San Antonio

Condensate Collection and Use Manual for Commercial Buildings

San Antonio Water System

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Condensate Drain System Seals

The purpose of the condensate drain system seal is to isolate the AHU from outside pressure conditions and allow the condensate to drain freely. The type of seal required depends upon whether the AHU is a draw-through or a blow-through system. In draw-through systems, the fan is located downstream of the cooling coil and the drain pan operates at a negative pressure (see Chapter 1). In blow-through systems, the fan is located upstream of the cooling coil and the drain pan operates at a positive pressure. Drain seals are required to prevent draw-through systems from ingesting ambient air and to prevent blow-through systems from exhausting conditioned air.

In draw-through systems, the air ingested through an unsealed drain outlet may be contaminated and pose a health threat. In addition, the pressure differential across the condensate drain pan outlet causes condensate to stand in the drain pan, often preventing condensate drainage and sometimes resulting in condensate overflowing the drain pan. Further, air entering the drain inlet at high velocity entrains condensate and sprays it onto internal components. These conditions not only cause damage to equipment, the buildings and the building contents, but also present a potential health hazard. Standing condensate in the drain pan, along with the wet internal components, provides a fertile growth place for health-threatening microorganisms (Trent et al. 1998).

In blow-through systems, drain seals are essential but are less critical than for draw-through systems. The positive pressure in the drain pan forces air to flow out through an unsealed drain pan outlet. Unlike the draw-through system, the blow-through systems reduces condensate standing in the drain pan as condensate entrained in the air exiting the AHU through the drain pan outlet also exits the AHU. However, there is an efficiency penalty associated with the conditioned cool air being unintentionally exhausted to the outside of the building when the drain seal fails in blow-through systems.

Condensate drain systems must be sealed as required by the equipment or appliance manufacturer [IMC§ 307.2.4] and are not required to be vented like sanitary drainage traps [IPC§Ch8]. The four common condensate drain system seal designs installed in buildings with draw-through AHU are the p-trap, the p-trap with added features, the in-pan condensate pump, and the pneumatic flow control system. These drain seal designs are illustrated in Figure 9.3. The vast majority of commercial AHUs are the draw-through type.

In cases where damage to building components could occur as a result of a drain system seal failure and subsequent drain pan overflow, an auxiliary (backup) drain system or AHU shutoff must be used [IMC§307.2.3].

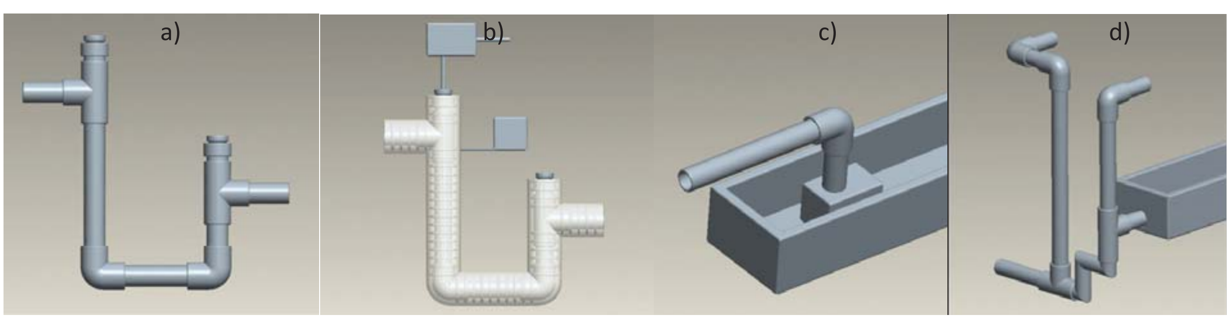

Figure 9.3 Schematics of common condensate drain system seals for HVAC systems: (a) p-trap, (b) p-trap with additions, (c) condensate pump, and (d) pneumatic seal

P-trap

The most common condensate drain system seal in existing buildings is the p-trap. The p-trap relies on the continuous presence of water in the trap to act as the seal against air passage in either direction through the drain line, thereby isolating the AHU from the outside environment. See the article by Brusha (2001) for p-trap design specifications. Unfortunately, the p-trap design is ill suited as a condensate drain system seal and suffers frequent failures, as outlined in the excerpt below from ASHRAE Standard 62-89R (American Society of Heating, Refrigerating, and Air-Conditioning Engineers 1989):

> Condensate traps exhibit many failure modes that can impact on indoor air quality. Trap failures are due to freeze-up, drying out, breakage, blockage, and/or improper installation and can compromise the seal against air ingestion through the condensate drain line. Traps with insufficient height between the inlet and outlet on draw-through systems can cause the drain to back-up when the fan is on, possibly causing the drain pan to overflow or water droplet carryover into the duct system. The resulting moist surfaces can become sources of biological contamination. Seasonal variations, such as very dry or cold weather, may adversely affect trap operation and condensate removal.

These failures often go unnoticed and or untreated until costly equipment damage or poor air quality is detected. Two examples of building-related illnesses from air contamination in draw-through AHUs are (i) Legionnaires' disease from bacterial contamination and (ii) inhalation of toxic gases from outside air that bypass a faulty drain seal. Because of common failures, an auxiliary drain system or AHU shut-off is required as a backup for the p-trap drain seal. Unless reliable scheduled inspections and subsequent maintenance is guaranteed, a p-trap is not a prudent choice for a condensate system drain seal.

P-trap with additions

Adding a heater and self-priming/flushing feature to mitigate p-trap freezing, drying out, and clogging improves the p-trap. However, these additional features add cost and themselves can incur electrical, mechanical, and control failures. An auxiliary drain system or AHU shutoff is required as a backup for the "p-trap with additions" drain seal. Note that if potable water is used for priming, the connection to the inlet side of the trap must include an approved vacuum breaker installed not less than 6 inches, or the distance according to the device's listing, above the flood-level rim of such trapped fixture, so that at no time will any such device be subjected to any back-pressure [IPC§608.15.4].

Condensate pump

One alternative to a p-trap is the installation of a pump in the drain pan to remove water from the drain pan when the water reaches a predetermined level. This design is often chosen when the drain or intended water application is above the elevation of the condensate drain pan located in the AHU. In this case the pump serves a dual purpose: to empty the drain pan and move the water to a higher elevation. The pump size depends on the desired pumping rate and required increase in water elevation for use or disposal. Failure of this drain seal option is due to mechanical or electrical failure of the pump or liquid level switch and/or flow blockage. These failures result in overflow of the drain pan, which leads to potential equipment and health hazards. Therefore, an auxiliary protection system in the form of a backup drain system or AHU shutoff is required for this option. Although this option requires power and can incur mechanical, electrical, and control problems associated with a pump, it is overall a more effective condensate drain system seal than the p-trap designs.

Pneumatic seal

An alternative to a p-trap and a condensate pump is a pneumatic seal. The pneumatic seal has no moving parts and operates on airflow created by pressure differentials in the heating, ventilation, and air-conditioning (HVAC) system. The pneumatic seal requires no maintenance and by design avoids the failures associated with the other options. The self-regulating and foolproof nature of the pneumatic seal makes it an obvious choice over the p-trap and the condensate pump for ease of operation. It does, however, come with a small energy penalty associated with intentional airflow out of the AHU through the drain line to maintain a positive flow of condensate from the AHU. For example, "Approximately 7-cubic feet per minute of air is pushed through the drain line leg of a commercially available pneumatic seal. This is on the order of 0.06% of the conditioned (cooled) air passing through a 30-ton HVAC unit" (Trent 2011). The energy penalty shrinks as the tonnage of the AHU increases because the 7 cubic feet per minute is a smaller percentage of the total flow as the total flow increases. The commercially available pneumatic seal[2] can handle up to negative 5 inches of water drain pan pressure in a draw-through unitary or split AHU up to 100 tons with a ¾- to 2-inch diameter drain pipe size and up to positive 5 inches of water drain pan pressure in a blow-through AHU. Several major HVAC manufacturers now offer the pneumatic seal as an option when ordering an AHU unit. An auxiliary drain system or AHU shutoff mechanism is required in case the drain pan exit or lines downstream of the pneumatic seal become clogged.

Comparison of condensate drain seal options

A properly functioning drain seal is critical to maintaining good indoor air quality and preventing costly equipment damage. Unless reliable scheduled inspections and maintenance is guaranteed, the water-filled p-traps are not a practical solution to continuously seal the condensate drain. Of the two remaining options, the pneumatic flow control is preferable because it is self-regulating and self-cleaning. It requires the least attention and maintenance over the lifetime of the system.

However, if the condensate must be pumped to a higher elevation to reach the location of the intended application or to reach a drain, then a pump will be required anyway, and leveraging the pump in the condensate pump drain seal design can optimize the systems for these two requirements. A third factor that can be leveraged in consideration with the pump is metering the condensate rate. Several of the metering options require a pump to force water through a meter. Often a reservoir and pump are included downstream of the drain seal to separate the function of the drain seal from the system used to elevate the condensate. Since the choice of one component may influence the choice of another component, it is wise to consider the system design holistically, especially when evaluating choices related to pumps and flow path.

The characteristics of each type of common condensate drain seal are summarized in Table 9.2. Data is not available for the frequency of failure for each type of drain seal. However, even limited failures can cause human health risks by allowing improper HVAC operation and subsequent growth of biological contaminants that get carried into building spaces by the conditioned airstream. Therefore, proper design and maintenance of the drain seal is imperative for good indoor air quality and should be a priority when implementing a condensate collection system.

Note that estimated first costs in Table 9.2 do not include materials and labor to install an auxiliary drain for any option, to supply electricity to the pumps for options 2 and 3, or to supply water to the automated primer/flusher in option 2. Maintenance costs and effort are expected for all options except the pneumatic flow control (option 4). More than 49,000 pneumatic flow control units (i.e., CostGard™) have been installed, and no failures have been reported to the company selling the units; inspection is only required to ensure proper installation and operation (Trent 2011).

[2] CostGard™ Condensate Drain Seal uses air to form the drain seal, instead of water. Trent Technologies, Inc., Tyler, TX 75703

Table 9.2 Summary of common condensate drain seals options

Drain Seal Options	Potential Failure Modes									Maintenance				Selection Factors					
	Poor Design	Poor Installation	Dry Trap	Blockage	Freezing	Cleanout Open	Mechanical	Electrical	Controls	Manual Prime & Flush	Electrical	Mechanical	Replacement of Parts	O&M Burden	Failure Risk	Requires Water Source	Requires Power Source	Requires Auxiliary Drain	First Cost[a]
P-trap	●	●	●	●	●	●				●				high	high			●	$20
P-trap with additions	●	●				●	●	●	●		●	●	●	med	high	●	●	●	$200-1,000
Condensate pump	●	●		●			●	●	●		●	●	●	low	med low		●	●	$50-100
Pneumatic flow control		●												virtually nil	virtually nil			●	$100-$300

[a] Estimated cost at time of publication of manual based on ¾-inch drain line

Auxiliary (backup) condensate drain system

Safeguards are designed into the condensate drain system to prevent water from backing up and subsequently overflowing the drip pan if the primary drain line becomes clogged or the drain seal fails. Where damage to any building components could occur as a result of overflow, one of the four methods in Table 9.3 is required [IMC§307.2.3]. An auxiliary condensate drain system and/or a warning alarm are recommended on all AHUs.

Table 9.3 Drain pan overflow protection methods [IMC§307.2.3]

	Overflow Protection Methods
1	Auxiliary drain pan with a separate overflow drain line to conspicuous point of disposal to alert facilities personnel
2	Primary drain pan with a separate overflow drain line (connected higher than the primary drain line) to conspicuous point of disposal to alert facilities personnel
3	Water-level detector, connected to HVAC shutoff, installed in auxiliary drain pan without a separate overflow drain
4	Water-level detector, connected to HVAC shutoff, installed in (i) primary drain pan above drain line connection and below rim of drain pan, (ii) primary drain line, or (iii) separate overflow drain line.

When an auxiliary drain pan is used, all parts and insulation subject to water damage must be above the rim level of the pan [IMC§307.2.3.2]. When an auxiliary drain pan and separate drain line are not feasible, option 4i in Table 9.3 must be employed. Option 2 is viable only if the secondary drain line is equipped with a reliable drain seal; otherwise an unsealed secondary drain seal causes the same types of problems as an unsealed primary drain seal. An alarm connected to an overflow indicator in the drain pan is a sensible addition to alert facility personnel if and when a drain seal failure occurs [IMC§307.2.3.1]. Detecting drain pan overflow prevents the numerous and potentially costly and hazardous effects of an overflowing drain pan on the inside of the AHU and on the conditioned space in the building.