TECHNICAL BRIEF

Benzene — A Common Air Pollutant

Background

Benzene (C_6H_6, CAS Number 71-43-2) is a carcinogenic, volatile organic compound (VOC) found in the indoor air. Primary sources of benzene include emissions from vehicles and gas-powered equipment often found in garages that can infiltrate homes and buildings. Benzene is found in petroleum-based products used in internal and external building materials including roofing, sheathing, waterproofing, adhesives, and various furnishings like furniture. Additionally, research shows that benzene is a primary emission from burning residential furniture. It can also be a byproduct of combustion sources including cigarette smoke, fireplaces, gas ranges, and ovens. Low levels of benzene can be found in the emissions of some photocopiers, laser printers, and 3D printers.

Indoor levels of benzene can range from about 2 to 10 µg/m^3. Levels have decreased over the years with the use of more water-based materials. People in a variety of occupations, such as firefighters, laboratory scientists, and skilled trades workers are often exposed more frequently to benzene.

Health Concerns

Benzene exposure most commonly occurs through inhalation, although exposure through ingestion and dermal contact does happen. Benzene exposure can result in neurologic, hematologic, and immunologic effects in people. Acute exposure to benzene may cause drowsiness, dizziness, headaches, and irritation. Chronic exposure can cause various blood disorders by affecting the bone marrow, the primary site of new blood cell production. Alteration of the blood cell count can further damage the immune system by changing the blood concentration of antibodies and reducing the white blood cell count. Currently, benzene is classified as a known human carcinogen from all routes of exposure due to the increased risk of cancer development in multiple organ systems.

Acceptable Exposure Levels

There are no regulated standards for acceptable indoor levels in nonindustrial environments such as homes, offices, and schools. Below is a list of some U.S. and global organizations with recommended exposure limits/odor thresholds **(Table 1).**

TABLE 1: *BENZENE EXPOSURE AND EMISSION STANDARDS*

Organization or Standard	Application	Exposure Limit	Additional Information
The United States Environmental Protection Agency (U.S. EPA)	Inhalation and oral exposure	**RfC:** 30 µg/m^3 **RfD:** 0.004 mg/kg/day for nervous and respiratory systems	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. IRIS has a reference concentration for inhalation exposure (RfC) and a reference dose for oral exposure (RfD). RfC and RfD are estimates of a daily exposure of the human population that is likely to be without an appreciable risk of deleterious effects during a lifetime.
CDC's Agency for Toxic Substances and Disease Registry (ATSDR)	General air/ Indoor air	**MRL Inhalation:** 0.003 ppm or 9.58 µg/m^3 (chronic) **MRL Oral:** 0.0005 mg/kg/day (chronic)	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.
CA 01350 Specification	Product emissions	1.5 µg/m^3	CDPH SM 01350 sets allowable concentrations that emission levels from building products and materials must meet within 14 days after installation. Certification programs like CHPS, GREENGUARD gold, and BIFMA have adopted this requirement.
U.S. Green Building Council Leadership in Environment and Energy Design (LEED)	Indoor air	3 µg/m^3	The LEED rating system specifies maximum acceptable concentrations for the clearance testing of air levels before a building or school is occupied.
California Office of Environmental Health Hazard Assessment (OEHHA)	General air/ Indoor air	**REL** = 3 µg/m^3 (chronic)	Reference exposure levels (RELs) address non-cancer health effects of volatile organic compounds (VOCs) and provide concentrations below which these health effects have been observed in studies.
California The Division of Occupational Safety and Health (Cal/OSHA)	Occupational	**PEL** = 1 ppm (3.19 mg/m^3)	California has the most extensive list of occupational exposure limits of all states in the US reported as permissible exposure limit (PEL).

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National Institute of Occupational Safety and Health (NIOSH)	Occupational	**REL** = 0.1 ppm (0.32 mg/m^3)	NIOSH recommended exposure limits (RELs) are intended to limit exposure to hazardous substances in workplace air to protect worker health.
American Conference of Governmental Industrial Hygienists (ACGIH)	Occupational	**TLV** = 0.5 ppm (1.60 mg/m^3)	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.
Occupational Safety and Health Administration (OSHA)	Occupational	**TWA** = 1 ppm (3.19 mg/m^3)	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 8-hour total weight average (TWA), which is an average value of exposure over an eight-hour work shift.

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