Reducing Building Materials Chemical Emissions to Help Create Healthier Indoor Environments

UL Solutions

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Because people in industrialized societies spend about 90% of their time indoors, indoor air quality (IAQ) has a tremendous impact on human health. The concentration of potentially harmful volatile organic compounds (VOCs) and other airborne pollutants is likely to be significantly higher indoors than outdoors. Today, most green building codes, standards and rating systems already incorporate requirements that address IAQ concerns. These requirements, along with growing consumer awareness of the potential consequences associated with poor IAQ, challenge manufacturers and retailers to offer a wider array of building materials, furniture and furnishing products that generate lower VOC emissions and contribute to healthier indoor environments.

In this white paper, UL Solutions experts provide building materials and commercial furniture manufacturers with insight into IAQ issues in relation to building materials and commercial furniture products. We discuss how certification programs can support manufacturers' efforts to substantiate legitimate claims for their products with reduced environmental impact. We begin by reviewing the causes and effects of poor IAQ and the common types of VOCs that can adversely impact human health. We then summarize the current state of product certification programs that address IAQ and discuss the UL GREENGUARD Certification program. Finally, we provide an overview of the UL GREENGUARD Certification process and discuss the advantages of UL GREENGUARD Certification.

Contributing factors to poor indoor air quality

In 2021, the combined end-use energy consumption by the residential and commercial sectors in the U.S. was about 21 quadrillion British thermal units (Btu). This was equal to about 28% of total U.S. end-use energy consumption in 2021.[1] Despite projections for modest U.S. population growth, energy consumption in residential and nonresidential buildings is expected to rise as the construction of new structures outpaces the demolition of old ones. Under those circumstances, creating more energy-efficient buildings will play an essential role in slowing the overall growth rate in energy consumption.

Several factors contribute to the deterioration of IAQ. 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 circulating throughout the building. Reduced air circulation also means that emissions from building construction materials, furniture and furnishings linger in the air for longer periods of time. The use of various kinds of cleaning products, consumer cleaning habits and behaviors such as smoking can further compromise 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.[2] In addition, elevated indoor VOC concentration levels can reach as much as 1,000 times greater than outdoor levels upon completing certain activities such as painting or paint stripping. VOC concentrations can persist in the air long after the product containing the VOC has been used.[3]

Scientists now link poor IAQ to increased incidences of certain health-related issues. For example, asthma, which indoor air pollutants like VOCs can often trigger, resulted in an estimated 1.6 million emergency department visits and 183,000 hospitalizations in the U.S. in 2017.[4] 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. Some VOCs have been shown to cause cancer in animals and are either a known or suspected cause of some types of cancer found in humans. Known health effects associated with VOC concentrations vary greatly depending on the specific compounds involved.

Because children have higher breathing rates than adults relative to their body mass, they are particularly susceptible to the health risks associated with poor IAQ. Children's immature immune systems and still-developing brains and other organs also contribute to their vulnerability.[5]

Volatile organic compounds commonly found in indoor environments

Various types of building materials, commercial furniture and other products emit an estimated 16,000 different chemicals and compounds. While many of these chemicals are thought to be harmless, their full impact on human health is unknown. The challenge of identifying potential human health effects further escalates as manufacturers introduce new chemicals and compounds into use. We discuss a few of the most common VOC compounds with known health concerns in the following sections.

Formaldehyde

Formaldehyde is present in substantial concentrations both indoors and outdoors. The most prevalent sources of formaldehyde in buildings include construction and furniture products made of pressed wood created with adhesives that use formaldehyde-based resins. Such products include plywood, particleboard and medium-density fiberboard used in furniture, cabinetry, shelving, flooring, paneling, subflooring and sheathing. The International Agency for Research on Cancer classifies formaldehyde as a Group 1 known human carcinogen.[6] The U.S. EPA's Integrated Risk Information System estimates a one in 10,000 risk of cancer in humans at relatively low concentration levels.[7]

Exposure to formaldehyde also correlates with decreased lung function and respiratory, eye, nose and throat irritation. Using pressed wood products certified to have low formaldehyde emissions, maintaining moderate indoor temperature levels, reducing humidity levels and increasing building ventilation after introducing new products made with formaldehyde can help reduce occupants' exposure to formaldehyde in buildings.

Acetaldehyde

Acetaldehyde primarily serves as an intermediate substance in synthesizing other chemicals, such as in the production of polyester resins and basic dyes, and as a solvent in the rubber, tanning and paper industries. This compound is also an important constituent component of tobacco smoke. Like formaldehyde, acetaldehyde is present in concentrations in both indoor and outdoor environments. In indoor settings, many flooring materials — including laminates, linoleum, varnished wood, cork and pine — contain acetaldehyde. Furniture made of composite wood, foam mattresses and many paint and adhesive products also emit this compound. The EPA classifies acetaldehyde 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.[8]

BTEX compounds

BTEX compounds — benzene, toluene, ethylbenzene and xylene — are aromatic hydrocarbons emitted from many coatings and adhesives. 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 in indoor air attributable to background indoor air quality sources.[9] Indoor air quality measurements from these sources are commonly referred to as "background" when assessing the potential for subsurface vapor intrusion into overlying building structures' indoor air. The International Agency for Research on Cancer (IARC) classified the BTEX compound benzene as carcinogenic to humans, and classified ethylbenzene as possibly carcinogenic to humans.[10] Prolonged exposure to BTEX compounds can result in adverse health effects involving human organs, including the kidney and liver, as well as the circulatory system.

Phenol

Indoor sources of phenol 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, as well as paint products that contain phenol as a biocide. In addition, phenol is present in cleaning products and disinfectants. Wood-burning fireplaces and cigarette smoke also generate phenol. Phenol is a strong irritant to the 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; the U.S. EPA has classified it as a noncarcinogen (Group D), and the International Agency for Research on Cancer has classified it as a Group 3 substance (not classifiable for human carcinogenicity).

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 tract irritation, and prolonged exposure can produce fatigue, nausea and 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.[11]

Strategies for improving indoor air quality

Using a few key strategies can help improve IAQ. Source control efforts, including the use of products designed and constructed to reduce the emission of VOCs, rank among the most effective and energy-efficient strategies. For instance, flooring can be constructed of concrete, wood and bamboo, and finished with a variety of products certified for low emissions. 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 increase the intake of outdoor air without significantly compromising the integrity of the building envelope or offsetting energy efficiency. In some instances, using air-cleaning appliances and systems can also help improve indoor air quality. Depending on their design and capacity, such systems, when operated in a manner consistent with the manufacturer's specifications with proper maintenance and service, may effectively reduce particulates and other indoor air pollutants from specific activities.

The importance of certifying low-emitting building materials

For manufacturers, green building certification programs and state and local building codes drive the increased importance of low-emitting products in improving IAQ. 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 several categories, and the USGBC has recently increased the number of product types eligible for LEED certification points.[12]

- 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 nonresidential buildings. In the area of indoor environmental quality, this 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).[13]

- U.S. EPA's proposed regulations to limit formaldehyde emissions from composite wood products – The U.S. EPA proposed regulations to implement the provisions of the federal Formaldehyde Standards for Composite Wood Products Act, signed into law by former U.S. President Obama in 2010. They were incorporated into law as part of the EPA's Toxic Substances Control Act (TSCA) Title VI. The emissions standards for formaldehyde in the TSCA Title VI, identical to those in place under California law (CARB Air Toxic Control Measure (ATCM) 93120), provide a single uniform standard for the country.[14]

To achieve compliance with the requirements of these and other programs and codes, and to gain increased visibility with buyers and consumers, manufacturers seek 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 – Do buyers and consumers recognize and trust the certification mark?

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

UL GREENGUARD Certification program

UL Solutions experts developed the UL GREENGUARD Certification program 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.

Building materials submitted for UL GREENGUARD Certification undergo testing in dynamic environmental chambers and are measured for chemical emissions. UL GREENGUARD testing addresses more than 360 individual chemicals. Products are additionally screened against 16,000 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 contaminant that a person will breathe in through exposure to the product. To earn certification, products must achieve allowable air concentration levels within seven to 14 days of installation. Maximum permissible air concentrations of chemical emissions from products under the UL GREENGUARD Certification program are based on existing limits as defined by the State of California, the U.S. EPA 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 UL GREENGUARD Certification.

UL 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. This boosts buyers' confidence that UL GREENGUARD Certified products are consistently produced in accordance with the specified emissions levels.

In the basic level of UL GREENGUARD Certification, products undergo evaluation for compliance with a variety of IAQ standards and codes, including the office furniture industry criteria presented in ANSI/BIFMA X7.1, Standard for Formaldehyde and TVOC Emissions. Under the UL GREENGUARD Gold Certification Program, products are tested for conformity with stricter air concentration limits consistent with the requirements of the California Department of Public Health (CDPH) standard for building and furniture products (also known as California Section 01350 or CDPH Standard Method v1.2). UL GREENGUARD Gold Certification distinguishes products that meet these more stringent requirements and that are suitable for use in schools, healthcare facilities and energy-efficient buildings.

The benefits of UL GREENGUARD Certification

As demand increases for environmentally sustainable, low-emitting building materials and furniture products, buyers and consumers expect objective, independent evidence that substantiates manufacturers' claims. The UL 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 and the total level of chemicals emitted. Components and finished products undergo testing as part of the certification process to provide data on a product's emission characteristics in real-world conditions. UL 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 evaluate ongoing compliance. As a result, the UL GREENGUARD and UL GREENGUARD Gold Certification Marks are widely recognized and trusted by code officials, specifiers, buyers and consumers.[15] More than 450 green building codes, rating systems, standards, guidelines and procurement policies recognize or provide credit for UL GREENGUARD Certified products. The wide acceptance of the UL GREENGUARD Mark provides greater market access for UL GREENGUARD Certified products, thereby providing manufacturers with important competitive advantages. Finally, UL GREENGUARD Certification signifies a manufacturer's commitment to producing healthier products.

Summary and conclusion

Today's indoor lifestyle and increased awareness of health and environmental factors have raised concerns about the extent to which building materials and commercial 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, because certification programs for low-emitting products vary in scope and applicability, manufacturers can find it difficult to select an appropriate certification strategy.

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

For further information about the UL GREENGUARD Certification program, contact us today.

Endnotes

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15. 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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