Breathing Easier:
HVAC Specifications for Schools

By Dr. C. Curtis Trent and Warren C. Trent

IT HAS been estimated that the annual cost of health care in the United States resulting from indoor air contamination is from 50 to 100 billion dollars annually and the amount of unnecessary human suffering is immeasurable. It also has been estimated that nearly 50 percent of the North American work force suffers from headaches, sore throats, or breathing problems brought on by polluted indoor air (Magon, May, 1990). In all likelihood, the figure may be higher for school children. According to one authority, "Some 40 percent of ailments in most buildings are attributable to bacteria, mold, yeast, and other biological contaminants" (Robson, August, 1990).

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Sources of Indoor Air Contaminants

There are many sources of indoor contaminants but a major source of contamination in schools originates within the heating, ventilating and air conditioning systems (HVAC), with draw-through systems being the worst offenders. According to Custer (1988):

> HVAC systems have been found to be a major cause of indoor air contamination. Inhalation of microbial contaminants that have been able to enter and breed within a HVAC system can cause allergic reactions that result in inflammation of the nose, the airways and alveoral spaces or alveoli and bronchioles.

During the past two cooling seasons, the writers examined scores of air conditioning units in schools throughout the Southeastern United States. They found the majority of them wet inside: various types of algae were growing in the drip pans and unit floors, and buildup of mold, mildew, and other fungi were found on the inside walls and duct work. They found stagnant water standing in the rusting deteriorating floors of many units and evidence of frequent overflows (see photos).

They were able to trace the conditions described above to one or more of eleven design deficiencies in the systems. The design deficiencies they observed were: excessive air flow; deficient air flow; inadequate provisions for ventilating air; non-insulated coolant or refrigerant lines in the airflow path; improper blower (fan) location; inadequate filters and filter holders; highly slanted cooling coils; unsuitable drip pan drain ports—position and design; long, undulating and poorly routed condensate drain lines; unduly large condensate drip pans; and inadequate seals on condensate drain lines (Trent & Trent, 1995).

The most flagrant and most detrimental of the deficiencies observed was "inadequate seals on condensate drain lines." Because the trap is so unreliable, most of the draw-through systems the writers observed were operating without a seal or with a dysfunctional seal on the condensate drain line.

Why Condensate Drain Seals Are Important

A primary function of an air conditioner is to remove moisture (water) from the air. During the cooling process, condensate (water) collects on the cooling coil and drips into the catch pan located below. From there, it is, ideally, drained away from the unit to a suitable disposal place. Unfortunately, the draining of condensate from a draw-through type air conditioner is no easy task, particularly if the unit is operating without an adequate seal on the drain pipe.

Investigations (Trent, 1992) have shown that a draw-through HVAC system operating without an adequate seal on the drain pipe (a not uncommon condition) can draw air in through the drain pipe at velocities above 30 mph. The air flow can also draw in outside contaminated air and gases. It can become strong enough to blow condensate into the system and duct work where it provides ideal conditions for the reproduction and growth of harmful microorganisms. These microorganisms can be spread directly into classrooms and offices.

This air flow can produce an aerosol mist (the only known mechanism for spreading Legionnaire's Disease bacteria). It can also impede the flow of condensate and cause the unit to overflow, resulting in extensive damage to the air conditioning unit and the building. Moreover, it provides an ideal breeding place for harmful microorganisms.

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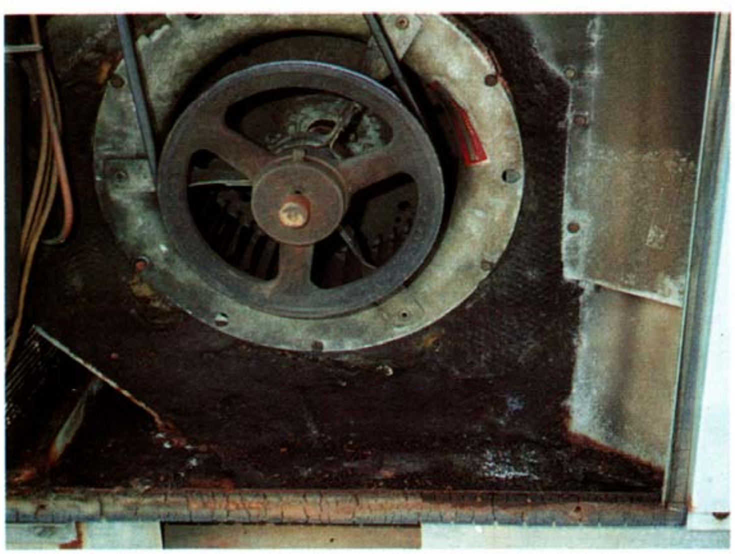
Air filters will not eliminate the growth of bacteria and fungi generated within the HVAC system. They are located in the wrong place to prevent internally grown microorganisms from being blown into classrooms.

Conventional water type P-traps are recognized failures as seals for condensate drain pipes because, more often than not, they are improperly designed, become blocked periodically and cause overflow, are often removed by service personnel, require extensive maintenance, and if located outside, tend to freeze and break in cold weather. (Trent, 1994) The key to alleviating the situation is the proper removal of condensate and preventing the blowing of condensate into the system and duct work.

The heating and air conditioning industry is aware of the maintenance, property damage, and pollution problems caused by draw-through HVAC systems designated for schools. It is also aware of remedies or proper engineering practices, which include a reliable seal on the drain line of draw-through systems. The industry, however, is not moved to take corrective action because too often, school administrators and school boards are not fully aware of the causes of their problems, and consequently, there is no demand that the problems be corrected.

But technology currently exists to design a school HVAC system that will eliminate moisture from the inside walls and



These photos illustrate conditions typical in many poorly-designed air conditioning units.

floor of the air conditioning unit and duct work, thus removing the conditions necessary for the growth of harmful bacteria, yeasts, molds and other fungi within the HVAC system. School administrators and school boards must take the initiative and insist that such systems be made available.

Fortunately, to improve the situation, school boards and administrators do not have to understand all of the technical details that constitute a well-designed HVAC system. They simply need to know what is necessary to ensure that HVAC systems are properly designed.

Designing It Correctly the First Time

School districts can ensure their HVAC systems are properly designed if they employ architects and designers who are able to design a HVAC system with the following provisions (technical details notwithstanding):

- The velocity of the airflow through the cooling coil is not high enough to blow condensate from the cooling coil into the unit and duct system;
- The velocity of the airflow through the cooling coil is not so low that moisture will form on the supply grilles in the classrooms and offices;
- Internal coolant lines in the air flow path are insulated to the extent that moisture will not form on them and be blown into the system and duct work or drip onto the floor of the unit (a condition found in many new high SEER packaged systems);
- The blower (fan) is positioned properly within the unit so that the airflow does not create "vortices" or "little hurricanes" that feed water into the system;
- Adequate provisions are made for ventilating air and for controlling relative humidity, under all operating conditions (Dozier, 1995). (Also see "Some Significant Provisions of ASHRAE Standard 62-89" in HVAC Design Criteria box.);
- Filter holders are tight fitting and do not allow air to be drawn in around the sides of the filters;
- Filters have a dust spot efficiency of at least 25 percent to prevent dust from adversely affecting the cooling coil (Ottney, 1993);
- Drain ports are located flush with the lowest point in the bottom of the drip pan. The pan is slanted toward the drain port, or the unit is tilted toward the drain exit;
- The drip pan is no larger than necessary, providing minimal space for water to stand. This standing water provides a growth haven for algae and other organisms;
- The base for the unit is high enough to allow a slope on the condensate drain line of at least 1/8" per linear foot;
- The condensate drain lines are properly supported and secured, so that no dips are formed to trap water and debris, and have a slope of at least 1/8" per linear foot; and
- Provisions are made for a reliable seal on the primary drip pan drain lines and secondary drain lines of draw-through units. This will: 1) prevent polluted air from being drawn into the system through the condensate drain pipe during both

HVAC System Design Criteria

The HVAC system shall:

1. Remain dry inside (except the cooling coil and a small drip pan) during all operating conditions.
2. Prevent outside air and contaminated gases from being drawn into the system through the condensate drain line under all operating conditions.
3. Be capable of controlling temperature and relative humidity of the occupied space within the human comfort zone established by the ASHRAE 1993 Handbook-Fundamentals—page 8.13 Figure 5—under all operating conditions.
4. Maintain a positive pressure within buildings of 2 Pascals (.008 in. wc.) minimum and not more than 10 Pascals (.040 in. wc.), during normal operating conditions (hot humid climates).
5. Meet or exceed the requirements identified in ASHRAE Standard 62-89* or the most recent version of that Standard.
6. Comply with applicable building, mechanical† and plumbing codes.

*** Some Significant Provisions of ASHRAE Standard 62-89**

1. Specific outside air ventilation rates.
2. No standing water in condensate pans (self-drainage).
3. Provisions for In-situ (in-place) cleaning of cooling coil and condensate pan .
4. Easy accessibility for inspection of fan and cooling coil.
5. Relative humidity in air ducts and air plenums: less than 70 percent.
6. Make-up air inlets and exhaust air outlets located away from polluting sources.

† Pertinent Requirement of the Standard Mechanical Code

(Paragraph 304.8)

304.8 Evaporators and Cooling Coils

304.8.1 General. Condensate drain systems shall be provided for equipment containing evaporators or cooling coils. Condensate drain systems shall be designed, constructed and installed in accordance with this sections.

304.8.2 Seal. The condensate drain system shall provide a seal that prevents ingestion of air or other gas, through the condensate drip pan drain and overflow connections, from all outside sources, including the condensate disposal place, during all operating conditions... (The conventional condensate trap does not meet the requirement of this code).

heating and cooling operations; 2) prevent condensate in the drip pan from being blown into the unit and duct work; 3) prevent the generation of an aerosol mist; 4) eliminate condensate overflow caused by drain blockage and negative pressure inside the system; 5) prevent condensate from standing more than 1/4" in the drip pan; 6) not be affected by condensate evaporation; 7) preclude damage from freezing temperatures; 8) have no moving parts; and 9) be self-cleaning and self-regulating.

The conventional condensate P-trap is not a reliable seal and cannot meet these provisions. Architects and designers should be made aware that there is a condensate control device available that can meet all these conditions as well as the requirements of the 1994 Standard Mechanical Code (Trent & Trent, 1995). The device is widely used in school districts in Texas, including Fort Worth, Lewisville, Tyler, Hawkins, Sulphur Springs, Palestine and others.

A set of criteria helpful to architects and designers in designing the HVAC system is presented in the accompanying box.

If school districts will demand that architects and system designers adhere to these criteria when planning new construction or renovations, they will not only avoid the exorbitant costs of excessive maintenance, property damage, early equipment replacement and absenteeism, but they will find themselves in a less vulnerable position should a litigation situation arise.

Adhering to the above mentioned criteria is neither difficult nor expensive. It requires only that designers utilize current technology and proper engineering practices. If there are architects and designers unwilling or unable to commit to these criteria, it would be to the school district's advantage to engage those who are willing and able to do so.❑

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