

OCCUPATIONAL SAFETY AND HEALTH GUIDELINE FOR FORMALDEHYDE POTENTIAL HUMAN CARCINOGEN

INTRODUCTION

This guideline summarizes pertinent information about formaldehyde for workers, employers, and occupational safety and health professionals who may need such information to conduct effective occupational safety and health programs. Recommendations may be superseded by new developments in these fields; therefore, readers are advised to regard these recommendations as general guidelines.

SUBSTANCE IDENTIFICATION

- **Formula:** CH₂O
- **Structure:** CH₂=O
- **Synonyms:** Formalin, methanal, methyl aldehyde, methylene glycol, methylene oxide, morbidic, paraform, superlysoform
- **Identifiers:** CAS 50-00-0; RTECS LP8925000; DOT 1198 and 2209, label required: "Combustible Liquid"
- **Appearance and odor:** Colorless gas with a pungent and irritating odor at ambient temperatures; also, commercially available at 30% to 55% formaldehyde in aqueous solution (formalin)

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**
 1. Molecular weight: 30.03
 2. Boiling point (at 760 mmHg): -19.5°C (-3.06°F); 98°C (208°F) for 37% formaldehyde (15% methanol)
 3. Specific gravity at 20°C (water = 1): 0.815; 1.075-1.081 for 37% formaldehyde (15% methanol)
 4. Vapor density (air = 1 at boiling point of formaldehyde): 1.07
 5. Melting point: -92°C (-133.5°F); -15°C (5°F) for 37% formaldehyde (15% methanol)
 6. Vapor pressure at -88°C (-126.3°F): 10 mmHg
 7. Soluble in water
 8. Ionization potential: 10.88 eV
- **Reactivity**
 1. Incompatibilities: Formaldehyde reacts violently with strong oxidants and alkaline materials.

2. Hazardous decomposition products: Toxic vapors and gases (e.g., carbon monoxide) may be released in a fire involving formaldehyde.

3. Caution: Formaldehyde should not be stored in confined spaces or near open flames, and containers should be protected from physical damage. Formaldehyde may react with hydrogen chloride to form bis-chloromethyl ether, a carcinogen.

- **Flammability**

1. Flash point: 50°C (122°F) for 37% formaldehyde (15% methanol) (closed cup); 85°C (185°F) for 37% formaldehyde (methanol free) (closed cup)
2. Autoignition temperature: 430°C (806°F) for 37% formaldehyde (methanol free)
3. Flammable limits in air, % by volume: Lower, 7; upper, 73
4. Extinguishant: Dry chemical, alcohol foam, carbon dioxide, or water spray (mist)
5. Class II Combustible Liquid (29 CFR 1910.106), Flammability Rating 2 (NFPA) for 37% formaldehyde (15% methanol); Class IIIA Combustible Liquid (29 CFR 1910.106), Flammability Rating 4 (NFPA) for 37% formaldehyde (methanol free)

- **Warning properties**

1. Odor threshold: 0.8 ppm
2. Eye irritation levels: In acclimated workers, mild to unpleasant irritation occurs at 2-10 ppm, and intolerable irritation (tissue damage possible) occurs at levels above 25 ppm.
3. Evaluation of warning properties for respirator selection: Warning properties are not considered in recommending respirators for use with carcinogens.

EXPOSURE LIMITS

The current Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for formaldehyde is 1 part of formaldehyde per million parts of air (ppm) as a time-weighted average (TWA) concentration over an 8-hour workshift; the OSHA short-term exposure limit (STEL) is 2 ppm for any 15-minute sampling period (see 29 CFR 1910.1048). The National Institute for Occupational Safety and Health (NIOSH) recommended exposure limit (REL) is 0.016 ppm [0.02 milligram of formaldehyde per cubic meter of air (mg/m³)] as an 8-hour TWA and 0.1 ppm (0.15 mg/m³) as a ceiling concentration determined in any 15-minute sampling

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period. This REL represents the lowest reliably quantifiable concentration at the present time. The American Conference of Governmental Industrial Hygienists (ACGIH) has designated formaldehyde as an A2 substance (suspected human carcinogen) having an assigned threshold limit value (TLV®) of 1 ppm (1.5 mg/m³) as a TWA for a normal 8-hour workday and a 40-hour workweek; the ACGIH short-term exposure limit (STEL) is 2 ppm (3 mg/m³) (Table 1).

Table 1.—Occupational exposure limits for formaldehyde

	Exposure Limits	
	ppm	mg/m ³
OSHA PEL TWA	1	—
STEL (15 min)	2	—
NIOSH REL TWA (Ca)*	0.016	0.02
Ceiling (15 min)	0.1	0.12
ACGIH TLV® TWA (A2)†	1	1.5
STEL (A2)	2	3

* (Ca): NIOSH recommends treating as a potential human carcinogen.

† (A2): Suspected human carcinogen.

HEALTH HAZARD INFORMATION

• Routes of exposure

Formaldehyde may cause adverse health effects following exposure via inhalation, ingestion, or dermal or eye contact.

• Summary of toxicology

1. *Effects on animals*: Chronic inhalation of formaldehyde by rats produced cancer of the nasal cavity.

2. *Effects on humans*: Acute inhalation of formaldehyde has caused bronchitis, pulmonary edema, pneumonitis, pneumonia, and death due to respiratory failure. Formaldehyde solutions have caused eye burns, permanent corneal opacification, and loss of vision.

Signs and symptoms of exposure

1. *Short-term (acute)*: Exposure to formaldehyde gas can cause irritation of the eyes and respiratory tract, tearing, coughing, dry throat, tightening of the chest, headache, sensation of pressure in the head, and palpitations of the heart. Ingestion of formaldehyde can cause irritation of the mouth, throat, and stomach, nausea, vomiting, convulsions, and coma.

2. *Long-term (chronic)*: Exposure to formaldehyde can cause dermatitis and sensitization of the skin and respiratory tract.

RECOMMENDED MEDICAL PRACTICES

• Medical surveillance program

Workers with potential exposures to chemical hazards should be monitored in a systematic program of medical surveillance intended to prevent or control occupational injury and disease. The program should include education of employers and work-

ers about work-related hazards, placement of workers in jobs that do not jeopardize their safety and health, earliest possible detection of adverse health effects, and referral of workers for diagnostic confirmation and treatment. The occurrence of disease (a "sentinel health event," SHE) or other work-related adverse health effects should prompt immediate evaluation of primary preventive measures (e.g., industrial hygiene monitoring, engineering controls, and personal protective equipment). A medical surveillance program is intended to supplement, not replace, such measures.

A medical surveillance program should include systematic collection and epidemiologic analysis of relevant environmental and biologic monitoring, medical screening, morbidity, and mortality data. This analysis may provide information about the relatedness of adverse health effects and occupational exposure that cannot be discerned from results in individual workers. Sensitivity, specificity, and predictive values of biologic monitoring and medical screening tests should be evaluated on an industry-wide basis prior to application in any given worker group. Intrinsic to a surveillance program is the dissemination of summary data to those who need to know, including employers, occupational health professionals, potentially exposed workers, and regulatory and public health agencies.

• Preplacement medical evaluation

Prior to placing a worker in a job with a potential for exposure to formaldehyde, the physician should evaluate and document the worker's baseline health status with thorough medical, environmental, and occupational histories, a physical examination, and physiologic and laboratory tests appropriate for the anticipated occupational risks. These should concentrate on the function and integrity of the eyes, skin, and respiratory system. Medical surveillance for respiratory disease should be conducted by using the principles and methods recommended by NIOSH and the American Thoracic Society (ATS).

A preplacement medical evaluation is recommended in order to detect and assess preexisting or concurrent conditions which may be aggravated or result in increased risk when a worker is exposed to formaldehyde. The examining physician should consider the probable frequency, intensity, and duration of exposure, as well as the nature and degree of the condition, in placing such a worker. Such conditions, which should not be regarded as absolute contraindications to job placement, include a history of asthma or of chronic skin disease, concurrent dermatitis, and significant breathing impairment due to preexisting chronic lung disease. Skin patch testing with formaldehyde is *not* recommended because of the risk of sensitization.

• Periodic medical screening and/or biologic monitoring

Occupational health interviews and physical examinations should be performed at regular intervals. Additional examinations may be necessary should a worker develop symptoms that may be attributed to exposure to formaldehyde. The interviews, examinations, and appropriate medical screening and/or biologic monitoring tests should be directed at identifying an ex-

cessive decrease or adverse trend in the physiologic function of the eyes, skin, and respiratory system as compared to the baseline status of the individual worker or to expected values for a suitable reference population. The following tests should be used and interpreted according to standardized procedures and evaluation criteria recommended by NIOSH and ATS: standardized questionnaires and pre- and post-shift tests of lung function. Because formaldehyde gas is rapidly metabolized to naturally occurring compounds in the nasopharyngeal tissues and therefore does not accumulate in the blood, biologic monitoring would not be effective in detecting the presence of formaldehyde or its metabolites in the blood or urine.

- **Medical practices recommended at the time of job transfer or termination**

The medical, environmental, and occupational history interviews, the physical examination, and selected physiologic and laboratory tests which were conducted at the time of placement should be repeated at the time of job transfer or termination. Any changes in the worker's health status should be compared to those expected for a suitable reference population. Because occupational exposure to formaldehyde may cause diseases of prolonged induction-latency, the need for medical surveillance may extend well beyond termination of employment.

- **Sentinel health events**

1. Acute SHE's include: Extrinsic asthma and allergic and/or contact dermatitis.
2. Delayed-onset SHE's include: Extrinsic asthma.

MONITORING AND MEASUREMENT PROCEDURES

- **TWA exposure evaluation**

Measurements to determine worker exposure to formaldehyde should be taken so that the TWA exposure is based on a single entire workshift sample or an appropriate number of consecutive samples collected during the entire workshift. Under certain conditions, it may be appropriate to collect several short-term interval samples (up to 30 minutes each) to determine the average exposure level. Air samples should be taken in the worker's breathing zone (air that most nearly represents that inhaled by the worker).

- **Ceiling concentration evaluation**

Measurements to determine worker exposure should be taken during periods of maximum expected airborne concentrations of formaldehyde. Each measurement to determine the NIOSH REL (ceiling exposure) in the worker's breathing zone (air that most nearly represents that inhaled by the worker) should consist of a 15-minute sample or a series of consecutive samples that total 15 minutes. A minimum of three measurements should be taken during one workshift, and the highest of all measurements taken is an estimate of the worker's exposure. If the periods of maximum exposure are not clearly defined, a statistical procedure which can be used as a peak exposure detection strategy is given in the *Occupational Exposure Sampling Strategy Manual*.

- **Method**

Sampling and analysis may be performed by collecting formaldehyde with solid sorbent tubes filled with 2-(benzylamino) ethanol on Chromosorb 102 or XAD-2, followed by desorption with isooctane, ultrasonic bath, or shaking, and analyzing by using a gas chromatograph with a hydrogen-air flame ionization detector. Direct reading devices calibrated to measure formaldehyde may also be used if available. A detailed sampling and analytical method for formaldehyde may be found in the *NIOSH Manual of Analytical Methods* (method number 2502).

PERSONAL PROTECTIVE EQUIPMENT

Chemical protective clothing (CPC) should be selected after utilizing available performance data, consulting with the manufacturer, and then evaluating the clothing under actual use conditions.

Workers should be provided with and required to use CPC, gloves, and other appropriate protective clothing necessary to prevent skin contact with formaldehyde.

SANITATION

Clothing which is contaminated with formaldehyde should be removed immediately and placed in sealed containers for storage until it can be discarded or until provision is made for the removal of formaldehyde from the clothing. If the clothing is to be laundered or cleaned, the person performing the operation should be informed of formaldehyde's hazardous properties. Reusable clothing and equipment should be checked for residual contamination before reuse or storage.

A change room with showers, washing facilities, and lockers that permit separation of street and work clothes should be provided.

Workers should be required to shower following a workshift and prior to putting on street clothes. Clean work clothes should be provided daily.

Skin that becomes contaminated with formaldehyde should be promptly washed with soap and water.

The storage, preparation, dispensing, or consumption of food or beverages, the storage or application of cosmetics, the storage or smoking of tobacco or other smoking materials, or the storage or use of products for chewing should be prohibited in work areas.

Workers who handle formaldehyde should wash their faces, hands, and forearms thoroughly with soap and water before eating, smoking, or using toilet facilities.

COMMON OPERATIONS AND CONTROLS

Common operations in which exposure to formaldehyde may occur and control methods which may be effective in each case are listed in Table 2.

Table 2.—Operations and methods of control for formaldehyde

Operations	Controls
During the synthesis and handling of formaldehyde resins; during the synthesis of chelating agents and dyes	Process enclosure, local exhaust ventilation, personal protective equipment
During use in textile manufacturing and handling and in tanning operations	Process enclosure, local exhaust ventilation, personal protective equipment
During the manufacture of particle board, soft wood plywood, sandpaper, and grinding wheels	Process enclosure, local exhaust ventilation, personal protective equipment
During use as an embalming fluid	Process enclosure, local exhaust ventilation, personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, remove the victim from further exposure, send for medical assistance, and initiate emergency procedures.

• Eye exposure

Where there is any possibility of a worker's eyes being exposed to formaldehyde, an eye-wash fountain should be provided within the immediate work area for emergency use.

If formaldehyde gets into the eyes, flush them immediately with large amounts of water for 15 minutes, lifting the lower and upper lids occasionally. Get medical attention as soon as possible. Contact lenses should not be worn when working with this chemical.

• Skin exposure

Where there is any possibility of a worker's body being exposed to formaldehyde, facilities for quick drenching of the body should be provided within the immediate work area for emergency use.

If formaldehyde gets on the skin, wash it immediately with soap and water. If formaldehyde penetrates the clothing, remove the clothing immediately and wash the skin with soap and water. Get medical attention promptly.

• Rescue

If a worker has been incapacitated, move the affected worker from the hazardous exposure. Put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILLS AND LEAKS

Workers not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.

If formaldehyde is spilled or leaked, the following steps should be taken:

1. If formaldehyde is in the gaseous form, stop the flow of gas. If the source of the leak is a cylinder and the leak cannot be stopped in place, remove the leaking cylinder to an area with local exhaust ventilation and repair the leak or allow the cylinder to empty.
2. Remove all ignition sources.
3. Ventilate area of spill or leak.
4. For small quantities of liquids containing formaldehyde, absorb on paper towels and place in an appropriate container.
5. Large quantities of liquids containing formaldehyde may be absorbed in vermiculite, dry sand, earth, or a similar material and placed in an appropriate container.
6. Liquids containing formaldehyde may be collected by vacuuming with an appropriate system. If a vacuum system is used to remove formaldehyde, there should be no sources of ignition in the vicinity of the spill, and flashback prevention devices should be provided.

WASTE REMOVAL AND DISPOSAL

U.S. Environmental Protection Agency, Department of Transportation, and/or state and local regulations shall be followed to assure that removal, transport, and disposal are in accordance with existing regulations.

RESPIRATORY PROTECTION

It must be stressed that the use of respirators is the least preferred method of controlling worker exposure and should not normally be used as the only means of preventing or minimizing exposure during routine operations. However, there are some exceptions for which respirators may be used to control exposure: when engineering and work practice controls are not technically feasible, when engineering controls are in the process of being installed, or during emergencies and certain maintenance operations, including those requiring confined-space entry (Table 3).

In addition to respirator selection, a complete respiratory protection program should be instituted which as a minimum complies with the requirements found in the OSHA Safety and Health Standards, 29 CFR 1910.134. A respiratory protection program should include as a minimum an evaluation of the worker's ability to perform the work while wearing a respirator, the regular training of personnel, fit testing, periodic environmental monitoring, maintenance, inspection, and cleaning. The implementation of an adequate respiratory protection program, including selection of the correct respirators, requires that a knowledgeable person be in charge of the program and that the program be evaluated regularly.

Only respirators that have been approved by the Mine Safety and Health Administration (MSHA, formerly Mining Enforcement and Safety Administration) and by NIOSH should be used. **Remember! Air-purifying respirators will not protect from oxygen-deficient atmospheres.**

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Table 3.—Respiratory protection for formaldehyde

Condition	Minimum respiratory protection*
Any detectable concentration	Any self-contained breathing apparatus with a full facepiece and operated in a pressure-demand or other positive pressure mode Any supplied-air respirator with a full facepiece and operated in a pressure-demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in a pressure-demand or other positive pressure mode
Planned or emergency entry into environments containing unknown or any detectable concentration	Any self-contained breathing apparatus with a full facepiece and operated in a pressure-demand or other positive pressure mode Any supplied-air respirator with a full facepiece and operated in a pressure-demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in a pressure-demand or other positive pressure mode
Firefighting	Any self-contained breathing apparatus with a full facepiece and operated in a pressure-demand or other positive pressure mode
Escape only	Any air-purifying full facepiece respirator (gas mask) with a chin-style or front- or back-mounted organic vapor canister Any appropriate escape-type self-contained breathing apparatus

* Only NIOSH/MSHA-approved equipment should be used.