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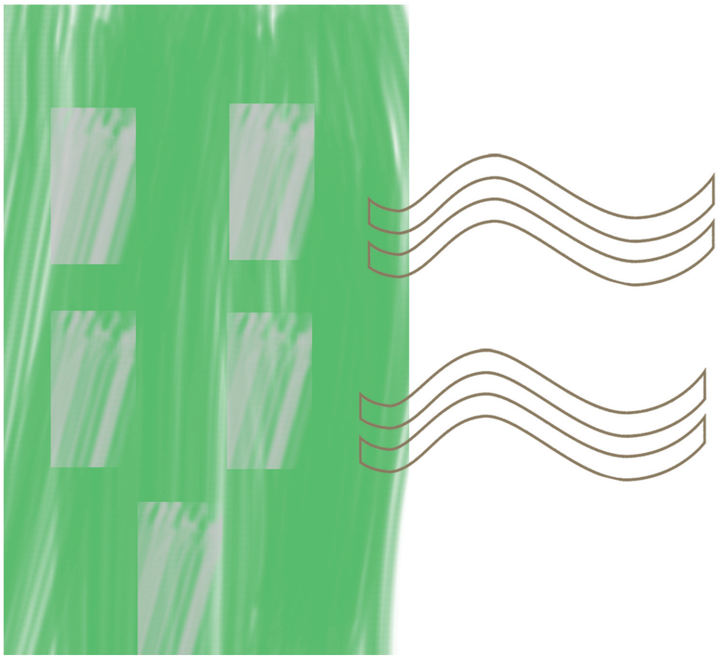

LEED® and Standard 62.1

By Steven T. Taylor, P.E., Fellow ASHRAE

Version 2.2 of the United States Green Building Council's popular Leadership in Energy and Environmental Design Green Building Rating System for New Construction & Major Renovations (LEED®-NC)[1] is scheduled to be released in November 2005. The rating system includes prerequisites and credits for six major design categories, summarized in *Table 1*. Points are awarded for the credits, and projects can achieve various levels of certification (shown at the bottom of *Table 1*) based on the number of awarded points.

The changes made in the proposed LEED-NC Version 2.2 were intended to fix implementation problems and clarify language while keeping the same basic structure and focus of each of the sections and credits. This article discusses the changes made to the Indoor Environmental Quality (abbreviated EQ) section related to ventilation. *Table 2* summarizes these changes.

EQ Prerequisite 1: Minimum IAQ Performance

EQ Prerequisite 1, which is intended to establish minimum indoor air quality performance for the building, requires compliance with ANSI/ASHRAE 62.1-2004 *Ventilation for Acceptable Indoor Air Quality*. Version 2.1 referenced the 2001 version of Standard 62. The 2004 version includes significant revisions, including adoption of Addendum 62*n* that completely revised the Ventilation Rate Procedure (VRP).

As with prior versions of LEED-NC, this prerequisite requires that outdoor air

LEED-NC Section	Points
Sustainable Sites	14
Water Efficiency	5
Energy & Atmosphere	17
Materials & Resources	13
Indoor Environmental Quality	15
Innovation & Design Process	5
Total	**69**
Certified 26–32 points; **Gold** 39–51 points	**Silver** 33–38 points; **Platinum** 52–69 points

Table 1: LEED-NC sections and point totals.

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rates be calculated using the VRP; use of the IAQ Procedure (IAQP) is not allowed. The VRP is a prescriptive approach where rates are determined using per-person and per-unit-area rates prescribed in a table based on occupancy category. The IAQP is a performance approach that requires data that are seldom fully available to designers, such as concentration limits of pollutants of concern and their source strengths from materials and activities in the space. Disallowing the use of the IAQP was due to concerns about the availability of these data and with the level of expertise and judgment required by the designer and by the enforcement authority.

One other change to EQ Prerequisite 1 is that compliance is explicitly required for Sections 4, 5, 6, and 7 of Standard 62.1. Many designers feel that simply providing the outdoor air rates prescribed by the standard in Section 6 constitutes complete compliance. In fact, the standard includes significant requirements other than outdoor air rates, such as requirements for equipment to reduce the potential for microbial growth, air cleaning requirements, and start-up and commissioning requirements. All of these requirements must be met to comply with this prerequisite.

EQ Credit 1: Outdoor Air Delivery Monitoring

EQ Credit 1 requires that ventilation system monitoring be provided to ensure that ventilation systems continue to work long into the life of the building. The original credit used carbon dioxide (CO_2) concentration as an indicator of acceptable ventilation (and, indirectly, of acceptable indoor air quality) for all buildings. But, several problems exist with this approach both conceptually and in practice:

- CO_2 concentration can be a reasonable indicator of the concentration of pollutants generated by people and their activities (e.g., bioeffluents), but it is not an indicator of pollutants generated by other sources such as off-gassing of volatile organic compounds from building materials and furnishings. These building-related sources can be the predominant source of indoor pollution in spaces that are not densely occupied. For instance, Standard 62.1-2004 requires about 0.025 cfm/ft^2 [0.125 L/s/m^2] of outdoor air for occupants in office spaces (based on an occupant density of five people per 1,000 ft^2) and 0.06 cfm/ft^2 [0.3 L/s/m^2] for building related sources. The building ventilation rate component is almost 2.5 times larger than the occupant component. Thus, in spaces that are not densely occupied, CO_2 may not be a good indicator of air quality.
- CO_2 concentration also cannot be used to accurately determine outdoor air rates, particularly overall rates (cfm or L/s) as opposed to per-person rates. This has been demonstrated theoretically[2] and also through detailed study of real buildings.[3] This weakness is particularly relevant now that Standard 62.1 no longer specifies rates solely on a per-person basis.
- No guidance was provided in the LEED rating system language or in the LEED Reference Guide[4] regarding placement of CO_2 sensors. In practice, it is not uncommon for sensors to be placed in the return airstream of air-handling units serving multiple spaces. This is a not a good location for several reasons. First, it indicates only the average CO_2 concentration from several spaces. It is possible that the average concentration may be acceptable while some spaces are under-ventilated and others are overventilated.

  Second, the concentration of CO_2 in the return air may not be indicative of space CO_2 concentration due to short-circuiting of supply air to return air (low air-change effectiveness) or due to infiltration of outdoor air into negatively pressurized return air ducts and plenums.

To address these issues, the requirements for this credit in proposed Version 2.2 for mechanically ventilated spaces were revised to:

- For densely occupied spaces (those with a design occupant density greater than or equal to 25 people per 1,000 ft^2), carbon dioxide concentration must be monitored within the space between 3 ft and 6 ft (0.9 m and 1.8 m) above the floor.
- For non-densely occupied spaces, an outdoor airflow measurement device must be installed in the ventilation system capable of measuring the outdoor airflow rate at all expected system operating conditions within 15% of the design minimum outdoor air rate.

Requirements to achieve this credit for naturally ventilated spaces also were addressed. Since outdoor airflow to these spaces cannot easily be measured directly, CO_2 concentration is once again used as an indicator of acceptable ventilation and air quality, despite its shortcomings noted previously. As with densely occupied mechanically ventilated systems, CO_2 concentration in naturally ventilated spaces must be monitored within the occupied space.

EQ Credit 2: Increased Ventilation

EQ Credit 2 was originally titled "Ventilation Effectiveness" and required that the ventilation system be designed to maintain an air change effectiveness (ACE) greater than or equal to 0.9 as determined by ANSI/ASHRAE Standard 129-1997, *Measuring Air-Change Effectiveness*.

Problems quickly arose as designers attempted to achieve this credit. First, ASHRAE Standard 129 is a laboratory method of test and not easily applied in the field. Full-scale mockups of each air-distribution design must be built and tested to achieve the credit using this standard. To avoid this expense, LEED 2.1 allowed compliance to be achieved by showing that the air-distribution system complied with the recommended design approaches in *2001 ASHRAE Handbook—Fundamentals* Chapter 32, Space Air Diffusion. This was interpreted to mean that for each space type and application, the designer had to show that diffusers were selected to maintain an Air Diffusion Performance Index (ADPI) of at least 0.8. In addition to calculations, plans and sections had to be submitted for each space and air-distribution application type, so this credit was expensive to document.

But the credit also had more fundamental problems:

- High ACE does not improve indoor air quality because Standard 62 requires that ventilation rates be adjusted upwards when effectiveness is less than one. The ventilation rate to the breathing level is the same. Thus, high ACE if anything is an energy conservation measure and does not qualify as an EQ credit.
- Virtually every laboratory and field study[5,6,7,8] has shown that ACE is always greater than 0.9 when supply air is cooler than room temperature regardless of diffuser location or design. The default table of zone ventilation effectiveness in Standard 62.1-2004 also reflects this fact. So virtually any cooling-only system earns this credit inherently, regardless of the details of the air-distribution system design.
- Low ACE can occur with heating systems, whether the air is supplied from the ceiling or from the floor. People have mistakenly assumed that underfloor supply systems and displacement ventilation systems have inherently high ACE, but that is only true when cooling. These systems have low ACE when heating, often lower than conventional overhead systems.
- The LEED credit equated high ACE with high ADPI. They are not the same, although high ADPI usually results in high ACE. But, ADPI only applies to cooling systems that inherently have high ACE. ADPI does not apply to heating systems where low ACE can occur. Thus, ADPI is not a good surrogate for ACE.

It was clear to the LEED EQ Technical Advisory Group (TAG) responsible for maintaining EQ credits that Credit 2 needed to be significantly revised. The TAG decided to replace the credit entirely with a new one that requires increasing outdoor air ventilation rates to the breathing zone of all occupied spaces by at least 30% above the minimum rates required by Standard 62.1-2004. The rationale for this change was the following:

- The majority of existing literature indicates that increasing ventilation rates will decrease respiratory illness and associated sick leave, reduce sick building syndrome (SBS) symptoms, and improve productivity. While the original credit had little or no effect on indoor air quality, increasing ventilation rates will have a positive impact. The following research supports this conclusion:
    - Wargocki et al.[9] concluded that outdoor air rates below 50 cfm per person in offices increase the risk of SBS symptoms, increase short-term sick leave, and decrease productivity.
    - Seppanen et al.[10] found that increases in ventilation rates above 20 cfm per person up to approximately 40 cfm per person, are associated with a statistically significant decrease in the prevalence of SBS symptoms.
    - Wargocki et al.[11] found that for outdoor airflow of 6, 20, and 60 cfm per person, for each twofold increase in ventilation rate, performance improved on average by 1.9%.
    - Milton et al.[12] determined that lower ventilation rates of 25 cfm per person were associated with a 50% increase in short-term absence (considered a surrogate for sick leave), relative to ventilation rates of 50 cfm per person.
    - Wargocki et al.[13] found that call center productivity increased 6% at 50 cfm/person vs. 5–10 cfm/person.
- Giving credit for increased rates also is justified by the fact that the revised Standard 62.1-2004 rates (now referenced in EQ Prerequisite 1) are lower than the previous standard for most occupancy types. The standard is considered a "code-minimum" document. It is consistent with LEED philosophy to encourage designers to go beyond code minimum. *Figure 1* shows the reduction in breathing zone ventilation rates for sample occupancies. The 30% increase above Standard 62.1-2004 rates was selected to increase breathing zone office outdoor air rates from the 15 cfm/person to 20 cfm/person range that results from the Standard 62.1-2004 formula (based on four to six people per 1,000 ft^2 occupant density) up to a range of 20 to 25 cfm/person. Even higher rates could be justified by the studies referenced earlier.
- It is acknowledged that increasing ventilation rates will, in most applications and climates, increase energy use. However, the impact is relatively small[14] and it can be mitigated using heat recovery and other technologies that can be modeled and taken credit for in Environment and Atmosphere (EA) Credit 1 (Optimize Energy Performance). Note that other EQ credits, Credit 7 (Thermal Comfort) and Credit 8 (Daylight and Views) also increase energy use, Credit 7 because it takes considerable energy to maintain temperature and humidity within acceptable ranges, and Credit 8 because windows result in a net increase in HVAC loads even if lighting is controlled to take advantage of daylight. The benefits of these credits

	LEED NC Version 2.1 Title	LEED NC Version 2.2 Title	Summary of Changes
EQ Prerequisite 1	Minimum IAQ Performance	Minimum IAQ Performance	Updates reference to ASHRAE Standard 62.1-2004. Emphasizes that all sections of the standard must be complied with, not just rate section.
EQ Credit 1	Carbon Dioxide (CO_2)	Outdoor Air Delivery Monitoring	CO_2 used to monitor ventilation only for densely occupied spaces. Other spaces must have outdoor airflow measuring devices.
EQ Credit 2	Ventilation Effectiveness	Increased Ventilation	Credit replaced with new credit for increasing ventilation rates to 30% more than those required by Standard 62.1-2004.

Table 2: LEED-NC Indoor Environmental Quality (EQ) prerequisites and credits related to ventilation.

are deemed to outweigh the energy impacts. Similarly, it is argued that the energy impact of increased ventilation is more than offset by the health and productivity benefits.[15,16]

- Complying with this increased ventilation credit will not jeopardize compliance with EA Prerequisite 2 (Minimum Energy Performance) nor will it likely reduce the number of credits achieved in EA Credit 1. The reason is that ASHRAE Standard 90.1 modeling rules require that the same ventilation rate be modeled for the proposed and baseline building. Thus, if the minimum outdoor air rate in the proposed building is increased 30%, so is the outdoor air rate in the baseline building to which the proposed building is compared. In fact, since most LEED buildings have heating and cooling plants that exceed Standard 90.1 minimum efficiency levels, the increase in ventilation rate will most likely increase the number of credits achieved in EA Credit 1. This is because the outdoor air rate will increase heating and cooling loads that the proposed design will be able to handle more efficiently than the baseline building.

EQ Credit 2 requirements for natural ventilation systems have also been refined, although they are still very general. The design must meet the recommendations set forth in the Carbon Trust "Good Practice Guide 237"[17] and the CIBSE "Applications Manual 10: 2005, Natural ventilation in Non-Domestic Buildings."[18]

Conclusions

The LEED Green Building Rating Program for New Construction & Major Renovations has been updated to proposed Version 2.2. The revisions are intended primarily to fix implementation problems, but changes to the Indoor Environmental Quality credits relating to ventilation are significant. EQ Prerequisite 1 now references Standard 62.1-2004 and emphasizes that compliance is required for all relevant sections of Standard 62.1, not just the ventilation rate section. EQ Credit 1 has been revised to require CO_2 sensing to monitor ventilation system performance in densely occupied spaces while direct outdoor airflow measurement is required for mechanical ventilation systems serving other spaces. EQ Credit 2 has been completely revised to require an increase in ventilation rates of 30% above Standard 62.1-2004 rates. The increase (and even higher rates) can be justified by recent research showing higher outdoor air rates improve occupant productivity and reduce sick building syndrome symptoms.

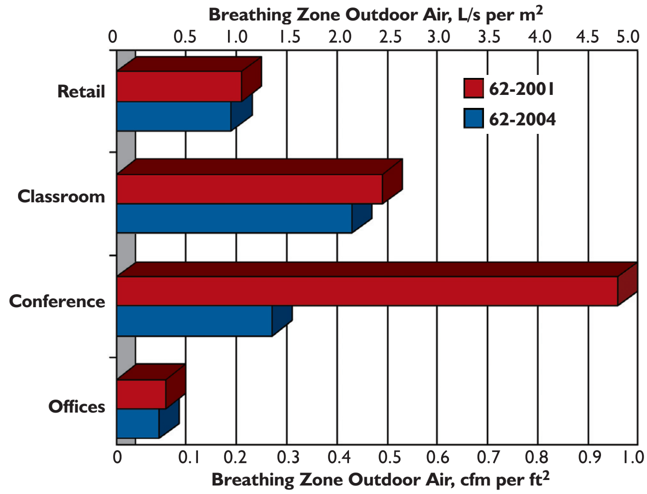

Figure 1: Breathing zone ventilation rate comparison for four common occupancy types.

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