Creating Healthier Furniture and Building Materials by Minimizing Chemical Emissions

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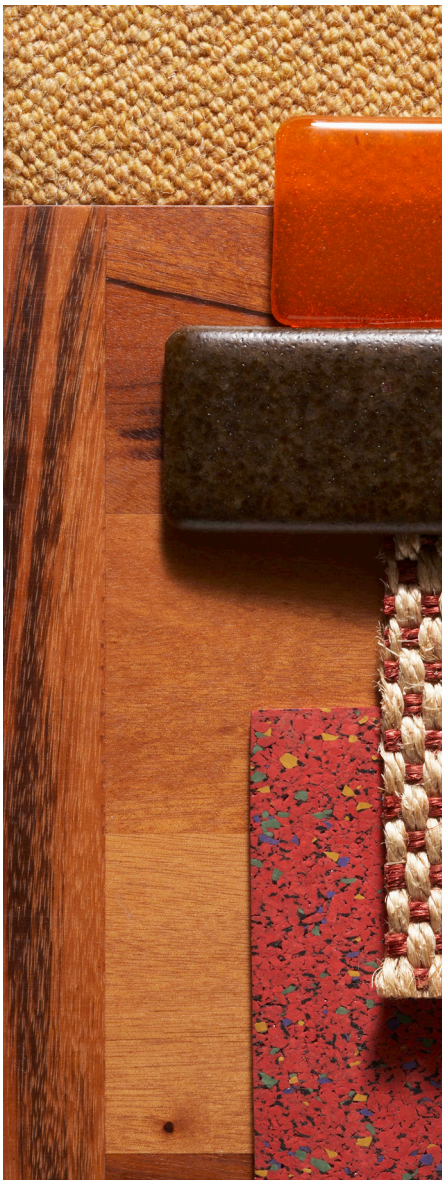
It is estimated that people in industrialized societies spend about 90 percent of their time indoors. Unfortunately, indoor concentration levels of potentially harmful volatile organic compounds (VOCs) and other airborne pollutants are likely to be significantly higher than outdoor levels. Therefore, it is not surprising that the importance of indoor air quality (IAQ) and its impact on human health is gaining increased attention.

Today, most green building codes, standards and rating systems already incorporate requirements that address IAQ concerns. These requirements, along with significant consumer awareness of the potential consequences associated with poor IAQ, have prompted manufacturers and retailers to offer a wider array of new furniture products and building materials that generate lower VOC emissions and contribute to healthier indoor environments.

This UL white paper provides an introduction to IAQ issues in relation to furniture products and building materials, and discusses how certification programs support manufacturers' efforts to substantiate legitimate claims for their products with reduced environmental impact. It begins with a review of the causes and effects of poor IAQ, and the common types of VOCs that can adversely impact human health. It summarizes the current state of product certification programs that address IAQ, and discusses UL's GREENGUARD Certification program for building materials and furniture products. It concludes with a review of the GREENGUARD Certification process and a discussion of the advantages of GREENGUARD Certification.



The Causes and Effects of Poor Indoor Air Quality

In 2010, commercial and residential buildings accounted for 41.2 percent of U.S. energy consumption,[1] and 74 percent of total U.S. electrical consumption.[2] Despite modest projections for future U.S. population growth, consumption of energy in residential and nonresidential buildings is expected to rise, as the construction of new structures outpaces the demolition of old ones. As such, the quest for more energy-efficient buildings is an essential element of efforts to slow the overall growth rate in energy consumption.

Construction methods designed to increase a building's energy efficiency primarily focus on securing the exterior envelope of the building to the greatest possible extent. However, a tighter building envelope generally results in less outdoor air being circulated throughout the building. Reduced air circulation also means that emissions from building construction materials, furniture products and household furnishings linger in the air for longer periods of time. IAQ can be further compromised by the use of various kinds of cleaning products as well as by consumer cleaning habits and behaviors such as smoking.

These and other factors contribute to the deterioration of IAQ. The U.S. Environmental Protection Agency (EPA) Office of Research and Development has found levels of common organic pollutants to be two to five times higher in buildings than levels found outdoors.[3] In addition, elevated indoor VOC concentration levels can be as much as 1,000 times greater than outdoor levels upon the completion of certain activities such as painting or paint stripping. And VOC concentrations can also persist in the air long after the product containing the VOC has been used.[4]

As a result, scientists are now linking poor IAQ to an increase in the incidence of certain health-related issues. For example, the incidence of asthma, which can often be triggered by indoor air pollutants like VOCs, has reportedly doubled over the past 20 years and now affects one in every six Americans.[5] Children exposed to high levels of VOCs are also far more likely to develop asthma.[6]

Other less severe but common effects from prolonged exposure to poor IAQ include eye, nose and throat irritation; allergic skin reactions; headaches; dizziness; and fatigue. Known health effects associated with VOC concentrations vary greatly depending on the specific organic chemicals and compounds involved. Some VOCs and organic compounds have been shown to cause cancer in animals, and are either a known or suspected cause of some types of cancer found in humans.

Volatile Organic Compounds Commonly Found In Indoor Environments

There are an estimated 11,000 different chemicals and compounds emitted from various types of products. While many of these chemicals are thought to be harmless, their full impact on human health is unknown, and the challenge of identifying potential human health effects further increases as new chemicals and compounds are introduced into use. A few of the most common VOC compounds with known health concerns are discussed in the following sections.

Formaldehyde

Formaldehyde is a specific VOC that is present in substantial concentrations both indoors and outdoors. The most prevalent sources of formaldehyde in buildings are construction products and furniture products made of pressed wood created with adhesives using formaldehyde-based resins. Such products include plywood, particleboard and medium density fiberboard used in furniture, cabinetry, shelving, flooring, paneling, subflooring and sheathing.

Formaldehyde is classified as a Group 1 known human carcinogen by the International Agency for Research on Cancer.[7] The U.S. EPA's Integrated Risk Information System estimates a cancer risk in humans of one in 10,000 at relatively low concentration levels.[8] Exposure to formaldehyde is also associated with decreased lung function and respiratory, eye, nose and throat irritation.

Reduction in exposure to formaldehyde in buildings can be achieved through the use of pressed wood products that have been certified to have low formaldehyde emissions. Additional overall reductions can be achieved through the maintenance

of moderate indoor temperature levels and reduced humidity levels. It is also advisable to increase building ventilation after introducing new products made with formaldehyde into the building environment.

Acetaldehyde

Acetaldehyde is primarily used as an intermediate substance in the synthesis of other chemicals such as in the production of polyester resins and basic dyes. It is also used as a solvent in the rubber, tanning and paper industries.

Like formaldehyde, acetaldehyde is present in concentrations in both indoor and outdoor environments. In indoor settings, acetaldehyde is commonly found in many flooring materials, including laminates, linoleum, varnished wood, cork and pine. It is also emitted from furniture made of composite wood, foam mattresses, and many paint and adhesive products. Acetaldehyde is also an important constituent component of tobacco smoke.

Acetaldehyde is classified by the EPA as a probable human carcinogen (Group B2). Exposure to acetaldehyde can also irritate the mucous membrane, throat and respiratory tract in humans and lead to chronic respiratory disease as well as kidney and liver damage. At higher levels of acetaldehyde exposure, pulmonary edema and necrosis may occur.[9]

BTEX Compounds

BTEX compounds are aromatic hydrocarbons emitted from many coatings and adhesives, and include benzene, toluene, ethylbenzene and xylene. BTEX compounds are typically found in petroleum products such as home heating oil. According to a study by the U.S. EPA, BTEX compounds are the most commonly detected VOCs attributable to background indoor air quality sources, such as consumer products, building materials and ambient air.[10] BTEX compounds are believed to be carcinogenic to humans and animals, and prolonged exposure to BTEX compounds can also result in adverse health effects involving human organs including the kidney and liver as well as the human blood system.

Phenol

Indoor sources of phenol can include building materials such as engineered wood products made with phenol-formaldehyde resin, vinyl flooring and wall coverings that use phenol as a thermal stabilizer, and paint products that contain phenol as a biocide. In addition, phenol is found in cleaning products and disinfectants. Phenol is also generated from wood-burning fireplaces and cigarette smoke. Phenol is a strong irritant to eyes and the human respiratory system. Acute inhalation can cause nausea, vomiting, convulsions, cardiac arrhythmias and circulatory collapse. Phenol is not believed to be carcinogenic and is classified as a non-carcinogen (Group D) by the U.S. EPA, and as a Group 3 substance (not classifiable for human carcinogenicity) by the International Agency for Research on Cancer.

Glycol Ethers

Glycol ethers include various forms of ethylene glycol used as solvents and additives in many types of paints, coatings and adhesives as well as household cleaning products. Exposure to glycol ethers can result in eye and upper respiratory track irritation, while prolonged exposure can produce fatigue and nausea as well as severe liver and kidney damage. Neither the U.S. EPA nor the International Agency for Research on Cancer has classified glycol ethers regarding their potential carcinogenic effect. However, the state of California has determined that glycol ethers are reproductive and developmental toxicants.

Strategies for Improving Indoor Air Quality

Improving the quality of indoor air generally relies on the use of a handful of basic strategies. The most generally effective and energy-efficient way to improve indoor air quality is through source control efforts, including the use of products that have been designed and constructed to reduce the emission of VOCs. For instance, furniture products can be constructed of pressed wood products that have been certified for low emissions and finished with low-emitting paints or stains. The use of these and other types of low-emitting products can contribute significantly to the reduction of indoor air pollution without compromising energy efficiency or increasing energy costs.

Increasing overall building ventilation to bring in additional outdoor air can further help reduce harmful concentrations of indoor air pollutants. Advanced heating and cooling systems technologies such as energy recovery ventilators are designed to increase the intake of outdoor air without significantly compromising the integrity of the building envelope and offsetting energy efficiency.

In some instances, indoor air quality can also be improved through the use of air cleaning appliances and systems. Depending on their design and capacity, such systems may be effective in reducing particulates and other indoor air pollutants from specific activities. However, to be effective, indoor air cleaners must be operated in a manner consistent with the manufacturer's specifications and properly maintained and serviced.

Factors in Certifying Low-Emitting Products

For manufacturers, the increased importance of low-emitting products in improving IAQ is being primarily driven by green building certification programs as well as state and local building codes. These programs and codes typically address IAQ issues as part of their scope, and usually include requirements governing the use of low-emitting building materials and furniture products. The most notable programs and codes include the following:

- **Leadership in Energy and Environmental Design (LEED) Certification** – Developed by the U.S. Green Building Council (USGBC) in March 2000, LEED certification provides a framework for developing sustainable building projects, and includes provisions that address issues of indoor environmental quality and IAQ. The LEED framework uses a point system to determine whether a specific building project qualifies for certification. LEED certification points are awarded in a number of categories, and the USGBC has recently increased the number of product types eligible for LEED certification points.[11]
- **California Green Building Standards Code** – California's Green Building Standards Code is currently the most comprehensive and detailed code in the U.S. dealing with green building design and construction for new residential and non-residential buildings. In the area of indoor environmental quality, the code is notable for specific content limits for VOCs for a range of adhesives and architectural coatings used in exterior and interior construction materials and finish work. The code also sets maximum formaldehyde emission limits for composite wood products such as plywood, particleboard and fiberboard. The code's VOC content and maximum formaldehyde emission limits are based on standards previously established by the California Air Resources Board (CARB).[12]
- **U.S. EPA's Proposed Regulations to Limit Formaldehyde Emissions from Composite Wood Products** – The U.S. EPA has proposed regulations to implement the provisions of the federal Formaldehyde Standards for Composite Wood Products Act, signed into law by President

Obama in 2010. The emissions standards for formaldehyde in the EPA's proposed rules are identical to those in place under California and are intended to eliminate a patchwork of state requirements by providing a single uniform standard for the country. [13]

To achieve compliance with the requirements of these and other programs and codes, and to gain increased visibility with buyers and consumers, manufacturers are increasingly seeking third-party certification for their low-emitting products and materials. However, certification programs vary considerably in their applicability and scope. In selecting an appropriate certification scheme, manufacturers should consider the following criteria:

- **Basis of evaluation**—Is the product evaluation based on objective, performance-based standards and criteria?
- **Scope of certification**—Does certification signify acceptable emission levels for all chemicals and chemical compounds that could adversely affect IAQ, or for only a single chemical or compound?
- **Regulator acceptance**—Is the certification recognized or accepted by regulators or sustainable building programs?
- **Buyer recognition**—Is the certification mark recognized and trusted by buyers and consumers?

Ideally, an effective third-party certification scheme is based on objective, performance-based standards that evaluate all potentially hazardous chemicals and chemical compounds, and which is recognized and trusted by regulatory authorities, sustainable building code programs and commercial buyers and consumers.

The GREENGUARD Certification Program

UL's GREENGUARD Certification Program was developed to provide a mechanism to scientifically assess the chemical emission characteristics of products designed for use in indoor spaces. Certification is based on conformity with product-specific, performance-based standards that detail product sample collection procedures, testing methods and frequency of testing, and allowable emission levels based on established toxicity limits.

Products submitted for GREENGUARD Certification are tested in a dynamic environmental chamber and are measured for chemical and particle emission. GREENGUARD testing addresses more than 360 individual chemicals. Products are additionally screened against 11,000 chemicals to assess exposure to complex chemical mixtures. Unlike other certification programs for low-emitting products, both product components and fully assembled products are subject to testing to best simulate actual product use.

Measured chemical emissions data is then converted to air concentration levels through a calculation that accounts for the expected use of the product and anticipated indoor air conditions including building volume and the exchange rate for fresh air. The resulting air concentration levels provide an accurate estimate of the amount of contaminants that a person will actually breathe in through exposure to the product. To achieve certification, products are required to achieve allowable air concentration levels within 7 to 14 days of installation.

Maximum permissible air concentrations of chemical and particle emissions from products under the GREENGUARD Certification Program are based on existing limits as defined by the U.S. EPA, the state of California, and other public health agencies. When multiple air concentration levels exist, tested building materials and furnishings are expected to meet the most stringent (lowest) concentration level to achieve GREENGUARD Certification.

GREENGUARD Certified products are also subjected to rigorous ongoing testing requirements for both components and fully assembled products. The frequency of verification and retesting can help to quickly identify changes in a product's emission profile due to component modifications or revised manufacturing processes. As such, buyers have increased confidence that GREENGUARD Certified products are being consistently produced in accordance with the specified emissions levels.

The basic level of GREENGUARD Certification assures compliance with the office furniture industry criteria presented

in ANSI/BIFMA X7.1, Standard for Formaldehyde and TVOC Emissions. Under the GREENGUARD Gold Certification Program, products are tested for conformity with stricter air concentration limits, consistent with the requirements of California's Department of Public Health Service standard for building and furniture products (also known as California Section 01350). GREENGUARD Gold Certification distinguishes products that meet these more stringent requirements and which are suitable for use in schools, healthcare facilities and energy efficient buildings.

The Benefits of GREEENGUARD Certification

As the demand increases for environmentally sustainable, low-emitting building materials and furniture products, buyers and consumers expect objective, independent evidence that substantiates manufacturers' claims. The GREENGUARD Certification Program provides manufacturers with a comprehensive and scientifically based assessment of each product's emissions profile, assessing emissions characteristics of more than 360 individual chemicals, including toxicity thresholds as well as the total level of chemicals emitted. Components as well as finished products are tested as part of the certification process to provide data on a product's emission characteristics in real-world conditions. GREENGUARD standards set chemical emissions limits consistent with those established by the U.S. EPA and state regulators as well as voluntary green building programs, paving the way for broad product acceptance. Certified products are also subject to a rigorous post-certification evaluation and retesting process to determine ongoing compliance.

As a result, the GREENGUARD and GREENGUARD Gold Certification Marks are widely recognized and trusted by code officials, specifiers, buyers and consumers.[14] More than 400 green building codes, rating systems, standards, guidelines and procurement policies recognize or provide credit for GREENGUARD Certified products. The wide acceptance of the GREENGUARD Mark provides greater market access for GREENGUARD Certified products, thereby providing manufacturers with important competitive advantages. Finally, GREENGUARD Certification serves as a testament to a manufacturer's commitment to the production of healthier products.

Summary and Conclusion

Today's energy-efficient construction has increased concerns about IAQ, and has focused attention on the extent to which building materials and furniture products contribute to poor IAQ. Source control is the most effective method of improving IAQ, and selecting low-emitting materials and products can significantly reduce concentrations of VOCs and other indoor air pollutants. However, certification programs for low-emitting products vary in scope and applicability, making it difficult for manufacturers to select an appropriate certification strategy.

UL's GREENGUARD Certification Program provides manufacturers with an objective, scientifically based assessment regarding the chemical emissions profile of their products. As such, the GREENGUARD Certification Mark is widely recognized and accepted by regulators, code officials and buyers as evidence of a product's environmental preferrability. This recognition can provide manufacturers with important advantages in a competitive marketplace, helping them to achieve greater market penetration while supporting their efforts to build a positive brand reputation.

For further information about UL's GREENGUARD Certification Program, contact Scott Steady, GREENGUARD product manager, at scott.steady@ul.com.

[1] Table 1.1.3, Building Share of U.S. Primary Energy Consumption, (Percent), from "Buildings Energy Data Book," U.S. Department of Energy, March 2012. Web. 21 August 2013. http://buildingsdatabook.eren.doe.gov/docs/xls_pdf/1.1.3.pdf.

[2] Table 1.1.9, Buildings Share of U.S. Electricity Consumption (Percent), from "Buildings Energy Data Book," U.S. Department of Energy, March 2012. Web. 21 August 2013. http://buildingsdatabook.eren.doe.gov/docs/xls_pdf/1.1.9.pdf.

[3] "The Inside Story: A Guide to Indoor Air Quality," U.S. EPA/Office of Air and Radiation, Office of Radiation and Indoor Air Quality. Web. 21 August 2013. http://www.epa.gov/iaq/pubs/insidestory.html#Intro1.

[4] "An Introduction to Indoor Air Quality (IAQ): Volatile Organic Compounds (VOCs)," U.S. Environmental Protection Agency. Web. 21 August 2013. http://www.epa.gov/iaq/voc.html.

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[10] "Background Indoor Air Concentrations of Volatile Organic Compounds in North American Residences (1990-2005): A Compilation of Statistics for Assessing Vapor Intrusion," U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, June 2011. Web. 16 October 2013. http://www.epa.gov/oswer/vaporintrusion/documents/oswer-vapor-intrusion-background-Report-062411.pdf.

[11] "Environmentally preferable interior finishes and furnishings," U.S. Green Building Council. Web. 23 August 2013. http://www.usgbc.org/node/2736716?return=/credits/new-construction/v2009

[12] "California 2010 Green Building Standards Code," California Building Standards Commission, June 2010. Web. 23 August 2013. http://www.documents.dgs.ca.gov/bsc/CALGreen/2010_CA_Green_Bldg.pdf.

[13] "Formaldehyde Emissions from Composite Wood Products," U.S. Environmental Protection Agency, 13 August 2013. Web. 23 August 2013. http://www.epa.gov/opptintr/chemtest/formaldehyde/

[14] GREENGUARD Certification is the most frequently named third-party certification used for specifying green products in the United States, according to World Green Building Trends, a SmartMarket Report issued by McGraw Hill Construction, 2013. A copy of the Report can be downloaded from http://analyticsstore.construction.com/index.php/world-green-building-trends-smartmarket-report-2013.html.

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