

OCCUPATIONAL SAFETY AND HEALTH GUIDELINE FOR CYCLOHEXANONE

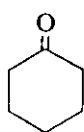
INTRODUCTION

This guideline summarizes pertinent information about cyclohexanone 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 Recommendations may be superseded by new developments in these fields; therefore, readers are advised to regard these recommendations as general guidelines.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:** C₆H₁₀O

• **Structure:**



• **Synonyms:** Anone, hexanon, ketoexamethylene, nadone, pimelic ketone, pimelin ketone

• **Identifiers:** CAS 108-94-1; RTECS GW1050000; DOT 1915, label required: "Flammable Liquid"

• **Appearance and odor:** Colorless to slightly yellow liquid with an odor like peppermint

CHEMICAL AND PHYSICAL PROPERTIES

• Physical data

1. Molecular weight: 98.16
2. Boiling point (at 760 mmHg): 155.6°C (312°F)
3. Specific gravity (water = 1): 0.95
4. Vapor density (air = 1 at boiling point of cyclohexanone): 3.4
5. Melting point: -47°C (-52.6°F)
6. Vapor pressure at 20°C (68°F): 2 mmHg; at 25°C (77°F), 4.5 mmHg
7. Slightly soluble in water
8. Evaporation rate (butyl acetate = 1): 0.23
9. Saturation concentration in air (approximate) at 20°C (68°F): 0.26% (2,600 ppm); at 25°C (77°F), 0.60% (6,000 ppm)
10. Ionization potential: 9.14 eV

• Reactivity

1. Incompatibilities: Cyclohexanone may react with oxidizing agents and nitric acid causing fires and explosions.
2. Hazardous decomposition products: Toxic vapors and gases (e.g., carbon monoxide) may be released in a fire involving cyclohexanone.
3. Caution: Cyclohexanone will dissolve most plastics, resins, and rubber.

• Flammability

1. Flash point: 43.9°C (111°F) (closed cup)
2. Autoignition temperature: 420°C (788°F)
3. Flammable limits in air, % by volume: Lower, 1.1; Upper, 9.4
4. Extinguishant: Alcohol foam, dry chemical, or carbon dioxide
5. Class II Combustible Liquid (29 CFR 1910.106), Flammability Rating 2 (NFPA)

• Warning properties

1. Odor threshold: 0.88 ppm
2. Eye irritation level: 75 ppm
3. Evaluation of warning properties for respirator selection: Because of its odor, cyclohexanone can be detected at concentrations below the National Institute for Occupational Safety and Health (NIOSH) recommended exposure limit (REL); thus, it is treated as a chemical with adequate warning properties.

EXPOSURE LIMITS

The current Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for cyclohexanone is 50 parts of cyclohexanone per million parts of air (ppm) [200 milligrams of cyclohexanone per cubic meter of air (mg/m³)] as a time-weighted average (TWA) concentration over an 8-hour workshift. The NIOSH REL is 25 ppm (100 mg/m³) as a TWA for up to a 10-hour workshift, 40-hour workweek. The American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit value (TLV[®]) is 25 ppm (100 mg/m³) (Skin) as a TWA for a normal 8-hour workday and a 40-hour workweek (Table I).

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health
Division of Standards Development and Technology Transfer

Table 1.—Occupational exposure limits for cyclohexanone

	Exposure limits	
	ppm	mg/m ³
OSHA PEL TWA	50	200
NIOSH REL TWA	25	100
ACGIH TLV [®] TWA (Skin)	25	100

HEALTH HAZARD INFORMATION

• Routes of exposure

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

• Summary of toxicology

Effects on animals: Subchronic inhalation of cyclohexanone by rabbits and monkeys caused central nervous system depression and liver and kidney degeneration. Cutaneous or subcutaneous application of cyclohexanone for several days caused cataracts in guinea pigs.

• Signs and symptoms of exposure

1. *Short-term (acute):* Exposure to cyclohexanone can cause dizziness and unconsciousness. Irritation of the eyes, nose, and throat can also occur.

2. *Long-term (chronic):* Dermal exposure to cyclohexanone can cause dryness, irritation, and inflammation of the skin.

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 workers 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 cyclohexanone, 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, liver, kidneys, 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 cyclohexanone at or below the NIOSH REL. 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 contraindication to job placement, include concurrent dermatitis or a history of chronic skin disease.

• 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 cyclohexanone. The interviews, examinations, and appropriate medical screening and/or biologic monitoring tests should be directed at identifying an excessive decrease or adverse trend in the physiologic function of the eyes, skin, liver, kidneys, and nervous and respiratory systems 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 the ATS: standardized questionnaires and tests of lung function.

• 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.

• Sentinel health events

Acute SHE's include: Contact and/or allergic dermatitis.

MONITORING AND MEASUREMENT PROCEDURES

• TWA exposure evaluation

Measurements to determine worker exposure to cyclohexanone 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 cer-

tain 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).

• **Method**

Sampling and analysis may be performed by collecting cyclohexanone vapors with charcoal tubes followed by desorption with carbon disulfide and analysis by gas chromatography. Detector tubes or other direct-reading devices calibrated to measure cyclohexanone may also be used if available. A detailed sampling and analytical method for cyclohexanone may be found in the *NIOSH Manual of Analytical Methods* (method number 1300).

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, face shields (8-inch minimum), and other appropriate protective clothing necessary to prevent skin contact with cyclohexanone.

Workers should be provided with and required to use splash-proof safety goggles where cyclohexanone may come in contact with the eyes.

SANITATION

Clothing which is contaminated with cyclohexanone should be removed immediately and placed in closed containers for storage until it can be discarded or until provision is made for the removal of cyclohexanone from the clothing. If the clothing is to be laundered or cleaned, the person performing the operation should be informed of cyclohexanone's hazardous properties.

Change and shower rooms should be provided with separate locker facilities for street and work clothes.

Skin that becomes contaminated with cyclohexanone 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 cyclohexanone 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 cyclohexanone 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 cyclohexanone

Operations	Controls
During surface coating or spray painting of fabrics and plastics	Local exhaust ventilation, personal protective equipment
During cleaning of leathers and textiles; during degreasing of leathers and metals	Local exhaust ventilation, personal protective equipment
During use as a solvent in crude rubber, insecticides, and epoxy resins; during use as a sludge solvent in lubricating oils	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 cyclohexanone, an eye-wash fountain should be provided within the immediate work area for emergency use.

If cyclohexanone 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 cyclohexanone, facilities for quick drenching of the body should be provided within the immediate work area for emergency use.

If cyclohexanone gets on the skin, wash it immediately with soap and water. If cyclohexanone 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 cyclohexanone is spilled or leaked, the following steps should be taken:

1. Remove all ignition sources.
2. Ventilate area of spill or leak.
3. For small quantities of liquids containing cyclohexanone, absorb on paper towels and place in an appropriate container. Place towels in a safe place (such as a fume hood) for evaporation. Allow sufficient time for evaporation of the vapors so that the hood ductwork is free from cyclohexanone vapors. Burn the paper in a suitable location away from combustible materials.
4. Large quantities of liquids containing cyclohexanone may be absorbed in vermiculite, dry sand, earth, or a similar material and placed in an appropriate container. Cyclohexanone should not be allowed to enter a confined space such as a sewer because of the possibility of an explosion.
5. Cyclohexanone may be collected by vacuuming with an appropriate system. If a vacuum system is used, 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.**

For each level of respiratory protection, only those respirators that have the minimum required protection factor and meet

other use restrictions are listed. All respirators that have higher protection factors may also be used.

BIBLIOGRAPHY

- American Conference of Governmental Industrial Hygienists: "Cyclohexanone," *Documentation of the Threshold Limit Values and Biological Exposure Indices* (5th ed.), Cincinnati, 1986.
- American Conference of Governmental Industrial Hygienists: *TLVs® Threshold Limit Values and Biological Exposure Indices for 1987-88*, Cincinnati, 1987.
- American Industrial Hygiene Association: "Cyclohexanone" (rev. 1980), *Hygienic Guide Series*, Detroit, 1980.
- American Lung Association of San Diego and Imperial Counties: "Taking the Occupational History," *Annals of Internal Medicine*, 99:641-651, November 1983.
- Amoores, J.E., and Hautala, E.: "Odor as an Aid to Chemical Safety: Odor Thresholds Compared with Threshold Limit Values and Volatilities for 214 Industrial Chemicals in Air and Water Dilution," *Journal of Applied Toxicology*, 3:272-290, 1983.
- Browning, E.: *Toxicology and Metabolism of Industrial Solvents*, Elsevier Publishing Co., New York, 1965.
- Clayton, G.D., and Clayton, F.E. (eds.): *Toxicology*, Vol. IIC of *Patty's Industrial Hygiene and Toxicology* (3rd rev. ed.), John Wiley & Sons, Inc., New York, 1982.
- *Code of Federal Regulations*, U.S. Department of Labor, Occupational Safety and Health Administration, 29 CFR 1910.106, 1910.134, 1910.1000, OSHA 2206, revised, July 1, 1986.
- *Code of Federal Regulations*, U.S. Department of Transportation, 49 CFR 172.101, Transportation 49, revised October 1, 1982.
- Deichmann, W.B., and Gerarde, H.W.: *Toxicology of Drugs and Chemicals*, Academic Press, New York, 1969.
- Goldman, R.H., and Peters, J.M.: "The Occupational and Environmental Health History," *Journal of the American Medical Association*, 246:2831-2836, 1981.
- Grant, W.M.: *Toxicology of the Eye* (2nd ed.), Charles C. Thomas, Springfield, Illinois, 1974.
- Halperin, W.E., Ratcliffe, J., Frazier, T.M., Wilson, L., Becker, S.P., and Shulte, P.A.: "Medical Screening in the Workplace: Proposed Principles," *Journal of Occupational Medicine*, 28(8): 547-552, 1986.
- Hankinson, J.L.: "Pulmonary Function Testing in the Screening of Workers: Guidelines for Instrumentation, Performance, and Interpretation," *Journal of Occupational Medicine*, 28(10):1081-1092, 1986.
- Leidel, N.A., Busch, K.A., and Lynch, J.R.: *Occupational Exposure Sampling Strategy Manual*, U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 77-173, Cincinnati, 1977.
- Levy, B.S., and Wegman, D.H. (eds.): *Occupational Health: Recognizing and Preventing Work-Related Disease*, Little, Brown and Company, Boston, 1983.

- National Fire Protection Association: *Fire Protection Guide on Hazardous Materials* (7th ed., 6th printing), Quincy, Massachusetts, 1978.
- National Institute for Occupational Safety and Health, U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control: *Criteria for a Recommended Standard. . . Occupational Exposure to Ketones*, DHEW (NIOSH) Publication No. 78-173, Cincinnati, 1978.
- National Institute for Occupational Safety and Health, U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control: *NIOSH Manual of Analytical Methods* (3rd ed., Vol. 1), Eller, P.M. (ed.), DHHS (NIOSH) Publication No. 84-100, Cincinnati, 1984.
- National Institute for Occupational Safety and Health, U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control: *Registry of Toxic Effects of Chemical Substances* (Microfiche Edition), Sweet, D.V., and Lewis, R.J. (eds.), Cincinnati, April 1985.
- Proctor, N.H., and Hughes, J.P.: *Chemical Hazards of the Workplace*, J.B. Lippincott Company, Philadelphia, 1978.
- Rom, W.N. (ed.): *Environmental and Occupational Medicine*, Little, Brown and Company, Boston, 1983.
- Rothstein, M.A.: *Medical Screening of Workers*, Bureau of National Affairs, Washington, DC, 1984.
- Rutstein, D.D., Mullan, R.J., Frazier, T.M., Halperin, W.E., Melius, J.M., and Sestito, J.P.: "Sentinel Health Events (Occupational): A Basis for Physician Recognition and Public Health Surveillance," *American Journal of Public Health*, 73:1054-1062, 1983.
- U.S. Department of Transportation, Coast Guard: *CHRIS Hazardous Chemical Data*, GPO Stock No. 050-012-00147-2, 1978.

Table 3.—Respiratory protection for cyclohexanone

Condition	Minimum respiratory protection*†
Concentration:	
Less than or equal to 625 ppm	Any supplied-air respirator operated in a continuous flow mode (substance causes eye irritation or damage—eye protection needed) Any powered air-purifying respirator with organic vapor cartridge(s) (substance causes eye irritation or damage—eye protection needed)
Less than or equal to 1,000 ppm	Any chemical cartridge respirator with a full facepiece and organic vapor cartridge(s)
Less than or equal to 1,250 ppm	Any air-purifying full facepiece respirator (gas mask) with a chin-style or front- or back-mounted organic vapor canister Any self-contained breathing apparatus with a full facepiece Any supplied-air respirator with a full facepiece
Less than or equal to 5,000 ppm	Any supplied-air respirator with a full facepiece and operated in a pressure-demand or other positive pressure mode
Planned or emergency entry into environments containing unknown concentrations or levels above 5,000 ppm	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 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.

†The respiratory protection listed for any given condition is the minimum required to meet the NIOSH REL of 25 ppm (100 mg/m³) (TWA).

