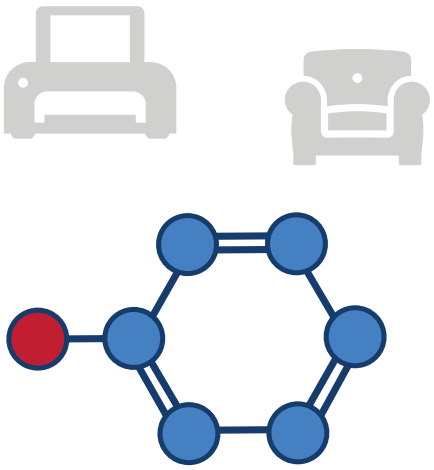
TECHNICAL BRIEF

Chemical Insights
An Institute of Underwriters Laboratories Inc.

Phenol — A Common Air Pollutant

Background

Phenol (C_6H_5OH, CAS number 108-95-2), also known as carbolic acid and hydrobenzene, is a manufactured and natural substance. Phenol is commonly found in the indoor environment and is one of the most frequently found VOCs in newly constructed buildings. Its levels are typically in the 20-30 µg/m³ range, and sources are numerous including operating electronics such as televisions and printers, 3D printers, furnishings such as flooring and furniture, and household materials made with adhesives. Phenol often arises from the heating of various resins and plastics used in electronic circuit boards, floor levelers used in construction and consumer products.



Phenol has a low odor threshold with a sweet, tar-like smell. Some people refer to it as a strong "Play-Doh" and find it very irritating, resulting in eye and nose irritation and headaches. It also absorbs into clothing and porous materials and can be observed indoors and on materials for extended periods of time.

Health Concerns

Phenol is irritating to the skin, eyes, and mucous membranes after acute inhalation or dermal exposures as phenol is quickly absorbed from the lungs and skin. Long term exposure may cause anorexia, weight loss, diarrhea, vertigo, and blood, kidney, and liver effects. It has not been classified as to human carcinogenicity, however animal studies have shown signs of abnormal fetus development/weight loss due to oral phenol exposure.

Acceptable Exposure Levels

Below is a list of US and global organizations with phenol odor threshold and/or exposure limits (Table 1).

Table 1: Phenol Odor and Exposure Standards

Organization or Standard	Application	Exposure Limit	Additional Information
AgBB	General air/ Indoor air	2.6 ppb 10 µg/m³	Ausschuss zur gesundheitlichen Bewertung von Bauprodukten (AgBB) sets Lowest Concentration of Interest (LCI) for VOC emissions from building products. LCI for phenol is 2.6 ppb (10 µg/m³).
CA 01350 Specification	Product emissions	26 ppb 100 µg/m³	California Specification 01350 requires that emission levels for phenol from building products and materials be equal to or less than 100 µg/m³ within 14 days after installation. Certification programs like CHPS and GREENGUARD gold have adopted this requirement.
U.S. Green Building Council Leadership in Environment and Energy Design (LEED)	Indoor air	52 ppb 200 µg/m³	The LEED rating system specifies a maximum concentration of phenol in indoor air of 200 µg/m³. This level applies to clearance testing of air levels before a building or school is occupied.

Table 1 Continued: Phenol Odor and Exposure Standards			
Organization or Standard	**Application**	**Exposure Limit**	**Additional Information**
The United States Environmental Protection Agency (U.S. EPA)	Odor threshold	40 ppb 154 µg/m^3	The odor threshold of phenol is 0.04 ppm (154 µg/m^3).
The United States Environmental Protection Agency (U.S. EPA)	Oral Exposure	RfD: 0.3 mg/kg/day	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. Phenol has a reference dose for oral exposure (RfD) of 0.3 mg/kg bw/day. RfD is an estimate of a daily exposure to 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	Acute oral: 1 mg/kg/day	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 phenol acute MRL is 1 mg/kg/day for acute oral exposure.
American Conference of Governmental Industrial Hygienists (ACGIH)	Occupational/ Indoor air	5 ppm (5,000 ppb) 19 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. The phenol TLV-8-hr time weighted average is 5 ppm (19 mg/m^3).
California PEL - TWA	Occupational/ Indoor air	5 ppm (5,000 ppb) 19 mg/m^3	California's Permissible Exposure Limits for Chemical Contaminants (CAPEL) has an 8 hr Time Weighted Average (TWA) of 5 ppm.
OSHA PEL	Occupational/ Indoor air	5 ppm (skin) (5,000 ppb) 19 mg/m^3	Occupational Safety Health Administration's permissible exposure limit (PEL) via skin exposure averaged over an 8-hour work shift is 5 ppm.
AIHA ERPG-2	Occupational/ Indoor air	50 ppm 193 mg/m^3	American Industrial Hygiene Association in their emergency response planning guideline has phenol's maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective action is 50 ppm.
NIOSH	Occupational/ Indoor air	REL: 5 ppm C REL: 15.6 ppm (15 min) IDLH: 250 ppm	National Institute for Occupational Safety and Health's reference exposure level (REL) time weighted average is 5 ppm (19 mg/m^3), ceiling REL is 15.6 ppm (60 mg/m^3) over 15 minutes, and immediately dangerous to life or health (IDLH) for phenol is 250 ppm (963 mg/m^3), all through skin exposure.

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References

1. PubChem. Phenol. Accessed October 25, 2021. https://pubchem.ncbi.nlm.nih.gov/compound/996
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3. CDC - NIOSH Pocket Guide to Chemical Hazards - Phenol. Accessed October 25, 2021. https://www.cdc.gov/niosh/npg/npgd0493.html
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