Engineers Should Balance the Need

Standard 62.1: First Cost and Energy Impacts

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I had a chance to attend the Region VII Chapters Regional Conferences (CRC) in Huntsville, Ala. This year's theme was "Going Green in Region VII." I gave a presentation about ANSI/ASHRAE Standard 62.1 requirements, attempting to highlight how they might impact both first cost and operating energy.

Terry Townsend, P.E., Fellow/Presidential Member ASHRAE, gave the keynote speech, emphasizing the urgent need to address energy use in our lives and especially within our industry. His speech seemed to lay out the climate-change facts and was just a little bit frightening for me, but at the same time, inspiring. In fact, it inspired me to write this quarterly column about the potential impact of Standard 62.1 requirements on building energy use.

The following paragraphs discuss energy-related aspects of some key Standard 62.1 requirements. All of these requirements, if met, should improve IAQ; some of them increase energy use, but some may actually help save energy while improving IAQ.

5.0 Systems and Equipment. Many of the general requirements in this section help to establish a "typical" level for indoor contaminant sources, so that the ventilation rates prescribed in Section 6 can be expected to "work" in most cases.

5.1 Natural Ventilation. Buildings can be ventilated without using mechanical fans, provided the design meets minimum requirements for size of and access to openings. Naturally ventilated systems may save operating energy, in terms of both fan horsepower and perhaps mechanical cooling, and in some climates at the right outdoor conditions.

5.2 Ventilation Air Distribution. Ventilation systems must be designed so that they can be "air-balanced" to ensure that the occupied zones actually receive the intended outdoor air. Proper air balancing contributes to zone comfort in terms of both thermal comfort and acceptable IAQ. However, improper air balancing might lead to inappropriate duct pressure, which can result in excessive air leakage into or out of the duct, or it might lead to excessive infiltration or exfiltration through the building envelope, which can result in significant unnecessary energy use in terms of increased fan energy and/or thermal load.

5.4 Ventilation System Controls. Mechanically ventilated systems must be designed to provide the minimum required ventilation, so the designer must provide controls to enable fan operation when occupied. It goes without saying that turning the fan on contributes to acceptable IAQ during occupied hours, but turning it off during unoccupied hours can save considerable operating energy. Unoccupied operation of supply fans, or more likely, local exhaust fans, can result in significant unnecessary energy use.

5.9 Particulate Matter Removal. Systems with wet surfaces in the supply air stream must include MERV 6 filters (per ANSI/ASHRAE Standard 52.2) to reduce the rate of dirt accumulation. Dirt on dehumidifying coils can lead to IAQ problems for two reasons: dirt plus water may encourage microbial grow on the coil, but dirt buildup on coil surfaces increases local air velocity. Higher coil-air velocity increases water droplet carryover, which leads to wet downstream surfaces; a wet surface with just a small amount of dirt can support microbial growth. In terms of energy use, dirty coils increase coil pressure drop, so the fan requires more horsepower to deliver the same airflow, and wet insulation downstream reduces insulating effect, which means cooling energy loss.

5.10 Dehumidification Systems. Mechanical systems with dehumidification capability must be designed to limit space relative humidity to 65% or less at the design dew-point condition. Avoiding excessive relative humidity reduces the potential for microbial growth on space surfaces, so it helps with IAQ, but it takes more energy to remove moisture than to simply ignore it. Constant volume HVAC systems with sensible-only thermostatic control—especially those in hot, humid climates—probably don't meet this 65% RH limit without some type of dehumidification enhancement, such as site-recovered reheat or return air bypass.

5.11 Drain Pans. Condensate drainage systems must be designed so that water drains out of the drain pan. Among other things, drain seals or P-traps must be designed to prevent ingestion of ambient air while allowing complete drainage with the fan on or off. Ingestion of ambient air results in water droplet carryover beyond the drain pan. This means wet downstream surfaces. As mentioned above, wet insulation downstream increases the risk of microbial growth and reduces insulating effect, which means reduced IAQ and loss of cooling energy.

5.12 Finned Tube Coils and Heat Exchangers. To reduce the potential for water droplet carryover beyond the drain pan, coils must be clean. Dirty coils result in increased coil air velocity, which leads to water droplet carryover, as mentioned above. Coil geometry impacts pressure drop and cleanability. Coils must be selected to limit coil pressure drop to 0.75 in. w.c. at 500 fpm (187 Pa at 3 m/s) and thereby, to ensure reasonable cleanability. Clean coils reduce microbial growth potential, wet insulation energy loss and fan horsepower.

5.15 Building Envelope and Interior Surfaces. The building design must use a weather barrier, a properly located vapor retarder and construction procedures that ensure sealing of envelope penetrations and cracks. Tighter buildings reduce the potential for water and unwanted condensation in the envelope and lower energy use by reducing air infiltration and wet insulation heat loss.

6.0 Procedures. Ventilation rates, the heart of Standard 62.1-2007, must be found using either the prescriptive Ventilation Rate Procedure (VRP) or the performance-based IAQ Procedure.

6.2 Ventilation Rate Procedure (VRP). In most applications, the new rates and calculation requirements in the VRP result in intake airflow values below those required by Standard 62-2001. Compared to the previous version of the standard, the minimum breathing zone outdoor airflow requirement dropped for about 70% of the listed occupancy categories (depending upon occupant density), since the older rates tended to result in higher-than-necessary minimum rates, especially in densely occupied zones. New multiple-zone system calculation-procedures help to ensure proper intake airflow at the air handler. Systems that need less outdoor air intake flow use less preconditioning energy without reducing IAQ below a minimum level. Although systems that need more intake flow use more energy than under-ventilated systems, the level of IAQ they provide also can be expected to increase.

6.2.1 Outdoor Air Treatment. In locations designated as "non-attainment" by the EPA, in accordance with the National Ambient Air-Quality Standards (NAAQS) for 10 micron particulate-matter (PM10), mechanical ventilation systems must use MERV 6 (or better) filters. (This duplicates the filtration requirement for dehumidifying systems in any location, mentioned previously.) In locations designated non-attainment for ozone AND with a high recorded ozone concentration (such as the Los Angeles area), at least 40% efficient ozone air cleaners must be used. These air cleaning requirements improve IAQ, but they also tend to add pressure drop and increase fan horsepower. (Incidentally, in the future, systems in locations designated non-attainment for PM2.5 may be required to use MERV 11 filters. If this becomes a requirement, IAQ for occupants will improve but likely at the expense of an additional fan horsepower increase.)

6.2.2 Zone Calculations. For each zone, the designer must calculate breathing-zone outdoor airflow, using Table 6-1 rates (cfm/person and cfm/ft^2). These rates result in reduced zone outdoor airflow in 70% of the occupancy categories, no change in 15% and an outdoor airflow increase in 15%. These rate changes reflect that earlier versions of the Standard over-simplified ventilation loads (considering only cfm/person or cfm/ft^2 in each zone), which resulted in overventilation and unnecessary preconditioning energy use for many occupancy categories. The 2007 rates result in acceptable IAQ without the outdoor air preconditioning penalty. The designer also must account for zone air-distribution effectiveness. In some cases (e.g., when heating from overhead diffusers), this results in increased outdoor air intake flow and increased preconditioning energy, when compared with overhead cooling.

6.2.3 – 6.2.5 System Calculations. The designer must calculate system level outdoor air intake flow based on zone outdoor airflow requirements.

For single-zone systems, intake airflow drops for 70% of the listed occupancy categories, which saves preconditioning energy when compared with all other versions of the standard (since 1989) without causing IAQ-related problems. However, intake airflow increases for 15% of the listed categories, which improves IAQ but also increases preconditioning energy use.

For 100% outdoor air (OA) systems, since intake airflow drops for 70% of the listed occupancy categories, preconditioning and fan energy use often drops. However, for constant volume dedicated outdoor air ventilation systems, all zones must be assumed to be occupied at peak population, regardless of actual population; these systems often include many over-ventilated zones, so they use excess (more than minimum) preconditioning and fan energy. Over-ventilation can be corrected by using a separately ducted ventilation system with a damper for each zone and a variable-air-volume (VAV) 100% OA unit, but this approach adds first cost and control complexity.

For multiple-zone recirculating systems, zone outdoor airflow again drops for many occupancies, but what about system outdoor air intake flow? The new multiple-zone system calculations tend to result in lower intake airflow than that required by Standard 62-1989. This is because appropriate credit now can be taken for occupant diversity. The ventilation airflow needed for occupants can be adjusted to account for the fact that peak population for a system usually is less than the sum-of-peak zone populations. For many systems, the results are higher system ventilation efficiency and lower outdoor air intake flow, which lower preconditioning energy use.

6.2.7 Dynamic Reset All Section 5 and Section 6 requirements discussed earlier relate to ventilation system design. What about operation? Existing ventilation systems (both "old" systems and newly designed and occupied systems), can use dynamic reset controls to adjust intake airflow based on current operating conditions. These optional controls can be used to reset outdoor air intake flow and/or zone outdoor airflow in response to changing conditions. Decreasing intake airflow when population drops or when system ventilation efficiency increases saves preconditioning energy, as well as local reheat energy in some systems. Increasing intake airflow when population rises ensures proper minimum ventilation and acceptable IAQ.

6.2.9 Ventilation in Smoking Areas. Standard 62.1-2007 does not prescribe specific minimum ventilation rates for areas with environmental tobacco smoke (ETS areas). It does require that these areas receive more outdoor airflow and/or more air cleaning than similar ETS-free areas. Because intake airflow increases (or air cleaner related pressure drop increases), systems with ETS areas use more operating energy in terms of outdoor air preconditioning and fan horsepower. And, indoor air might still be unacceptable in terms of comfort or health outcomes.

6.3 IAQ Procedure. As an alternative to the prescriptive VRP described earlier, some designers use the performance-based IAQ Procedure (IAQP), primarily to take ventilation credit for the use of air-cleaning devices. Although this is a valid approach that can save preconditioning energy in some cases, it is difficult and relatively expensive to design, install and operate, and the additional air-cleaning devices required often increase fan horsepower requirements. Designers must be aware that IAQP does not meet a key LEED-NC® prerequisite. Indoor Environmental Quality (EQ), prerequisite 1, requires that designers use the VRP to find the required outdoor air intake flow, not the IAQP. USGBC (The U.S. Green Building Council reasoned that the flexible nature of the IAQP could lead to "compliant" systems with widely differing levels of intake airflow and consequently, IAQ. So, if a project is to achieve any LEED credits at all, it must use the VRP to find the minimum outdoor air intake flow required.

7.0 Construction and System Start-Up. A properly designed ventilation system must also be installed properly to reduce the likelihood of IAQ problems and to ensure minimum operating energy use. Section 7.1 requirements relate to proper construction and installation, while Section 7.2 requirements relate to initial ventilation start-up. Although not addressed specifically by the standard, these minimum requirements can be used as a basic part of the overall building commissioning process. Proper building commissioning is key to acceptable IAQ and reduced energy use.

7.1.2 Filters. To keep ducts and equipment clean and reduce the potential for IAQ problems, filters must be in place if the fans are operated during construction. Construction filters can increase fan horsepower usage, especially as they load up with construction debris.

7.1.4.2 Protective Measures. In some cases, construction takes place in partially occupied buildings. When such construction generates significant amounts of particulate matter or gaseous contaminants, occupants must be protected, for instance, by sealing the construction area with temporary walls or sheeting, exhausting the construction area or pressurizing occupied areas. These measures increase IAQ, but they also tend to increase energy use, due to increased exhaust fan operation and in some cases, additional preconditioning energy for outdoor air introduced for pressurization.

7.2.2 Air Balancing. The air-distribution system must be balanced during start-up. Proper air balance helps provide acceptable IAQ, while improper air balance can lead to supply duct leakage (increasing supply fan energy), infiltration (increasing thermal load unnecessarily) or exfiltration (resulting in a significant loss of thermal capacity).

8.0 Operations and Maintenance. A properly designed and installed ventilation system must also be operated properly to avoid IAQ problems and to minimize operating energy usage. Although not addressed specifically by the standard, the minimum requirements in Section 8.3 can form the basis of a "persistence-commissioning" process, where building performance is continuously monitored and adjusted to ensure proper on-going operation.

8.3 Ventilation System Operation. For each properly designed and installed ventilation system, the designer knows how the system was intended to operate. Proper system operation must be described in the operations and maintenance manual and the system must then be operated in accordance with the recommendations in the O and M manual. Improper operation can cause a range of problems which can result in decreased IAQ and increased energy use.

8.4 Ventilation System Maintenance. The designer knows how the ventilation system was intended to be maintained. Proper system maintenance also must be described in the Operations and Maintenance Manual. The facilities management team must maintain the system as recommended by the O/M manual. Of course, improper maintenance of the building and/or the ventilation system can result in decreased IAQ and increased energy use.

Conclusions

All of the requirements of Standard 62.1-2007 can help provide acceptable IAQ. Many result in decreased energy use in terms of preconditioning energy and fan horsepower. As conscientious citizens of Earth, as well as conscientious building system engineers and scientists, we should be continually mindful of the energy impacts of the ventilation systems we influence. We should weigh each design decision carefully to balance the need for minimum indoor air quality performance with the desire for minimum energy impact. This is what engineers do best!

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Feedback

We welcome your comments and letters. Please submit them by e-mail to iaq@ashrae.org.