

REFERENCE DATA SHEET ON FORMALDEHYDE

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POTENTIAL EXPOSURE SOURCES AND USES

- Formaldehyde manufacture
- Resins and plastics
- Permanent press fabrics
- Plywood and particle board
- Disinfectant
- Tissue preservative
- Embalming fluid
- Laboratory reagent
- Tanning operations
- Urea-formaldehyde insulation
- Tobacco smoke
- Pentaerythritol production
- Seed and bulb treatment
- Paint preservative

PHYSICAL DATA

Formaldehyde is a colorless gas at normal conditions, and has a pungent, irritating odor. It is very soluble in water. It is usually sold as formalin, a 37% to 55% solution in water, usually with 0.5% to 15% methyl alcohol added to prevent polymerization to a solid crystalline form. In these commercial concentrations it is flammable, and has explosive limits between 7% and 73% by volume in air. It is also available as paraformaldehyde, a solid, polymerized form. The molecular formula is HCHO, and the molecular weight is 30. Formaldehyde vapor is about 1.03 times as heavy as air. A 37% formaldehyde solution has a vapor pressure of about 1.3 mm at 68 °F, and 67 - 88 mm at 98 °F. The exact vapor pressure depends on the amount of methyl alcohol added.

Formaldehyde released to the atmosphere is degraded rapidly by direct oxidation by sunlight, and by oxidation by photochemically produced hydroxyl radicals. About 1/2 is degraded within a few hours. Additional formaldehyde is removed by rain, or by solution in surface waters. In water it will biodegrade to low levels within a few days.¹

IMPLICATIONS

Formaldehyde is a very common industrial and commercial chemical. U.S. production in 1991 was 6.6 billion pounds. It has been estimated that approximately 1.3 million to 1.5

million workers in the U.S. are exposed to formaldehyde either full time or part time.^{2,3} It can be found in homes, where it may be released from adhesives in plywood, particle board, and carpets, or from consumer products or permanent press clothing. It may also be found in laboratories, funeral homes, and hospitals. It can usually be detected by odor at concentrations reported as 0.07 to 1.2 parts per million (ppm) in air.⁴ However, prolonged exposure can result in temporary nasal fatigue, so the odor may no longer be detected at such low concentrations. The OSHA Permissible Exposure Limit (PEL) is an average of 0.75 ppm for an eight hour work day. The Short Term Exposure Limit (STEL) is 2 ppm (15 minute average). The OSHA "action level" is 0.5 ppm.⁵ If employees are exposed to formaldehyde concentrations above the "action level," additional sampling and a medical surveillance program are required. The American Conference of Governmental Industrial Hygienists (ACGIH) has established a Threshold Limit Value (TLV) of 0.3 ppm as a "ceiling limit," not to be exceeded at any time, and has classified it as a "Suspected Human Carcinogen."⁶ Formaldehyde is not persistent in the atmosphere or in water, and is not transported very far from the source by the atmosphere.

HEALTH EFFECTS DATA^{7,8}

Reported **short-term effects** of inhalation of formaldehyde gas include bronchitis, pulmonary edema (fluid in the lungs), inflammation of the lungs and respiratory tract, pneumonia, and respiratory failure resulting in death. Lower concentrations (2 - 3 ppm) can cause tingling of the nose and back of the throat, but tolerance to higher concentrations can occur in some individuals. Most people can tolerate 4 - 5 ppm for up to 30 minutes, but after that time period discomfort increases. Breathing becomes difficult at 10 - 20 ppm. Serious injury is likely to occur with brief exposures to 50 - 100 ppm, which could cause edema (fluid build-up) in the lungs, inflammation of the lungs, and death. Pulmonary edema can develop several hours after exposure to these high concentrations. The National Institute for Occupational Safety and Health (NIOSH) has established a tentative IDLH (Immediately Dangerous to Life and Health) value of 30 ppm. This means that exposure to that concentration for thirty minutes or more could result in permanent injury or death.⁹

Skin contact with formaldehyde solution can cause irritation, and drying and reddening of the skin. Long-term contact can cause sensitization of the skin, resulting in a rash or eczema. Subsequent exposure to low concentrations may cause a recurrence of the rash. Formaldehyde is not absorbed through the skin.

Eye irritation may occur at formaldehyde concentrations of about 0.2 ppm, and tears will form at about 4 - 5 ppm. Massive and intolerable tear formation occurs at concentrations higher than about 10 ppm in most people. Contact of the eyes with concentrated formaldehyde solutions can cause severe eye irritation and injury and possible blindness.

Ingestion (swallowing) of formaldehyde is unlikely, but if it occurred it would result in irritation and severe pain in the mouth, throat, and digestive tract. Later dizziness, coma, and lowered body temperatures can occur. The methyl alcohol contained in formaldehyde solution could also contribute to damage to the optic nerve and possible blindness.

Long-term exposure to elevated concentrations of formaldehyde gas may cause respiratory irritation, obstruction of the airways, and impaired lung function. Formaldehyde does not accumulate in the body, since it is readily metabolized to formic acid, and then to carbon dioxide and water.

Laboratory tests have shown that formaldehyde can cause nasal cancers in rats exposed to a concentration of 14.3 ppm of formaldehyde for 24 months. Mice exposed to the same concentration of formaldehyde did not develop a statistically significant increase in cancers. In humans, numerous epidemiological (causes of death) studies have been done on various groups of workers exposed to formaldehyde. These have included morticians, garment workers, wood workers, foundry workers, painters, and barbers, among others. To date, there do not appear to have been any statistically significant increases in cancers at any site in humans. Many of these studies have suffered from lack of exposure and smoking history data. Due to cancers found in animal studies, and the limited and controversial human epidemiological studies, both the Environmental Protection Agency (EPA) and the Occupational Safety and Health Administration (OSHA) consider formaldehyde to be a possible human carcinogen, and regulate it accordingly.

IMPLICATIONS

Formaldehyde is a very toxic material, and must be handled carefully to avoid serious injury. Although it is classified by OSHA and EPA as a possible carcinogen, studies that have been performed to date have not shown that it has caused cancer in humans.

RECOMMENDED EXPOSURE LIMITS

Table 1 below gives a comparison of selected recommended exposure limits for formaldehyde since 1946. The values listed are for eight-hour time-weighted-average exposures. The OSHA limits are enforceable by law, while the ACGIH limits are recommendations that are intended as guidelines for use by persons trained in the discipline of industrial hygiene.⁶

Table 1 - Selected Formaldehyde Exposure Limits

| Year | Recommended By | Exposure Limit (ppm) |
|-------------|-----------------------|-----------------------------|
| 1946 | ACGIH | 10 |
| 1948 | ACGIH | 5 |
| 1963 | ACGIH | 5C* |
| 1972 | ACGIH | 2C* |
| 1972 | OSHA | 3 |
| 1985 | ACGIH | 1 |
| 1988 | OSHA | 1 |
| 1992 | OSHA | 0.75 |
| 1992 | ACGIH | 0.3C* |

* = a ceiling limit, not to be exceeded at any time

The present OSHA regulation also includes a Short Term Exposure Limit (STEL) of 2 ppm (15 minute average) and an "action level" of 0.5 ppm. OSHA also requires medical monitoring for all employees exposed to a time-weighted-average concentration of 0.1 ppm or more.

MEASUREMENT OF FORMALDEHYDE

There are numerous methods for determining the concentration of formaldehyde in air in the workplace. The following is a brief summary of some of the methods.

TABLE 2 - Formaldehyde Analytical Methods

| Method I.D. | Sampling Method | Purpose of Sample* |
|-----------------|--------------------------------|--------------------|
| OSHA 52 | Coated XAD-2 tube | TWA or STEL |
| OSHA ID-205 | Passive dosimeter | TWA |
| Airscan Monitor | Dosimeter (length-of-stain) | TWA |
| Detector Tubes | Colorimetric (length-of-stain) | Grab |
| Miran 1A | Non-dispersive infra-red | STEL |

* TWA = time-weighted average (usually 8 hours) STEL = Short Term Exposure Limit (15 minutes)

Grab = short or instantaneous sample

IMPLICATIONS

Reliable methods are available for measuring formaldehyde concentrations. Employers are required to determine if their employees are exposed to formaldehyde. This can only be done through use of one or more of the available methods.

REFERENCES

1. Philip H. Howard, *Handbook of Environmental Fate and Exposure Data for Organic Chemicals, Volume 1 - Large Production and Priority Pollutants*. Chelsea, MI, Lewis Publishers, 1989.
2. "Formaldehyde: Evidence of Carcinogenicity," *NIOSH Current Intelligence Bulletin No. 34*. Cincinnati, National Institute for Occupational Safety and Health, 1981.
3. M. Gough et al., "Report on the Consensus Workshop on Formaldehyde," *Environmental Health Perspectives* v. 58 (1984): 324-380.
4. *Odor Thresholds for Chemicals with Established Occupational Health Standards*. Akron, OH, American Industrial Hygiene Association, 1989, p. 60.
5. "Occupational Exposure to Formaldehyde: Final Rule," 29 CFR 1910.1048. Washington, Occupational Safety and Health Administration, effective dates vary, [57 FR 22290, May 27, 1992].
6. *1993-1994 Threshold Limit Values for Chemical Substances and Physical Agents*. Cincinnati, American Conference of Governmental Industrial Hygienists, 1993.
7. *Documentation of the Threshold Limit Values and Biological Exposure Indices*, 6th ed. Cincinnati, American Conference of Governmental Industrial Hygienists, 1991.
8. "Occupational Safety and Health Guideline for Formaldehyde," in *Occupational Safety and Health Guidelines for Chemical Hazards*. Cincinnati, National Institute for Occupational Safety and Health, 1988.
9. *NIOSH Pocket Guide to Chemical Hazards*. Cincinnati, National Institute for Occupational Safety and

Health, 1990.

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