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Engineers Newsletter

ASHRAE Standard 62-89 Analysis
Part I: General Requirements

Because of recent IAQ litigation, many HVAC system designers view ASHRAE Standard 62-89, Ventilation Standard for Acceptable Indoor Air Quality, as a minimum ventilation standard that must be met, in addition to local codes. If a building designer fails to conform to appropriate ASHRAE standards, claims of negligence and strict product liability may result. Also, building regulations in more and more states reference ASHRAE 62-89 for ventilation requirements.

But what does the standard actually say? How does it really impact the designer? The following analysis of the various requirements of the standard is presented as an aid to designers and installers. It is based on our best judgement of the meaning and purpose of the various provisions. Of course, the ultimate responsibility for interpretation and compliance rests with the individual designer and installer.

The expressed purpose of ASHRAE Standard 62-89 is to specify **minimum ventilation rates** and **indoor air quality that will be acceptable to human occupants;** both specifications "...are intended to avoid adverse health effects." The standard attempts to accomplish this dual purpose by presenting a series of general requirements for systems and equipment (Section 5.0), then offering two alternative procedures for providing acceptable indoor air quality (Section 6.0).

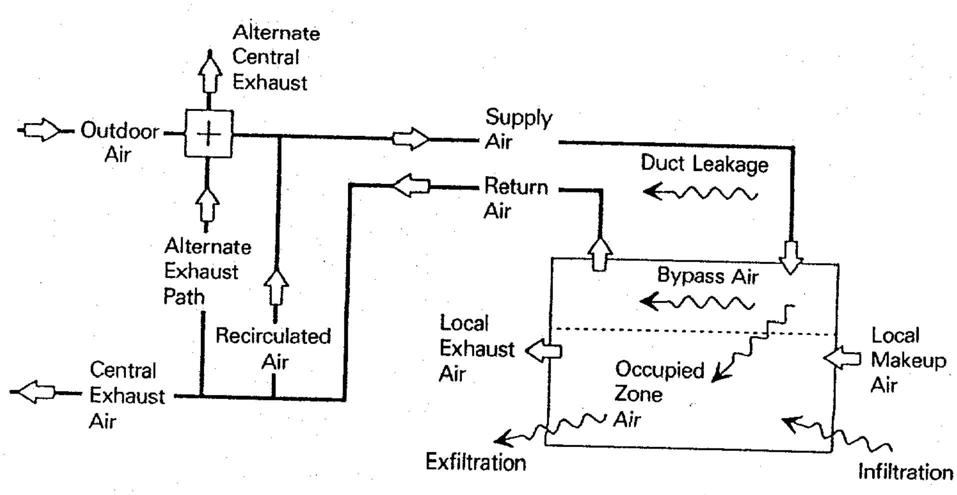
Section 5.0, Systems and Equipment, is discussed below. Section 6.0, Procedures, is the subject of subsequent **Engineers Newsletters**.

General Terms

Throughout the standard, both **suggestions** (signaled by use of the words **should** and **may**) and **requirements** (denoted by **shall** and **must**) are presented. Requirements must be met to claim conformance with the standard. On the surface, it seems that suggestions need not be met for compliance. However, ignoring these suggestions may not be **prudent** in the context of potential litigation. After all, the suggestions reflect the consensus of experts in the HVAC industry and might, therefore, be viewed as the minimum criteria a prudent designer would follow when designing a ventilation system.

ASHRAE Standard 62-89 makes several references to the **occupied zone**. This zone is a defined region within the occupied space, "...between planes 3 and 72 inches above the floor and more than 2 feet from the walls." The **occupied space** is assumed to refer to all inhabited areas of the building ... usually rooms within the building. Figure 1 shows the typical airflow paths in a ventilation system. The occupied space is shaded; the occupied zone is in the occupied space below the dashed line.

Figure 1: Ventilation System Airflows



Analysis of Section 5.0: Systems and Equipment

Section 5.0 presents general suggestions and requirements for ventilation systems and equipment to assure acceptable indoor air quality. Key points presented in Section 5.0 are arranged by topic and discussed below.

Airflow Measurement

- Is outdoor airflow measurement required? No. Provision for measurement is **suggested**.

"When mechanical ventilation is used, provision for airflow measurement should be included" (Section 5.1).

This phrase seems to suggest continual measurement of outdoor airflow entering the building at the air handler. Why? Presumably, so that outdoor airflow rates can be monitored, recorded and used at a future date to prove that the building was ventilated properly. On the other hand, perhaps this phrase only suggests that the outdoor airflow stream be accessible for **periodic** flow measurements. In any event, litigation-conscious designers tend to read this suggestion as a requirement for continuous outdoor airflow monitoring at the air handler. Incidentally, continuous measurement of outdoor airflow may be required for control of outdoor airflow, regardless of the need for airflow monitoring.

- Is mechanical ventilation required? Yes.

"When infiltration and natural ventilation are insufficient to meet ventilation requirements, mechanical ventilation shall be provided" (Section 5.1).

If natural ventilation (windows and cracks) is insufficient to meet ventilation requirements presented later in the standard, a fan is **required** to draw outdoor air into the building.

Energy Recovery

- Does the standard require the use of energy recovery systems? No. The use of energy recovery systems is **suggested**.

"The use of energy recovery ventilation systems should be considered for energy conservation purposes in meeting ventilation requirements" (Section 5.1).

More outdoor airflow results in more exhaust airflow. Since energy is invested to condition the air that enters the occupied space and is then exhausted, it seems logical to try to recover some of this invested energy from the exhaust airstream. Energy recovery systems include **sensible heat** recovery systems (coil loops and heat pipes), as well as **enthalpy** recovery systems (heat wheels). In practice, however, the installed and operating costs of an exhaust air energy recovery system in a commercial building may not result in a reasonable payback. Furthermore, cross contamination potential restricts energy recovery choices. Therefore, this suggestion is seldom pursued by the designer.

Room Air Distribution

- Should ventilation air supplied to the occupied space reach the occupants? Of course! This is a **requirement**.

"Ventilating systems shall be designed and installed so that the ventilation air is supplied throughout the occupied zone" (Section 5.2).

Air supplied to the occupied **space** (the room) must be well distributed throughout the occupied **zone** (the occupied region of the room). Room air distribution is directly related to room geometry and air temperature; diffuser type, size, location and air velocity; return air type and location; and supply air temperature. The building designer is responsible for a properly **designed** room air distribution system. Furthermore, proper **installation** is **required**. But does the standard require the designer to be responsible for the work of the installer? On the other hand, does the standard require the system installer to assume responsibility for proper room air distribution, in spite of a weak design? The standard is not clear on this point. This could open the door to finger pointing.

To help building designers properly design room air distribution systems, manufacturers of VAV terminal units, room air diffusers, zone-mounted terminal units (such as fan coils and unit ventilators) and unitary air conditioners should provide pertinent air distribution data, such as throw patterns and distances.

- Can the occupied zone be uncomfortable, in terms of air movement? No. The standard **requires** that no conditions in the occupied zone conflict with the human comfort factors presented in ASHRAE Standard 55-81.

"Ventilating systems shall be designed and installed so that they do not cause conditions that conflict with ASHRAE Standard 55-1981 . . . " (Section 5.3).

In a properly designed room air distribution system, occupied zone air velocities do not exceed 30 fpm (winter) or 50 fpm (summer), and the temperature gradient does not exceed 5 F. The designer must be aware of the factors that impact human comfort and design the room air distribution system to maintain these factors within acceptable ranges. In general, the diffusers

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must not **dump** cold air at high velocities into the occupied zone at any load condition, and the occupied zone temperature must not be allowed to stratify. As above, the standard **requires** proper **installation** of the ventilating system, but does not clearly assign this responsibility to the building designer or the installer.

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Can room air distribution requirements be relaxed at part load conditions? No. Acceptable indoor air quality in the occupied zone is **required** at all load conditions.

"When the supply of air is reduced during times the space is occupied (e.g. variable air volume systems), provision shall be made to maintain acceptable indoor air quality throughout the occupied zone" (Section 5.4).

One provision often incorporated in VAV systems to assure proper room air distribution at part-load conditions (reduced primary airflow) is the fan-powered or induction VAV terminal unit. In effect, the occupied space is actually supplied with variable temperature air at a constant diffuser airflow rate. The room air distribution system is designed for constant air volume, so room air distribution always operates as designed.

An alternative provision, which also fulfills this requirement, is the use of minimum flow settings at the shutoff VAV terminal unit in conjunction with properly selected and located diffusers (i.e. selected and located to operate properly over the full range of flows). To assure proper low-flow operation, the flow through the VAV terminal unit is not allowed to drop below the minimum flow required by the diffusers. Typically, two minimum flow settings are needed: one for the delivery of cool air, and another higher setting for the delivery of warm air. Experience shows that linear slot diffusers operate over the widest range of flows and are, therefore, commonly specified in VAV systems.

Design Documentation

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Should the building designer document assumptions and design calculations? Yes. This is a **requirement**.

"The design documentation shall state assumptions that were made in the design with respect to ventilation rates and air distribution" (Section 5.2).

Although not stated explicitly, the standard implies that ventilation system design documentation is a required part of the overall building design documentation package. This documentation is necessary for checking the design (part of the commissioning process) as well as for operating, maintaining and altering the system in the future. The building designer is responsible not only for building plans, specifications and installation/operation/maintenance documents, but also for building system-related design documents.

External Contamination Sources

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Is the location of makeup air inlets important? Yes. Proper location of air inlets, with respect to exhaust air outlets, is a **requirement**.

"Makeup air inlets and exhaust air outlets shall be located to avoid contamination of the makeup air" (Section 5.5).

The building designer must position equipment in a way that prevents makeup air contamination, i.e. the makeup air inlet location must prevent exhaust air from being reintroduced into the building via the makeup air inlet. This requirement can usually be met in applied systems since makeup air inlets and exhaust fans are in separate units. However, compliance can be more difficult when rooftop unitary equipment is used. Rooftop units typically house both the makeup air inlet and exhaust air outlet. Therefore, the designer must determine the likelihood of makeup air contamination and either select equipment designed to avoid this problem or add external ducts or baffles to correct it.

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Is the designer required to keep contaminants from outside sources out of the building? No. But the standard **suggests** avoiding such contaminants.

"Contaminants from sources such as cooling towers, sanitary vents, vehicular exhaust from parking garages, loading docks, and street traffic should be avoided" (Section 5.5).

"Special care should be taken to avoid entrainment of moisture drift from cooling towers into the makeup air and building vents" (Section 5.12).

Although these are only suggestions, they seem to be corollaries to the requirement for locating the makeup air intake, discussed above. These are merely additional external contamination sources. If viewed as corollaries, these statements **require** the building designer to account for all possible external contamination sources when locating the system outdoor air intake. Incidentally, the second statement (from Section 5.12) can be interpreted to include any outdoor equipment with standing water as a potential external contamination source.

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Is the designer required to keep radon out of the building? No. The standard **suggests** that the building designer avoid designing systems that accelerate radon infiltration.

"Where soils contain high concentrations of radon, ventilation practices that place crawl spaces, basements, or underground ductwork below atmospheric pressure . . . should be avoided" (Section 5.5).

Although this is only a suggestion, a ventilation system design that actually draws radon into the building is not acceptable to many building owners, occupants or building codes. For this reason, building designers often interpret this suggestion as a requirement for a good design. HVAC systems should be designed so that subsurface system elements (particularly basements) are maintained at a positive pressure with respect to the atmosphere. In this way, infiltration from the ground, another major external contamination source, is minimized.

Air System Cleaning

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Are dirty ducts and plenums acceptable? No. Microorganisms grow in dirt. The designer is **required** to design and specify duct systems that can be cleaned.

"Ventilating ducts and plenums shall be constructed and maintained to minimize the opportunity for growth and dissemination of microorganisms through the ventilation system" (Section 5.6).

This requirement is commonly extended by building designers to include not only ducts and plenums, but also other air system equipment, such as air handlers and VAV terminal units. It leads to the specification of external insulation, foil-faced insulation or dual-wall construction and away from internal insulation, fibrous ducts and duct liners. It also leads to the specification of adequate access doors and panels for convenient periodic cleaning.

The installer, who actually constructs the air distribution system, is **required** by the standard to install the air system so that it can be cleaned. A good access door is useless if it is against a brick wall.

Also, the air system owner, so it seems, is **required** to maintain (clean) the air system. After all, even easy-to-access metal surfaces get dirty. One major challenge that this requirement presents to the system maintainer is cleaning the ceiling plenum. Many systems utilize the ceiling plenum as the return air path. Ceiling plenums are not often designed for easy cleaning!

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Are inaccessible coils and condensate pans in air handlers or fan-coil units acceptable? No. Access for cleaning of coils and drain pans is a **requirement**.

"Provision shall be made for periodic in-situ cleaning of cooling coils and condensate pans. Air-handling and fan coil units shall be easily accessible for inspection and preventive maintenance" (Section 5.12).

The requirement for in-situ cleaning of cooling coils and condensate pans usually results in equipment specifications calling for adequate access panels and area. The equipment supplier must provide equipment that can be cleaned, inspected and maintained **in place**. In addition, the equipment must be located and installed within the building to assure adequate access to cooling coils, drain pans, and inspection and maintenance areas.

Local Exhaust

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Are local exhaust systems ever needed? Yes. Stationary local contaminant sources **require** local exhaust systems.

"Contaminants from stationary local sources within the space shall be controlled by collection and removal as close to the source as practicable." (Section 5.7).

"Fuel-burning appliances. . . .shall be provided with. . . .adequate removal of combustion products" (Section 5.8).

"Combustion system. . . vents shall not be exhausted into attics, crawl spaces, or basements" (Section 5.8).

The building designer must provide local exhaust for local air contamination sources, such as copy machines, in compliance with industrial ventilation standards. Fuel-burning appliances are a special local contamination source. Products of combustion must be removed via a local exhaust system, and must not be exhausted inside the building.

Local Makeup Air

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Is local makeup air ever required? Yes. Air-consuming processes **require** sufficient air.

"Fuel-burning appliances. . . shall be provided with sufficient air for combustion. . . When infiltration supplies all or part of the combustion air, the supply rate shall be demonstrable." (Section 5.8).

The designer is required to account for the air consumed by indoor fuel-burning appliances. When determining the amount of outdoor air required for a given space, the need for combustion air must be accounted for in design calculations. Special provision for makeup air to appliances may be needed, separate from the ventilation system.

Filtration

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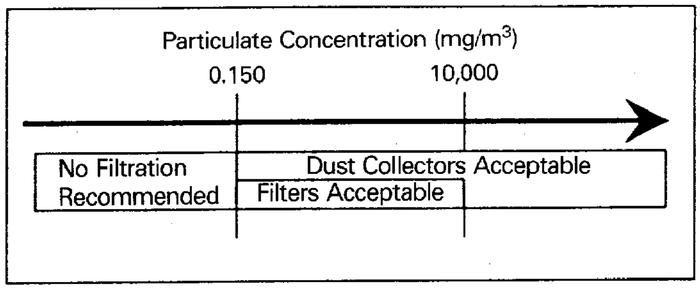
Are filters always required? No. If particulate removal is needed, the standard **suggests** using air filters or dust collectors.

"When it is necessary to remove particulate contaminants, air filters or dust collectors should be used. Dust collectors, not air filters, should be used where dust loading equals or exceeds 10 mg/m³" (Section 5.9).

Table 1 of ASHRAE 62-89 (presented here) cites EPA Ambient-Air Quality Standards for Outdoor Air (i.e. the acceptable total particulate content for outdoor air). Particle removal is necessary if outdoor or recirculated air exceeds this total particulate concentration.

If it is necessary to remove particles from the outdoor or recirculated airstream, use of air filters or dust collectors is recommended, but not required. However, many building designers interpret this suggestion as a requirement for filtration. Either air filters or duct collectors can be used if dust loading is less than 10 mg/m³ (low particulate content). However, if dust loading equals or exceeds 10 mg/m³ (high particulate content), then the use of dust collectors, not air filters, is suggested, Figure 2.

Figure 2



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Is any type of filter or dust collector acceptable? No. If particle removal is used, proper selection of the air filter or dust collector is **required**.

"Air filters and dust collectors shall be selected for the particulate size and loading encountered. Filters shall be tested in accordance with ASHRAE Standard 52-76" (Section 5.9).

Although the standard does not provide detailed guidelines for filter selection, it does require that the building designer, and presumably the building maintainer, select filters and dust collectors based on the size and quantity of the target particles. It also requires that the filters be tested in accordance with ASHRAE Standard 52-76.

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What about gaseous contaminants? The standard **requires** the use of sorption methods to control gaseous contaminants in the air.

"When compliance with this section does not provide adequate control of gaseous contaminants, methods based on sorption with or without oxidation or other scientifically proven technology shall be used" (Section 5.10).

If air filtration, as described in Section 5.9, does not clean the outdoor or recirculated air to acceptable levels, more sophisticated gaseous contaminant removal methods must be used. As a result of this requirement, many building designers specify the use of activated carbon filters in either the outdoor or supply airstream. Acceptable concentration levels for gaseous contaminants are given by the EPA, Table 1.

Table 1 National Primary Ambient-Air Quality Standards for Outside Air as set by the U.S. Environmental Protection Agency

	Long Term Concentration Averaging			Short Term Concentration Averaging		
Contaminant	ug/m³	ppm	years	ug/m³	ppm	hours
Sulfur Dioxide	80.0	0.030	1.00	365	0.14	24
Total Particulate	50.0		1.00	150		24
Carbon Monoxide				40,000	35.00	1
Carbon Monoxide				10,000	9.00	8
Oxidants (ozone)				235	0.12	1
Nitrogen Dioxide	100.0	0.055	1.00			
Lead	1.5		1.25			

Dehumidification

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Is dehumidification required by the standard? No. The standard strongly **suggests** that high humidity levels be avoided, but does not require dehumidification.

"High humidities can support the growth of pathogenic or allergenic organisms . . . Relative humidity in habitable spaces preferably should be maintained between 30% and 60% relative humidity. . . .to minimize growth of allergenic or pathogenic organisms" (Section 5.11).

This statement suggests that the humidity level in the occupied space be controlled so that it is below 60 percent relative humidity. As a result, some building designers specify dehumidification control systems to maintain space humidity at this level during occupied hours.

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Are there special requirements for high humidity areas? Yes. Bathrooms, in particular, are **required** to conform to minimum ventilation flow rates to remove humidity.

". . . bathrooms shall conform to the ventilation rates in Table 2.3" (Section 5.11).

This requirement seems to imply that bathroom ventilation rates for all buildings (not just residential) conform to Table 2.3 of ASHRAE 62-89, Outdoor Requirements for Ventilation of Residential Facilities (not presented here). However, bathroom ventilation rates for commercial buildings are also given in Table 2.1 of ASHRAE 62-89 (not presented here). It is not clearly stated, but this requirement seems to mean that minimum ventilation rates must be applied for bathrooms, regardless of the procedure followed to achieve acceptable indoor air quality. In other words, if the building designer decides to follow the Indoor Air Quality Procedure presented in Section 6.2 of ASHRAE 62-89, bathrooms must still be ventilated at the rates presented in Tables 2.1 and 2.3.

Incidentally, as a result of the reference to fiberboard in Section 5.11, many building designers specify that no fibrous material may be used anywhere in the air system, including not only ducts, but air handlers and VAV terminal units as well. Not only are fibrous air system surfaces hard to clean, as mentioned earlier, but they also enhance the growth of pathogenic and allergenic organisms.

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Must relative humidity be limited to 70 percent or less throughout the air system? No. The standard merely **observes** that fungal contamination can occur at high humidities.

"If the relative humidity in the occupied spaces and low velocity ducts and plenums exceeds 70%, fungal contamination (for example, mold, mildew, etc.) can occur" (Section 5.12).

This statement of fact is neither a requirement nor a suggestion, yet some building designers use this fact to specify that the relative humidity of the air anywhere within the building cannot exceed 70 percent. Of course, this is not possible when a cooling coil is used, since the air leaving the cooling coil is often 55 F and nearly saturated (80 to 95 percent relative humidity). To assure 70 percent relative humidity in the duct system, some building designers specify the use of coil bypass schemes so that the saturated coil air mixes with warm bypass air before continuing down the duct. Other designers specify induction or fan-powered VAV terminal units to mix saturated primary air and low-humidity plenum air locally. This, in effect, moves coil bypass from the central coil to each terminal unit.

The standard does not clearly define a **low velocity duct**. However, air system velocities are usually higher near the fan and lower near the occupied space. The low velocity distinction is probably related to duct cleanliness, i.e. high air velocities tend to keep dust and dirt from building up, while low air velocities might allow dust to accumulate. With that in mind, low air velocity duct is usually the final duct connection to the diffusers.

Ignoring duct system relative humidity, many building designers specify an occupied dehumidification control system to keep the occupied space humidity below 60 percent, thereby preventing fungal contamination. Also, many designers specify an unoccupied dehumidification control system. This is perhaps more important than occupied dehumidification control, since the relative humidity in an unoccupied space rises as the space cools at night. For instance, a space at 75 F, 50 percent relative humidity need only cool to approximately 65 F to attain 70 percent relative humidity.

Humidification

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Is humidification required by the standard? No. The standard strongly **suggests** that low humidity levels be avoided, but does not require humidification.

"Relative humidity in habitable spaces preferably should be maintained between 30% and 60% relative humidity. . . .to minimize growth of allergenic or pathogenic organisms" (Section 5.11).

This statement suggests that the humidity level in the occupied space be controlled so that it is above 30 percent relative humidity. As a result, some building designers specify humidification control systems to maintain space humidity above 30 percent during occupied hours.

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Are steam humidifiers required? No. Steam humidifiers are **suggested** for space humidification.

"Steam is preferred as a moisture source for humidifiers. . . " (Section 5.12).

Though steam is suggested as a moisture source, other moisture sources are acceptable, too. No comment related to the control of humidification is made, but it is implicit that a humidity control system is required to modulate the addition of moisture to the building.

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If evaporative humidifiers are used, must they receive special treatment? No. However, the Standard **suggests** the use of antimicrobial treatments.

"Standing water used in conjunction with water sprays in HVAC air distribution systems should be treated to avoid microbial buildup" (Section 5.12).

This statement suggests treating standing water within the air distribution system to avoid the buildup of microbial organisms. More specifically, the water treatment suggested here is for humidification system water, but some building designers specify water treatment for **any** standing (or potentially standing) water within the air distribution system. Such treatment may include the use of chemicals (microbiocides) or special coatings; consequently, building designers may specify antimicrobial coatings in drain pans, on cooling coils and in humidifiers. In fact, the EPA has just registered the use of an antimicrobial for use in HVAC systems.

Drain Pans

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Are drain pans allowed to accumulate water? No. Drain pans **must** drain completely.

"Air handling unit condensate pans shall be designed for self-drainage to preclude the buildup of microbial slime" (Section 5.12).

Today, building designers specify sloped drain pans to assure positive draining. This includes drain pans in all HVAC equipment with cooling coils (air handlers, fan coils, unit ventilators, rooftops and so on). Also, some designers specify the use of antimicrobial treatments on air handler surfaces to further ". . . preclude the buildup of microbial slime". Condensate removal systems are becoming more common and increasingly sophisticated, too.

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Must the drain pans be maintainable? Yes. The standard **requires** periodic cleaning of coils and drain pans.

"Provision shall be made for periodic in-situ cleaning of cooling coils and condensate pans. Air-handling and fan coil units shall be easily accessible for inspection and preventive maintenance" (Section 5.12).

Cooling coils and condensate pans must be accessible and constructed to allow periodic cleaning; to assure this, many building designers specify ducts and equipment with adequate access doors or panels. Equipment with cooling coils must also provide sufficient access for proper periodic cleaning, inspection and maintenance, and the equipment itself must be located and installed to assure adequate in-situ access to the cooling coils, drain pans, and inspection and maintenance areas.

Summary

Building designers must make many decisions when designing and specifying HVAC systems and equipment. Section 5.0 of ASHRAE 62-89 helps with **some** ventilation system-related questions, but is inconclusive on others. Overall, it does give the building designer valuable guidelines for designing and specifying ventilation systems that deliver acceptable indoor air quality.

Our analysis of this standard continues in subsequent **Engineers Newsletters** with a discussion of Section 6.0, Procedures, which presents the two procedural paths to acceptable indoor air quality.