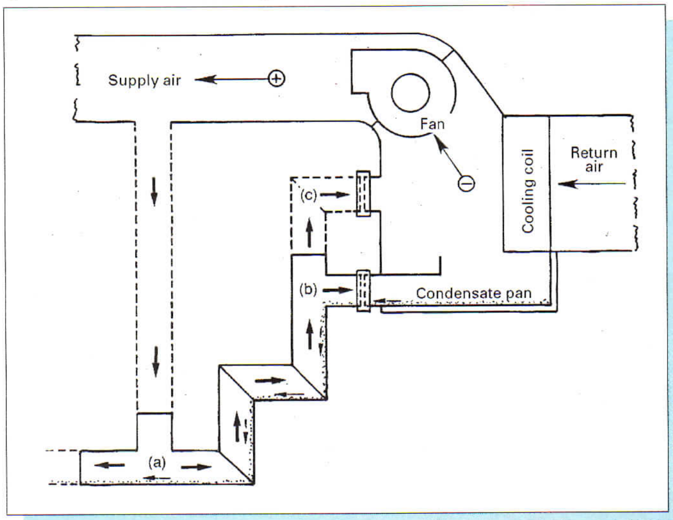


FIGURE 5: Operating principles of the fluid flow-control device.

empty);

- Prevent condensate in the drain pan from being blown into the air conditioning unit and ductwork (during both normal and start-up operations);
- Remove the condensate drain system as a source of an aerosol mist; and
- Eliminate condensate overflow caused by trap blockage and negative pressure inside the system.[5, 6]

ECONOMIC FACTORS

Economic factors are paramount when selecting a seal for condensate drain lines. Both the initial costs and operating costs must be considered.

Of the three types of seals discussed, the initial cost of the conventional condensate trap is lowest, followed by the fluid flow-control, then the condensate pump. However, total costs (initial and operating) are not at all related to the initial costs.

Despite the low initial cost of the conventional condensate trap, its operating and total costs can be extremely high. One should factor in the reality of possible excessive service calls, expensive maintenance, damage to surrounding property, and shortened equipment life.

Although less visible than others, the effect of the condensate trap on IAQ and health-related costs may far exceed other operating costs.

Although less visible than others, the effect of the condensate trap on IAQ and health-related costs may far exceed other operating costs.

Adding a water-replenishing system and a heating device can address two major failures of the condensate trap: empty traps and damaged traps. But they can introduce other failures, add to the initial costs, and contribute little, if anything, to increasing reliability and reducing system operating costs.

Meanwhile, the cost of a condensate pump installed in an hvac drain system, including special condensate drain pan designs, is greater than the cost associated with either of the other drain line seals. However, because it exhibits fewer failures than the conventional condensate trap, annual costs due to maintenance and property damage will not reach those caused by the trap.

Finally, the cost of a fluid flow-control device and its installation in an hvac unit can be quite nominal: greater than the conventional condensate trap (without a water-replenishing system and a heating device to avoid freezing in an outside location), but less than the condensate pump. The economic advantage of the fluid flow-control device usually accrues from reductions in:

- Service calls;
- Required maintenance effort;
- Damage to equipment and surrounding property; and
- Human health problems.

SUMMARY

To summarize, the seal on the condensate drain line of draw-through hvac systems should be designed to:

1. Allow condensate to flow freely from the air conditioning unit;
2. Prevent air (which may be contaminated) from being drawn into the system through the condensate drain pipe during both heating and cooling start-up operations (when p-traps are usually empty);
3. Prevent condensate in the drain pan from being blown into the air conditioning unit and the ductwork (during both normal and start-up operations);
4. Remove the condensate drain system as a source of an aerosol mist;
5. Eliminate condensate overflow caused by trap blockage and negative pressure inside the system;
6. Not be affected by algae growth;
7. Not be affected by condensate evaporation (as are traps);
8. Preclude damage from freezing temperatures;
9. Have no moving parts; and
10. Be self-cleaning and self-regulating.

Next month: *High relative humidity and low temperature in the hvac air supply system can result in serious degradation in indoor air quality, and considerable damage to exposed hardware components. Good design practices dictate that these factors be considered carefully in hvac system design.*

References

[1] *W. and C. Trent, "Indoor Air Quality and the Condensate Trap," paper presented at the Ninth Symposium on Improving Indoor Air Quality in Hot and Humid Climates, Arlington, TX, May 19-20, 1994.*

[2] *J.Cummings et al., "Uncontrolled Air Flow in Non Residential Buildings," Final Report FSEC-CR-878-96, Florida Solar Energy Center, Cocoa, FL, April 15, 1996, pp. 14-15.*

[3] Standard Mechanical Code, 1994 Edition, *Southern Building Code Congress International, Inc., Birmingham, AL, 1994, pp. 36-37.*

[4] *One fluid flow-control device is a patented product manufactured and marketed by Trent Technologies, Inc., Tyler, TX, under the trade name CostGard™ Condensate Control Device.*

[5] *W. and C. Trent, "The Condensate Trap: A Costly Failure," Air Conditioning, Heating and Refrigeration News, Feb. 21, 1994, p. 3.*

[6] *W. and C. Trent, "Considerations in Designing Drier, Cleaner Hvac Systems," Engineered Systems, August 1995, p. 30.* **ES**

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