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potential ASHRAE Standard conflicts

Indoor Air Quality *and* Energy Standards

from the editor …
Buildings need outdoor air for ventilation, and during hot, humid, or cold weather, it takes energy to cool, dehumidify, or heat every cubic foot of outdoor air introduced into the building. More outdoor air introduced for ventilation means more energy use for conditioning outdoor air and for maintaining zone conditions. So, it's not surprising that the ventilation requirements and the energy requirements could be viewed as conflicting.

Introduction. More and more designers must comply with the requirements of two key ASHRAE standards - Standard 62.1-2007[1] "Ventilation for Acceptable Indoor Air Quality" (Standard 62.1) and Standard 90.1-2007[2] "Energy Standard for Buildings Except Low-Rise Residential Buildings" (Standard 90.1). Why? For two important reasons: 1) many of the enforceable requirements from both standards have been incorporated into the two major model codes, as well as many local jurisdictions, so compliance with regulations means compliance with parts of both standards, and 2) key requirements from both standards are prerequisites for compliance with the popular building certification program for new construction—LEED for New Construction (NC) version 2.2[3] from the U.S. Green Building Council (USGBC). If a designer wants to comply with regulations or wants to qualify for LEED-NC certification, most requirements found in each standard must be met.

Some designers have concluded that conflicting requirements in the standards prevent compliance with both, especially in VAV systems. Real conflict would arise, of course, if Standard 62.1 required something that 90.1 prohibited, or vice versa, but this doesn't happen. However, *apparent* conflicts arise whenever it's difficult (but not impossible) to comply with requirements in both standards simultaneously.

Many would agree that for VAV systems, the greatest potential for conflict relates to requirements in three important areas: ventilation control, dehumidification, and simultaneous cooling and heating (VAV reheat). The sections that might contain conflicting requirements are discussed below. Let's examine each of these more closely.

Demand-Controlled Ventilation

In most climates it takes energy to condition (cool, dehumidify, or heat) outdoor air introduced for ventilation purposes. In most buildings, the outdoor airflow required changes because, for example, the number of people in the building changes. So, energy can be saved by reducing outdoor air intake flow during operation to match the current population (the demand).

Standard 62.1: Section 6.2.7. Most contaminants generated indoors can be associated with either people or the building and its furnishings. Standard 62.1 requires the designer to determine minimum "breathing zone outdoor airflow" at *design* (see p.5 inset "Minimum Outdoor Airflow") based on both the peak zone population (outdoor airflow rate per person) and the size of the zone (outdoor airflow rate per unit area). However, high occupant-density zones very often *operate* at less-than-peak population. According to Section 6.2.7 (see inset "Demand-Controlled Ventilation") the actual zone outdoor airflow currently needed during operation can be found using the equations in Section 6.2.2 and the current population rather than peak zone population. Design intake airflow can be reset dynamically based on current population, reducing the current people-related outdoor airflow requirement and therefore, the current demand for ventilation air.

Demand-Controlled Ventilation
Standard 62.1-2007

6.2.7 Dynamic Reset. The system may be designed to reset the design *outdoor air intake flow* (*Vot*) and/or space or zone airflow as operating conditions change. These conditions include but are not limited to:

1. Variations in occupancy or ventilation airflow in one or more individual zones for which ventilation airflow requirements will be reset.
   ***Note*:** Examples of measures for estimating such variations include: occupancy scheduled by time-of-day, a direct count of occupants, or an estimate of occupancy or ventilation rate per person using occupancy sensors such as those based on indoor CO_2 concentrations.
2. Variations in the efficiency with which outdoor air is distributed to the occupants under different ventilation system airflows and temperatures.
3. A higher fraction of outdoor air in the air supply due to intake of additional outdoor air for free cooling or exhaust air makeup.

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Standard 90.1: Section 6.4.3.9.

Standard 90.1 covers demand-controlled ventilation (DCV) requirements in Section 6.4.3.9 (see inset "DCV and Energy"). In many cases, the population in zones designed to accommodate many occupants (high-occupancy areas) varies widely, so it's likely that reducing the outdoor airflow to match current demand can save a significant amount of operating energy. For this reason, Standard 90.1 includes DCV for high occupant-density zones as a mandatory requirement for compliance. Specifically, in systems with economizers, modulating outdoor air dampers or more than 3000 cfm of outdoor air, Section 6.4.3.9 requires that many zones (those larger than 500 ft^2) with high occupant density (more than 40 people per 1000 ft^2) include controls to vary the current outdoor airflow based on demand.

Let's look at some examples.

Consider a 1000 ft^2 school administrative office designed for five people (Pz = 5). For design purposes, the office needs breathing zone outdoor airflow no less than: Vbz = 5 people x 5 cfm/person + 1000 ft^2 x 0.06 cfm/ft^2 = 85 cfm. If population in the office during some occupied hours drops to two people (effectively, Pz' = 2), Standard 62.1 allows outdoor airflow to be reduced: Vbz' = 2 people x 5 cfm/person + 1000 ft^2 x 0.06 cfm/ft^2 = 70 cfm. A 70% drop in population results in only a 15 cfm (18%) drop in the required breathing zone outdoor airflow—not much energy value. In fact, with indoor air at 75°F, 55% RH (h = 29.0 Btu/lb) and outdoor at 95°F, 48% RH (h = 41.5), this outdoor airflow reduction only saves about 850 Btu/h—less than 0.1 tons. Building sources dominate office outdoor airflow needs, so DCV seldom pays for itself. Standard 90.1 does not require DCV for this example office because it has low occupant density (only five people per 1000 ft^2).

On the other hand, consider a 1000 ft^2 lecture classroom designed for 65 people (Pz = 65). For design, the classroom needs breathing zone outdoor airflow no less than: Vbz = 65 people x 7.5 cfm/person + 1000 ft^2 x 0.06 cfm/ft^2 = 550 cfm. If population in the classroom drops to 20 people (Pz' = 20), Standard 62.1 allows much less outdoor airflow: Vbz' = 20 people x 7.5 cfm/person + 1000 ft^2 x 0.06 cfm/ft^2 = 210 cfm. A 70% drop in population results in a 340 cfm drop in the required breathing zone outdoor airflow (about 62%)—a significant percentage reduction but not in terms of flow rate. Assuming the same indoor/outdoor conditions, this 340 cfm outdoor airflow reduction saves about 19,000 Btu/h—about 1.6 tons. Standard 90.1 does not require DCV for this example lecture classroom because, even though it's densely occupied (65 people/1000 ft^2), it requires less than 3000 cfm of outdoor air at design. Of course, some designers might still choose to apply DCV to the lecture classroom. If payback periods are acceptable, DCV might make sense even if the standard doesn't require it.

Finally, consider a 5000 ft^2 auditorium designed for 750 people. For design, the space needs breathing zone outdoor airflow no less than: Vbz = 750 people x 5 cfm/person + 5000 ft^2 x 0.06 cfm/ft^2 = 4050 cfm. If population drops to 225 people, Standard 62.1 allows much less outdoor airflow: Vbz = 225 people x 5 cfm/person + 5000 ft^2 x 0.06 cfm/ft^2 = 1420 cfm. A 70% drop in population results in a 2639 cfm drop in the required breathing zone outdoor airflow. With the indoor/outdoor conditions used above, this airflow reduction saves 148,000 Btu/h or 12.3 tons—now we have some real potential energy savings. Standard 90.1 requires DCV for this auditorium: it's larger than 500 ft^2, its design population exceeds 40 people/1000 ft^2, and it requires more than 3000 cfm of outdoor air at design. With its high energy-savings potential, it makes sense for the energy standard to require DCV for this zone.

DCV and Energy
Standard 90.1-2007

6.4.3.9 Ventilation Controls for High-Occupancy Areas. Demand control ventilation (DCV) is required for spaces larger than 500 ft^2 and with a design occupancy for ventilation of greater than 40 people per 1000 ft^2 of floor area and served by systems with one or more of the following:

a. an air-side economizer,

b. automatic modulating control of the outdoor air damper, or

c. a design outdoor airflow greater than 3000 cfm.

Exceptions:

a. Systems with energy recovery complying with Section 6.5.6.1.

b. Multiple-zone systems without DDC of individual zones communicating with a central control panel.

c. Systems with a design outdoor airflow less than 1200 cfm.

d. Spaces where the supply airflow rate minus any makeup or outgoing transfer air requirement is less than 1200 cfm.

Conflict? Standard 62.1 clearly allows optional controls to reset zone outdoor airflow (downward from the design value) in response to changing operating conditions, including variations in occupancy in individual zones. Standard 90.1 includes a mandatory requirement for DCV in high-occupancy zones, which makes sense from an energy perspective. No conflict related to DCV arises. Both standards support DCV.

Dehumidification and Ventilation Standard 62.1-2007

5.10 Dehumidification Systems. Mechanical air-conditioning systems with dehumidification capability shall be designed to comply with the following.

5.10.1 Relative Humidity. Occupied space relative humidity shall be limited to 65% or less when system performance is analyzed with outdoor air at the dehumidification design condition (that is, design dew point and mean coincident dry-bulb temperatures) and with the space interior loads (both sensible and latent) at cooling design values and space solar loads at zero.

Note: System configuration and/or climatic conditions may adequately limit space relative humidity at these conditions without additional humidity-control devices. The specified conditions challenge the system dehumidification performance with high outdoor latent load and low space sensible heat ratio.

Exception: Spaces where process or occupancy requirements dictate higher humidity conditions, such as kitchens, hot tub rooms that contain heated standing water, refrigerated or frozen storage rooms and ice rinks, and/or spaces designed and constructed to manage moisture, such as shower rooms, pools, and spas.

Dehumidification

High relative humidity in occupied zones raises the "water activity" level in porous materials, which can result in microbial growth on surfaces. Limiting zone relative humidity can reduce the potential for indoor air quality (IAQ) problems associated with mold, bacteria, and general indoor dampness.

Standard 62.1: Section 5.10. Section 5.10 of Standard 62.1 includes a design requirement intended to limit relative humidity in zones (see inset "Dehumidification and Ventilation"). To comply with this part of the standard, designers must analyze the performance of the proposed mechanical system at relatively severe latent load conditions, namely, with outdoor air at dehumidification design condition (design dew point and mean coincident dry-bulb temperature) and with no zone sensible-heat gain due to solar load.

This analysis tests the dehumidification capability of the HVAC system configuration and control. It must show that zone relative humidity does not exceed 65% RH at these conditions. Some systems in some buildings in some climates can meet this requirement without direct humidity control, e.g., VAV systems that supply cool, dry primary air at all conditions. Other systems, however, such as traditional single-zone constant volume systems, supply warmer, moister air at part-sensible load and cannot maintain 65% RH or less without some enhancement[4]. To comply with Standard 62.1, these systems must be reconfigured, using return-air bypass, for instance, or variable air volume to limit relative humidity indirectly, or using a zone humidistat and local reheat or a dedicated OA system, for instance, to control relative humidity directly.

Standard 90.1: Section 6.5.2.3. To reduce the overall energy used by dehumidifying systems with humidistatic controls, Section 6.5.2.3 in the prescriptive path of Standard 90.1 (see inset "Dehumidification and Energy") requires controls to prevent reheating cooled air, mixing of hot and cold airstreams, or any other means of simultaneously heating and cooling the same airstream. This requirement limits the use of reheat in the course of dehumidifying, but Standard 62.1 limits design relative humidity levels. So, dehumidifying systems must be designed carefully to assure compliance with both standards.

In some climates, any type of HVAC system can provide appropriate dehumidification to meet Standard 62.1 without any enhancement, but especially in humid climates, system configuration and/or control must be altered.

For instance, for constant-volume, single-zone systems, if coil-leaving temperature is low enough to offset zone latent load, supply air tempering (reheat) might be required to match cooling capacity to zone sensible load. Supply air tempering can be accomplished by mixing coil-leaving air with return air (return-air bypass), by reheating with recovered energy, or by reheating using new energy. Of these

Dehumidification and Energy Standard 90.1-2007

6.5.2.3 Dehumidification. Where humidistatic controls are provided, such controls shall prevent reheating, mixing of hot and cold airstreams, or other means of simultaneous heating and cooling of the same airstream.

Exceptions:

a. The system is capable of reducing supply air volume to 50% or less of the design airflow rate or the minimum rate specified in Section 6.2 of Standard 62.1, whichever is larger, before simultaneous heating and cooling takes place.

b. The individual fan cooling unit has a design cooling capacity of 80,000 Btu/h or less and is capable of unloading to 50% capacity before simultaneous heating and cooling takes place.

c. The individual mechanical cooling unit has a design cooling capacity of 40,000 Btu/h or less. An individual mechanical cooling unit is a single system composed of a fan or fans and a cooling coil capable of providing mechanical cooling.

d. Systems serving spaces where specific humidity levels are required to satisfy process needs, such as computer rooms, museums, surgical suites, and buildings with refrigerating systems, such as supermarkets, refrigerated warehouses, and ice arenas. This exception also applies to other applications for which fan volume controls in accordance with Exception (a) are proven to be impractical to the enforcement agency.

e. At least 75% of the energy for reheating or for providing warm air in mixing systems is provided from a *site-recovered* (including condenser heat) or *sitesolar energy source*.

f. Systems where the heat added to the airstream is the result of the use of a desiccant system and 75% of the heat added by the desiccant system is removed by a heat exchanger, either before or after the desiccant system with energy recovery.

tempering approaches, return-air bypass is allowed because it doesn't include humidistatic controls; reheating with 75% recovered energy (Exception e) is allowed. And, reheat with new energy is allowed if: (Exception b) the dehumidifying unit capacity is small (80,000 Btu/h or less) and cooling capacity can be reduced to 50% of design capacity before reheat takes place; (Exception c) the unit capacity is smaller still (40,000 Btu/h or less); or (Exception d) a zone has special humidity requirements.

Systems using a 100% outdoor air unit to condition outdoor air before delivering it to occupied zones might need a low coil-leaving temperature (to offset zone latent load) and central reheat to raise the temperature of the air supplied to the zone. If these systems include humidistatic controls to modulate coil capacity, they can use reheat if in accordance with Exception a, they only supply the minimum outdoor air rate specified by Standard 62.1.

Most multiple-zone recirculating systems (VAV systems) deliver primary air at 55°F or cooler at all conditions, which maintains reasonable humidity without humidistatic controls, so Section 6.5.2.3 reheat restrictions typically do not apply.

Conflict? Is there a conflict between the two standards related to dehumidification? No. Standard 62.1 requires that the designer choose a system configuration that results in zone RH of 65% or less at a particular design condition. Many such configurations are available. Some approaches limit RH indirectly without using humidistats, so Standard 90.1 limitations don't apply. Other approaches use humidistatic controls, so Standard 90.1 requirements might impact system choice. For large and medium size systems, either 100% outdoor air or VAV systems can be designed to meet both Standard 62.1 and 90.1 requirements. For small systems, traditional sensible-only constant volume units might not meet Standard 62.1, but very small units with reheat can meet both standards, as can larger units with return-air bypass, with site-recovered reheat (such as hot-gas reheat), or a dedicated OA system[4].

Again, the requirements of the two standards do not conflict—both standards can be met by proper choice of system configuration and control.

VAV Minimum Primary Airflow and Reheat

Single-path VAV systems supply constant-temperature primary air to all zones, while local thermostats adjust the primary airflow to each zone to match cooling capacity to cooling load. As cooling load in a zone drops, airflow drops as well. However, since the primary airstream provides both cooling and ventilation, primary airflow can only be reduced to a ventilation-related minimum. Once primary airflow reaches this minimum airflow, further reductions in cooling load result in zone sub-cooling.

To avoid sub-cooling while maintaining minimum primary airflow for ventilation, heat must be added to the primary air or directly to the zone. Many VAV systems use local reheat to raise the discharge air temperature as necessary to assure control of zone temperature.

The challenge for designers becomes: "What minimum primary airflow setting complies with Standard 62.1 ventilation requirements at all load conditions, AND meets the reheat limitations of Standard 90.1?" The right answer is really a compromise between requirements found in both standards and the need for compromise sows the seeds of potential conflict.

Let's look at Standard 90.1 requirements first.

Standard 90.1: Section 6.5.2.1. The prescriptive language in Section 6.5.2.1 of Standard 90.1 (see inset "Reheat and Energy"), prohibits zone-level

Reheat and Energy
Standard 90.1-2007

6.5.2 Simultaneous Heating and Cooling Limitation

6.5.2.1 Zone Controls. *Zone* thermostatic controls shall be capable of operating in sequence the supply of heating and cooling energy to the *zone.* Such controls shall prevent

1. *reheating,*
2. *recooling,*
3. mixing or simultaneously supplying air that has been previously mechanically heated and air that has been previously cooled, either by mechanical cooling or by economizer systems, and
4. other simultaneous operation of heating and cooling systems to the same *zone.*

Exceptions:

a. *Zones* for which the volume of air that is reheated, recooled or mixed is no greater than the larger of the following:

1. the volume of *outdoor air* required to meet the ventilation requirements of Section 6.2 of Standard 62.1 for the *zone*,
2. 0.4 cfm/ft^2 of the *zone* conditioned floor area.
3. 30% of the zone design peak supply rate.
4. 300 cfm—this exception is for zones whose peak flow rate totals no more than 10% of the total fan system flow rate, or
5. any higher rate that can be demonstrated, to the satisfaction of the *authority having jurisdiction*, to reduce overall system annual energy usage by offsetting reheat/recool energy losses through a reduction in *outdoor air* intake for the system.

b. *Zones* where special pressurization relationships, cross-contamination requirements, or code-required minimum circulation rates are such that variable air volume systems are impractical.

c. *Zones* where at least 75% of the energy for reheating or for providing warm air in mixing systems is provided from a *site-recovered* (including condenser heat) or *site-solar energy source*.

reheat in general, but according to the following specific exceptions, it allows reheat if:

(a) The volume of air that is reheated is no greater than the highest of several listed values. This exception applies to zones in VAV systems or in 100% outdoor-air systems.

(b) VAV control is deemed inappropriate for a zone (e.g., zones with special pressurization requirements or code-minimum circulation rates). Some zones require constant airflow volume for pressure control, for instance, and local reheat for temperature control.

(c) A zone uses site-recovered or solar energy for at least 75% of reheat needs. For VAV systems with hot-water reheat, chilled-water systems with heat-pump "sidestream" chillers might be the best source for recovered energy[5]. While more difficult in DX VAV systems, recovered energy can still be considered; for instance, water-source heat pumps can heat water using plenum energy or water-to-water heat pumps can heat it using energy from central return air.

For designers following the Standard 90.1 prescriptive path, Exception c might be the best alternative to ensure proper ventilation and reduced energy usage in a single-path VAV system while avoiding any conflict, real or perceived, between Standard 62.1 and 90.1.

However, many designers seek to provide reheat by qualifying for Exception a, which allows reheat of previously cooled air if the volume of air reheated in a zone is no greater than the larger of:

1. For 100% outdoor-air and single-zone VAV systems only: The zone outdoor airflow value (*Voz*) required by Standard 62.1. These systems normally supply no more than the minimum required outdoor airflow to each zone.

2. For any zone in a VAV system: An airflow value equal to 0.4 cfm/ft^2 of zone floor area. This exception allows a relatively high "reheat minimum" setting for VAV zones.

3. For any zone in a VAV system: An airflow value equal to 30% of the design primary airflow. For some zones, this exception may allow a higher reheat minimum setting than Exception 2.

4. For only a few zones in a VAV system: A value equal to 300 cfm, provided the sum of design (peak) primary airflows for all zones using this exception equals no more than 10% of total fan system design airflow (*Vps*). This approach can be applied to a few zones in a system and will result in high reheat minimum settings for those zones, but one of the other exceptions (2 or 3) must be met for reheat minimum settings in the other zones in a VAV system.

5. For any zone in a VAV system: Any airflow value larger than any of the values for Exceptions 2, 3, or 4—that can be demonstrated to reduce overall system annual energy usage. This exception recognizes that increasing the reheat minimum setting in the critical zone increases system ventilation efficiency and results in lower outdoor-air intake airflow. To use this exception, most designers would model annual energy performance using an economic analysis program, such as TRACE™ 700. However, the authority having jurisdiction (AHJ) might be reluctant to approve design settings based on simulations, so, Exception 5 depends on the AHJ. It can be used by some designers but maybe not in all cases.

Standard 62.1: Section 5.4, 6.2.2 and 6.2.5. Turning to Standard 62.1, three key sections include requirements that relate to minimum primary airflow settings for VAV systems (see inset "Minimum Outdoor Airflow").

Minimum Outdoor Airflow
Standard 62.1-2007

5.4 Ventilation System Controls. Mechanical ventilation systems shall include controls, manual or automatic, that enable the fan system to operate whenever the spaces served are occupied. The system shall be designed to maintain the minimum outdoor airflow as required by Section 6 under any load condition. …

6.2.2 Zone Calculations. Zone parameters shall be determined in accordance with Sections 6.2.2.1 through 6.2.2.3.

6.2.2.1 Breathing Zone Outdoor Airflow. The design outdoor airflow required in the breathing zone of the occupiable space or spaces in a zone, i.e., the breathing zone outdoor airflow (*Vbz*), shall be determined in accordance with Equation 6-1.

$Vbz = (Rp \times Pz) + (Ra \times Az)$ (6-1)
where

Az = *zone floor area*: the net occupiable floor area of the zone m^2 (ft^2)

Pz = *zone population*: the largest number of people expected to occupy the zone during typical usage. If the number of people expected to occupy the zone fluctuates, Pz may be estimated based on averaging approaches described in Section 6.2.6.2

Note: If Pz cannot be accurately predicted during design, it shall be an estimated value based on the zone floor area and the default occupant density listed in Table 6-1.

Rp = outdoor airflow rate required per person as determined from Table 6-1

Note: These values are based on adapted occupants.

Ra = outdoor airflow rate required per unit area as determined from Table 6-1

6.2.5 Multiple-Zone Recirculating Systems. When one air handler supplies a mixture of outdoor air and recirculated return air to more than one zone, the *outdoor air intake flow* (*Vot*) shall be determined in accordance with Sections 6.2.5.1 through 6.2.5.4.

6.2.5.1 Primary Outdoor Air Fraction. When Table 6-3 is used to determine system ventilation efficiency, the zone primary outdoor air fraction (*Zp*) shall be determined in accordance with Equation 6-5.

$Zp = Voz/Vpz$ (6-5) …

Minimum Outdoor Airflow *(continued)*
Standard 62.1-2007

6.2.5.2 System Ventilation Efficiency. The *system ventilation efficiency* (Ev) shall be determined using Table 6-3 or Appendix A [Ev = minimum (Evz),
where
$Evz = 1 + Xs - Zd$,
where
$Xs = Vou/Vps$].

6.2.5.3 Uncorrected Outdoor Air Intake. The design *uncorrected outdoor air intake* (Vou) shall be determined in accordance with Equation 6-6.

$$Vou = D\Sigma_{all\ zones}(Rp \times Pz) + \Sigma_{all\ zones}(Ra \times Az) \quad (6\text{-}6)$$

The *occupant diversity, D*, may be used to account for variations in occupancy within the zones served by the system. The *occupancy diversity* is defined as

$$D = Ps/\Sigma_{all\ zones} Pz, \quad (6\text{-}7)$$

where the system population (Ps) is the total population in the area served by the system ...

6.2.5.4 Outdoor Air Intake. The design *outdoor air intake flow* (Vot) shall be determined in accordance with Equation 6-8.

$$Vot = Vou/Ev \quad (6\text{-}8)$$

Section 5.4 "Ventilation System Controls," requires that each occupied zone receive no less than the minimum required outdoor airflow at *any load condition*. This means that both at design and part load, at least the minimum zone outdoor airflow (*Voz*, determined by Section 6 requirements) must be supplied to each occupied zone; zone primary airflow cannot be reduced to zero in occupied VAV zones, even at low cooling load.

Section 6.2.2 "Zone Calculations" prescribes the lowest breathing zone outdoor airflow rate required for a wide range of occupancy categories, along with the lowest zone outdoor airflow (*Voz*). While this value establishes the "floor" for reheat minimum settings on the VAV boxes, if a zone actually operates at this setting, the multiple-zone system equations (Section 6.2.5) show that the central air-handling unit must provide 100% outdoor air. So, designers don't use this value (*Voz*) to find the reheat minimum settings, but rather to help find the required outdoor-air intake flow for the system, for both design and operation.

Although Standard 62.1 includes ventilation requirements for single-zone and 100% outdoor-air systems, this newsletter only considers Section 6.2.5 "Multiple-Zone Recirculating Systems." Along with Appendix A, this section prescribes equations to be used to find VAV system outdoor-air intake flow at design conditions, as well as during operation. These equations allow designers to account for two important multiple-zone system characteristics: inherent system ventilation efficiency (non-critical zones receive excess outdoor air so some unused outdoor air exhausts from the building) and population diversity (population does not peak simultaneously in all zones).

We've looked closely at these equations in earlier publications[6]. Based on that earlier work, we know that outdoor-air intake flow for the system is inversely related to the primary airflow in the critical zone—the zone needing the richest mixture of outdoor air in its primary airstream. Low primary airflow in the critical zone requires high intake flow for proper ventilation, while high primary airflow reduces the intake airflow requirement.

For design purposes, the highest intake airflow needed depends on the "minimum expected" primary airflow in the critical zone and the "highest expected" value for system primary airflow. Designers must decide what they expect. For most VAV systems, the highest outdoor air intake flow needed in cooling mode occurs when system primary airflow equals block airflow. For the zones, however, the "minimum expected" value for zone primary airflow for design purposes requires some decisions (judgment) by the designer, and different designers look at things differently.

Conservative designers use the reheat minimum setting for the VAV box as the "minimum expected" primary airflow value for design calculations, solving for the highest outdoor air intake flow. While straightforward, this approach results in low system ventilation efficiency and high intake airflow at design. But it also assures that the system will never need more outdoor airflow than this worst-case value.

But what do these conservative designers use as the reheat minimum setting? It can be any value deemed appropriate by the designer, perhaps based on airflow sensor operation or diffuser operation, provided it meets the reheat minimum limitations in Standard 90.1. Note that increasing this setting as high as permissible in the critical zone is a good idea because it decreases the required outdoor air intake flow for design purposes. Using the zone outdoor airflow (*Voz*) value for this setting is a bad idea because it requires intake airflow to be 100% outdoor air.

Less conservative designers might want to use "minimum expected" primary airflow values that exceed the reheat minimum settings. They base these "minimum expected" values on a building simulation (for instance, an 8760-hour analysis of building performance) or on engineering judgment. Compared to the more conservative approach, this method is harder to do (it takes a system performance analysis or repetitive "what if" calculations), but it results in lower outdoor-air intake flow at design. And, if done properly, it also assures that the design intake flow is indeed the worst-case value.

These designers use a rationale similar to the more conservative designers to pick reheat minimum settings—any value that makes sense, provided it meets Standard 90.1 requirements and exceeds the zone outdoor airflow (*Voz*) value.

When properly executed, either of these outdoor-air intake design approaches (as well as many others) comply with both Standard 90.1 and Standard 62.1 requirements.

Conflict? No direct conflict between the two standards exists. But the real questions related to reheat minimum settings might be:

1) (Exception b) Does the system have special pressure or circulation rate requirements? If so, use whatever minimum setting works for the system.

2) (Exception c) Can the system be configured to use site-recovered or solar energy for reheat? If so, no problems; use minimum settings as high as necessary to assure compliance with Standard 62.1 requirements while reducing intake airflow.

3) (Exception a1) Is it a 100% outdoor air ventilation system? If so, don't reheat more than the minimum zone outdoor airflow required by Standard 62.1.

4) (Exception a2-5) Is it a VAV reheat system? If so, limit the reheat minimum setting to the larger of 0.4 cfm/ft^3, 30% of maximum zone airflow, 300 cfm (for a small number of zones), or ANY higher value that results in less annual energy usage than would be needed using the largest of the previous three values.

Summary

While the potential for conflict between Standards 62.1 and 90.1 does exist for VAV systems, we've shown that the requirements of both can be met with careful planning by the designer. The following summarizes each discussion point:

Demand-Controlled Ventilation. Standard 62.1 allows optional "dynamic reset" controls, which can be used to reduce outdoor air intake flow in response to varying conditions, including zone-level demand-controlled ventilation (DCV). Standard 90.1 requires DCV in some densely occupied zones. DCV is allowed by one standard and required at times by the other: **no conflict arises**.

Dehumidification. Standard 62.1 requires analytical proof that the HVAC system can dehumidify adequately at a specific design condition. Standard 90.1 limits new-energy reheat used in the process of actively dehumidifying, one of many dehumidification configurations. The two standards help direct designers to make system choices that limit humidity in an energy-efficient manner: **no conflict arises**.

VAV Minimum Primary Airflow and Reheat. Standard 90.1 limits new energy used for reheat and, in VAV systems, it establishes an upper limit for reheat minimum settings. Standard 62.1 requires that ventilation systems deliver at least a minimum outdoor airflow to each zone; for design, it requires establishment of a "minimum expected" zone outdoor airflow as part of the process for determining outdoor-air intake flow for the system. One standard limits reheat minimum settings to reduce local reheat, while the other standard encourages increased "minimum expected" zone airflow to reduce intake airflow at design; although reheat minimum settings must be chosen with care, **no conflict arises**.

Designers must design.

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You can find this and previous issues of the Engineers Newsletter at www.trane.com/engineersnewsletter. To comment, e-mail us at comfort@trane.com

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Engineers Newsletter LIVE!

mark your calendar for

ASHRAE Standards 90.1, 62.1 and VAV Systems
November 12

2009 Schedule:

LEED 2009 Modeling and Energy Savings
March 11

Ice Storage Design: Around-the-Clock Operation for Office Buildings and K-12 Schools
May 13

Air-Handling Systems, Energy and IAQ
October 14

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