TECHNICAL BRIEF

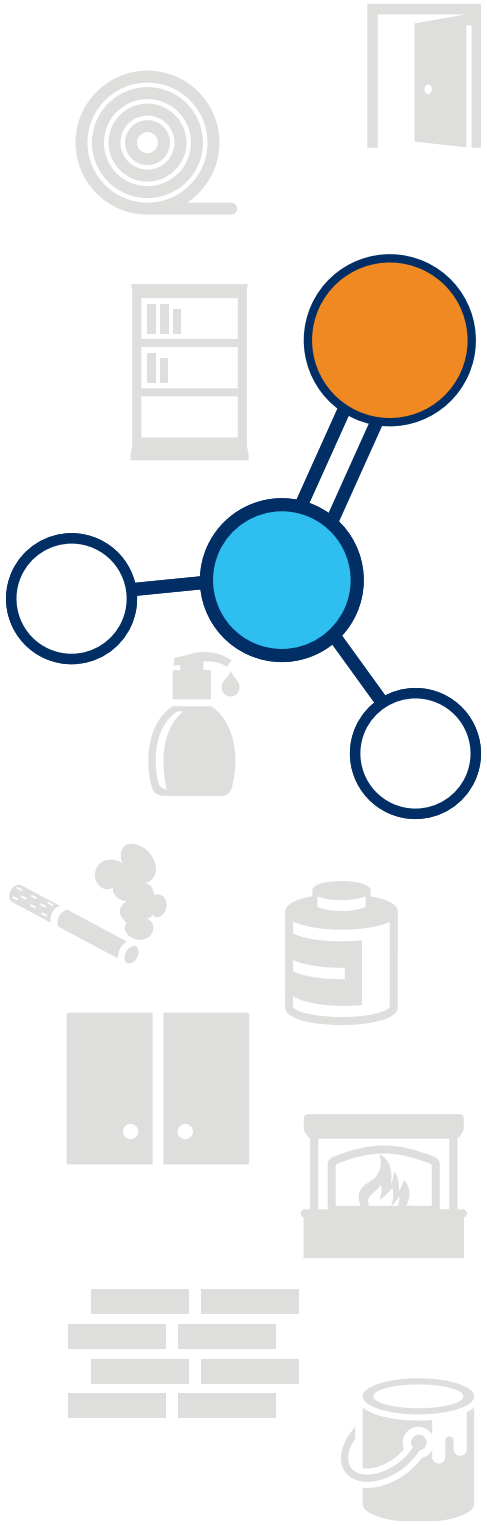
Chemical Insights
An Institute of Underwriters Laboratories Inc.

Formaldehyde — A Common Air Pollutant

Background

Formaldehyde is one of the most prolific air pollutants found in our homes, offices, schools, and public environments. It is colorless but can often be observed by its pungent odor. Sources of formaldehyde are numerous and can include composite wood products like particleboard and medium density fiberboard, preservatives in medicine, cosmetics, and soaps. Also, construction and furnishing materials such as glues, paints, finishes, textiles, insulations, furniture, and paper products; fertilizers and pesticides; and combustion sources such as gas stoves, indoor fireplaces, and tobacco smoke contain formaldehyde. Formaldehyde is a naturally found chemical in numerous foods and is produced in small levels by the human body.

People are primarily exposed to formaldehyde by breathing contaminated indoor and outdoor air. Air levels are significantly higher in the indoor air where people spend about 90% of their time. Indoor/outdoor air can be affected by numerous sources with outdoor levels typically ranging from 2-20 ppb and indoor air levels ranging up to 100 ppb. In some cases of new construction or newly applied materials, formaldehyde levels can be higher. Our recent research has shown that formaldehyde is a common emission found in 3D printing and electronic vaping processes as well as current upholstered furniture. Formaldehyde is the third highest volatile organic compound (VOC) detected from vaping emissions that get directly inhaled by a smoker.



Health Concerns

Formaldehyde can produce irritation of the skin, eyes, nose, and throat, and high levels of exposure may contribute to certain cancers (myeloid leukemia, sinonasal and nasopharyngeal cancer). Acute and chronic health effects from exposure to formaldehyde vary depending on individual sensitivity. For example, a link between childhood asthma and formaldehyde exposure has been shown. The typical threshold for developing acute symptoms due to inhaled formaldehyde is 800 ppb (0.8 ppm); however, sensitive individuals have reported symptoms at levels around 100 ppb (0.1 ppm) or less. Most people can detect formaldehyde's pungent odor at levels as low as 50 ppb (0.05 ppm).

Acceptable Exposure Levels.

Although there are established occupational (workplace) exposure limits for formaldehyde exposure, there are no regulated standards for acceptable airborne levels of formaldehyde in more traditional environments such as schools or homes. Exposure control is managed with recommended air guidelines or product control standards. The most recent product regulation from the state of California (Composite Wood Products Airborne Toxic Control Measure-ATCM) addresses formaldehyde emissions from composite wood boards that go into the manufacturing of flooring and other interior construction and furnishing products; and a similar law was implemented by the U.S. federal government. The Federal Law (Formaldehyde Standards for Composite Wood Products Act) is the first updated regulation of formaldehyde emissions from composite wood boards since 1984 when they were first regulated by HUD (the U.S. Department of Housing and Urban Development) for use in manufactured housing (i.e., mobile homes). On the following page is a list of U.S. organizations and standards with most current formaldehyde exposure limits (Table 1).

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Table 1: Formaldehyde Exposure and Emission Standards			
Organization or Standard	**Application**	**Exposure Limit**	**Additional Information**
National Institute of Occupational Safety and Health (NIOSH)	Occupational/ Indoor air	0.016 ppm (16 ppb)	Recommended exposure limits (RELs) are time-weighted average (TWA) concentrations for up to a 10-hour workday during a 40-hour workweek. NIOSH recommends REL of 0.016 ppm or 16 ppb. The Federal Emergency Management Agency (FEMA) uses this level as an acceptable air level within its trailers. The ceiling limit (C), not to be exceeded, is 100 ppb.
Occupational Safety and Health Administration (OSHA)	Occupational/ Indoor air	0.75 ppm (750 ppb)	Permissible exposure limits (PELs) are how OSHA defines the maximum concentration of chemicals to which a worker may be exposed. PELs are defined in two ways: STEL (15-minute time-weighted average not to be exceeded) or an eight-hour TWA, which is an average value of exposure over an eight-hour work shift. The OSHA TWA PEL for formaldehyde is 0.75 ppm based on an 8-hour day, 40-hour workweek with a STEL of 2 ppm.
American Conference of Governmental Industrial Hygienists (ACGIH)	Occupational/ Indoor air	0.1 ppm (100 ppb)	Threshold Limit Values (TLV®s) are guidelines for the level of exposure that the typical worker can be exposed to without adverse health effects. They are not quantitative estimates of risk at different exposure levels or by different routes of exposure. The formaldehyde TLV-8-hr time weighted average is 0.1 ppm and STEL (short term exposure limit) recommended by the ACGIH is 0.3 ppm.
California Office of Environmental Health Hazard Assessment (OEHHA)	General air/ Indoor air	0.007 ppm (7 ppb)	Reference exposure levels (RELs) address non-cancer health effects of volatile organic compounds (VOCs), including formaldehyde, and provide concentrations below which these health effects have been observed in studies. New formaldehyde 8-hour REL: 9 µg/m^3 (.007 ppm).
California Proposition 65 (Prop 65)	General air/ Indoor air	40 µg/day	Prop 65 No Significant Risk Level (NSRL) is the level developed by OEHHA to which if exposed to every day for 70 years will result in one excess case of cancer in 100,000 people. The NSRL for formaldehyde is 40 µg/day.
CDC's Agency for Toxic Substances and Disease Registry (ATSDR)	General air/ Indoor air	acute: 0.04 ppm (40 ppb); intermediate: 0.03 ppm (30 ppb); chronic: 0.008 ppm (8 ppb)	The CDC's Agency for Toxic Substances and Disease Registry (ATSDR) has developed Minimal Risk Levels (MRLs) which estimate the daily level to which a substance may be exposed without the likelihood of adverse, non-cancer health effects. MRLs are derived for acute (1 - 14 days), intermediate (>14 - 364 days), and chronic (365 days and longer) exposure durations. The formaldehyde acute MRL is 40 ppb (0.04 ppm), the intermediate MRL is 30 ppb (0.03 ppm), and the chronic MRL is 8 ppb (0.008 ppm).
The United States Environmental Protection Agency (U.S. EPA)	General air/ Indoor air	0.8 µg/m^3	The U.S. EPA maintains the Integrated Risk Information System (IRIS), a database on information on noncancer and cancer health effects that may result from exposure to various substances in the environment, based on toxicological reviews. Formaldehyde has been classified as a probable human carcinogen with a cancer risk for 1 excess person in 100,000 found to develop at a continuous lifetime exposure concentration of 0.8 µg/m^3. Oral reference dose (RfD) of 0.2 mg/kg/day.
The World Health Organization (WHO)	Indoor air	0.1 ppm (100 ppb)	Guideline for the maximum formaldehyde level in non-occupational settings is 0.08 ppm for 30 minutes. (Guideline was created to protect against sensory irritation in the general population.)
Green Building Council Leadership in Environment and Energy Design (LEED)	Indoor air	0.027 ppm (27 ppb)	The LEED rating system specifies a maximum concentration of formaldehyde in indoor air of 0.027 ppm. This level applies to clearance testing of air levels before a building or school is occupied.

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Table 1 Continued: Formaldehyde Exposure and Emission Standards			
Organization or Standard	**Application**	**Exposure Limit**	**Additional Information**
Federal Emergency Management Agency (FEMA)	Indoor air (specifically emergency housing)	0.016 ppm (16 ppb)	FEMA has selected an indoor air formaldehyde level of 0.016 ppm, which is near the lowest level frequently found indoors (0.01 ppm) and below the midpoint range that the Centers for Disease Control and Prevention (CDC) calls "typical" for conventional homes. This goal targets certain travel trailers and modular housing.
U.S. Department of Housing and Urban Development (HUD)	Product emissions	0.3 ppm (300 ppb) for particleboard and 0.2 ppm (200 ppb) for plywood	HUD's regulation is product-specific and requires formaldehyde emissions below 0.3 ppm for particleboard and 0.2 ppm for plywood materials. The levels were chosen with the expectation of maintaining actual room exposure levels below 0.4 ppm.
CA 01350 Specification	Product emissions	0.007 ppm (7 ppb)	California Specification 01350 requires that emission levels for formaldehyde from building products and materials be equal to or less than 0.007 ppm within 14 days after installation. Certification programs like LEED, CHPS and GREENGUARD gold have adopted this requirement.
California Air Resources Board CARB ATCM Phase II	Product emissions	0.13 ppm (130 ppb) for thin MDF; 0.11 ppm for MDF; 0.09 ppm for particleboard; 0.05 ppm for hardwood plywood	All hardwood plywood, particleboard and medium density fiberboard (MDF) panels have been required to meet specific emission standards. Allowable emission levels include 0.13 ppm for thin MDF, 0.11 ppm for MDF, 0.09 ppm for particleboard and 0.05 ppm for hardwood plywood with a composite or veneer core.
USEPA TSCA Title VI Compliant	Product emissions	mirrors CARB (above)	The Formaldehyde Standards for Composite Woods Product Act of 2010 established emission standards for composite wood products.

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