

NIOSH/OSHA STANDARDS COMPLETION PROGRAM

DRAFT TECHNICAL STANDARD AND
SUPPORTING DOCUMENTATION FOR

*** 2-HEXANONE ***

NIOSH/OSHA Draft Technical Standard
and Supporting Documentation for 2-HEXANONE

The basic text of this document contains the draft technical standard approved by the Joint Review Committee of the NIOSH/OSHA Standards Completion Program and the supporting documentation for the substance 2-HEXANONE.

The SCP draft technical standards are recommendations to the Department of Labor for its consideration in rulemaking and have no legal status until final rules have been promulgated by that agency. This draft standard is provided for your information only.

The References and Sources, Respirator Table Documentation and Use/Exposure and Control Documentation are the working documents used by the various SCP working groups during the development of the draft technical standard and serve as the technical foundation for the standard. The classification for each substance and the regulatory statements were derived following a decision logic established for the various sections of the standard.

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(a) Definitions. (1) "Permissible exposure" means exposure of employees to airborne concentrations of 2-hexanone not in excess of 100 parts per million (ppm) (410 milligrams per cubic meter (mg/M3)), averaged over an eight-hour work shift (time weighted average), as stated in § 1910.1000, Table Z-1.

(2) "Action level" means one half of the permissible exposure for 2-hexanone.

(b) Exposure determination and measurement. (1) Each employer who has a place of employment in which 2-hexanone is released into the workplace air shall determine if any employee may be exposed to airborne concentrations of 2-hexanone at or above the action level. The determination shall be made each time there is a change in production, process, or control measures which could result in an increase in airborne concentrations of 2-hexanone.

(2) A written record of the determination shall be made and shall contain at least the following information:

(i) Any information, observations, or calculations which may indicate employee exposure to 2-hexanone;

(ii) Any measurements of 2-hexanone taken;

(iii) Any employee complaints of symptoms which may be attributable to exposure to 2-hexanone; and

(iv) Date of determination, work being performed at the time, location within work site, name, and social security number of each employee considered.

(3) If the employer determines that any employee may be exposed to 2-hexanone at or above the action level, the exposure of the employee in each work operation who is believed to have the greatest exposure shall be measured. The exposure measurement shall be representative of the maximum eight-hour time weighted average exposure of the employee.

(4) If the exposure measurement taken pursuant to paragraph (b) (3) of this section reveals employee exposure to 2-hexanone at or above the action level, the employer shall:

(i) Identify all employees who may be exposed at or above the action level; and

(ii) Measure the exposure of the employees so identified.

(5) If an employee exposure measurement reveals that an employee is exposed to 2-hexanone at or above the action level, but not above the permissible exposure, the exposure of that employee shall be measured at least every two months.

(6) If an employee exposure measurement reveals that an employee is exposed to 2-hexanone above the permissible exposure, the employer shall:

(i) Measure the exposure monthly of the employee so exposed; and

(ii) Institute control measures as required by paragraph (d) of this section; and

(iii) Individually notify, in writing, within five days, every employee who is found to be exposed to 2-hexanone above the permissible exposure. The employee shall also be notified of the corrective action being taken to reduce the exposure to at or below the permissible exposure.

(7) If two consecutive employee exposure measurements taken at least one week apart reveal that the employee is exposed to 2-hexanone below the action level, the employer may terminate measurement for the employee.

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(8) For purposes of this paragraph, employee exposure is that which would occur if the employee were not using a respirator.

(c) Methods of measurement. (1) An employee's exposure shall be obtained by any combination of long term or short term samples which represents the employee's actual exposure averaged over an eight-hour work shift (See Appendix B (iv) of this section).

(2) The method of measurement shall have an accuracy, to a confidence level of 95 percent, of not less than that given in Table 1.

Table 1

Concentration	Required Accuracy
Above permissible exposure	$\pm 25\%$
At or below permissible exposure and above the action level	$\pm 35\%$

At or below the action level $\pm 50\%$

(d) Compliance. (1) No employee shall be exposed to 2-hexanone above the permissible exposure as defined in paragraph (a)(1) of this section.

(2) Employee exposures to airborne concentrations of 2-hexanone shall be controlled to at or below the permissible exposure by engineering and work practice controls:

(i) Engineering and work practice controls shall be instituted to reduce exposures to at or below the permissible exposure, except to the extent that such controls are not technically feasible.

(ii) Wherever engineering and work practice controls are not sufficient to reduce exposures to at or below the permissible exposure, they shall nonetheless be used to reduce exposure to the lowest level feasible and shall be supplemented by respirators in accordance with paragraph (d)(4) of this section.

(3) Engineering controls. (i) When mechanical ventilations is used to control exposure, measurements which demonstrate system effectiveness, for example, air velocity, static pressure, or air volume, shall be made at least every three months. Measurements of system effectiveness shall also be made within five days of any change in production, process, or control which might result in an increase in airborne concentrations of 2-hexanone.

(ii) In the design of open surface tank ventilation for the purposes of § 1910.94(d), operations involving 2-hexanone shall be classified as B-2 at 70 degrees F (21 degrees C).

(4) Compliance with the permissible exposure shall not be achieved by the use of respirators except:

(i) During the time period necessary to install or implement engineering or work practice controls; or

(ii) In work situations in which engineering and work practice controls are technically not feasible; or

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(iii) To supplement engineering and work practice controls when such controls fail to reduce airborne concentrations of 2-hexanone to at or below the permissible exposure; or

(iv) For operations which require entry into tanks or closed vessels; or

(v) In emergencies.

(5) Where respirators are needed and permitted under this paragraph to reduce employee exposure, the employer shall select and provide the appropriate respirator from Table 2 and shall ensure that the employee uses the respirator provided.

TABLE 2 RESPIRATORY PROTECTION FOR 2-HEXANONE

CONDITION	PERMISSIBLE RESPIRATORY PROTECTION
Vapor Concentration	
1000 ppm or less	Any chemical cartridge respirator with an organic vapor cartridge(s).
	Any supplied-air respirator.
	Any self-contained breathing apparatus.
5000 ppm or less	A gas mask with a chin-style or a front- or back-mounted organic vapor canister.
	Any supplied-air respirator with a full facepiece, helmet or hood.
	Any self-contained breathing apparatus with a full facepiece.
Greater than 5000 ppm or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
	A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
Escape	Any gas mask providing protection against organic vapors.
	Any escape self-contained breathing apparatus.

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(6) Respirators shall be approved by the Mining Enforcement and Safety Administration (formerly Bureau of Mines) or by the National Institute for Occupational Safety and Health under the provisions of 30 CFR Part 11.

(7) The employer shall institute a respiratory protection program in accordance with § 1910.134(b), (d), (e), and (f).

(e) Fire and safety. (1) The employer shall familiarize himself with the information contained in the Substance Technical Guidelines (Appendix B of this section) for 2-hexanone.

(2) For the purpose of compliance with § 1910.309, locations classified as hazardous locations due to the presence of 2-hexanone shall be Class I, Group D.

(3) For the purpose of compliance with § 1910.157, 2-hexanone is classified as a Class B fire hazard.

(4) For the purpose of compliance with § 1910.178, locations classified as hazardous locations due to the presence of 2-hexanone shall be Class I, Group D.

(5) For the purpose of compliance with § 1910.106, liquid 2-hexanone is classified as a Class IC flammable liquid.

(6) Spray finishing operations shall be performed in accordance with §§ 1910.107 and 1910.94(c).

(7) Dip tank operations shall be performed in accordance with §§ 1910.108 and 1910.94(d).

(8) Where a fan is located in ductwork and where 2-hexanone is present in the ductwork in concentrations greater than 3000 ppm (approximately 25% of the lower flammable limit), the fan rotating element shall be of non-sparking material or the casing shall consist of, or be lined with, non-sparking material. There shall be sufficient clearance between the fan rotating element and the fan casing so as to prevent contact.

(9) Sources of ignition such as smoking or open flames are prohibited where 2-hexanone presents a fire or explosion hazard.

(10) 2-Hexanone shall be stored so as not to come in contact with strong oxidizers.

(f) Personal protective equipment. (1) Employers shall provide and ensure that employees use impervious clothing, gloves, face shields (eight-inch minimum) and other appropriate protective clothing necessary to prevent skin contact with liquid 2-hexanone, where skin contact may occur. Face shields shall comply with § 1910.133(a)(2), (a)(4), (a)(5), and (a)(6).

(2) Employers shall ensure that clothing wet with liquid 2-hexanone is placed in closed containers for storage until it can be discarded or until the employer provides for the removal of 2-hexanone from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the 2-hexanone, the employer shall inform the person performing the operation of the hazardous properties of 2-hexanone.

(3) Employers shall ensure that non-impervious clothing which becomes contaminated with 2-hexanone be removed promptly and not reworn until the 2-hexanone is removed from the clothing.

(4) Employers shall ensure that clothing which becomes wet with liquid 2-hexanone be removed immediately and not reworn until the 2-hexanone is removed from the clothing.

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(5) Employers shall provide and ensure that employees use splash-proof safety goggles (cup-cover type dust and splash safety goggles) which comply with § 1910.133(a)(2)-(a)(6) where liquid 2-hexanone may contact the eyes.

(g) Spills and disposal. (1) In the event that liquid 2-hexanone is spilled the employer shall immediately eliminate potential sources of ignition, provide available ventilation and then clean up the spill.

(2) Liquid 2-hexanone shall not be allowed to enter a confined space, such as a sewer, because of the possibility of an explosion.

(h) Sanitation. Employers shall ensure that employees whose skin becomes contaminated with 2-hexanone promptly wash or shower with soap or mild detergent and water to remove any 2-hexanone from the skin.

(i) Training and information. (1) Each employer who has a workplace in which 2-hexanone is present shall keep a copy of this regulation with Appendixes A, B and C at the workplace. This material shall be made readily available to affected employees.

(2) Each employer who has employees exposed to 2-hexanone above the action level or employees who may have skin or eye contact with liquid 2-hexanone, or employees who work where a spill of 2-hexanone may occur, or employees who work where 2-hexanone presents a fire or explosion hazard, shall annually:

(i) Inform affected employees of the information contained in the Substance Safety Data Sheet for 2-hexanone (Appendix A of this section);

(ii) Advise affected employees as to the signs and symptoms of exposure to 2-hexanone.

(iii) Instruct affected employees to advise the employer of the development of signs and symptoms of exposure to 2-hexanone which are listed in Appendix A of the section;

(iv) Provide training to ensure that employees understand the precautions of safe use, emergency procedures, and the correct use of protective equipment relative to 2-hexanone.

(j) Medical surveillance. (1) The employer shall provide medical procedures as required by this paragraph. All medical procedures shall be performed by or under the supervision of a physician at no cost to the employee.

(2) The employer shall make available to each employee who is to be exposed to liquid 2-hexanone or airborne concentrations of 2-hexanone at or above the action level a medical examination which shall include a medical history and physical examination with emphasis on the nervous system, eyes, lungs and skin.

(3) The employer shall obtain from the physician, as a record of the examination, a written opinion which conforms with paragraph (j)(7) of this section.

(4) The employer shall make available to each employee, exposed to 2-hexanone in excess of the action level at 12 months from the date of the employee's first exposure, and at every 12 months of exposure in excess of the action level thereafter, a medical examination which must include a medical history and physical examination with emphasis on the nervous system, eyes, lungs and skin.

(5) The employer shall obtain from the physician, as a record of the periodic examination, a written opinion which conforms with paragraph (j)(7) of this section.

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(6) The employer shall provide to the examining physician the following information:

(i) A copy of this regulation with its Appendixes A, B, and C for 2-hexanone;

(ii) A description of the employee's duties as they relate to his exposure to 2-hexanone;

(iii) A description of any personal protective equipment and respirators required to be used;

(iv) The results of any measurements, which may indicate the affected employee's exposure;

(v) The affected employee's anticipated exposure; and

(vi) Upon request of the physician, any available information from previous medical examination of the affected employee.

(7)(i) The physician's written opinion shall be a signed statement by the examining physician specifically stating: (A) Whether the employee has any detected medical condition which would place the employee at increased risk of material impairment of the employee's health from exposure to 2-hexanone or would directly or indirectly aggravate any detected medical condition;

(B) Any recommended limitations upon the employee's exposure to 2-hexanone, including limitations upon the use of personal protective equipment and respirators;

(C) That the employee has been informed by the physician of any detected medical conditions which require further medical examination or treatment.

(ii) The physician's written opinion shall not reveal specific medical findings or diagnoses unrelated to exposure to 2-hexanone.

(iii) The employer shall provide the employee with a copy of the physician's written opinion.

(8) No employee shall be exposed to liquid 2-hexanone or airborne concentrations of 2-hexanone in such a way as would put the employee at increased risk of material impairment of his health from such exposure. This determination may be based on the physician's written opinion.

(9) The employer shall provide emergency and follow-up medical examinations and treatment for any employee injured through exposure to 2-hexanone.

(10) If an employee refuses any required medical examination, the employer shall inform the employee of the possible health consequences of such refusal and obtain a signed statement from the employee indicating that the employee understands the risks involved by refusing to be examined.

(11) No medical procedure which would be performed pursuant to this section need be performed if records of a previous such procedure performed within the past six months are acceptable to the examining physician.

(k) Recordkeeping. (1) Exposure determination. (i) The employer shall keep an accurate record of all determinations required to be made pursuant to paragraph (b)(1) of this section.

(ii) This record shall include the written determination required in paragraph (b)(2) of this section.

(iii) This record shall be maintained until replaced by a more recent record.

(2) Exposure measurements. (i) The employer shall keep an accurate record of all measurements taken to determine employee exposure to 2-hexanone.

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(ii) This record shall include:

(A) The date of measurement;

(B) Operations involving exposure to 2-hexanone which are being monitored;

(C) Sampling and analytical methods used and evidence of their accuracy, including the method, results and date of calibration of sampling equipment;

(D) Number, duration, and results of samples taken; and

(E) Name, social security number and exposure of the employee monitored.

(iii) This record shall be maintained until replaced by a more recent record but in no event for less than one year.

(3) Mechanical ventilation. (i) When mechanical ventilation is used as an engineering control, the employer shall maintain an accurate record of the measurements demonstrating the effectiveness of such ventilation required by paragraph (d)(3) of this section.

(ii) This record shall include:

(A) Date of measurement;

(B) Type of measurement taken;

(C) Result of measurement.

(iii) These records shall be maintained for at least one year.

(4) Employee training and information. (i) The employer shall keep an accurate record of all employee training and information required by paragraph (i) of this section.

(ii) This record shall include:

(A) Date of training;

(B) Name and social security number of employee trained;

(C) Content or scope of training provided.

(iii) This record shall be maintained until replaced by a more recent record.

(5) Medical surveillance. (i) The employer shall keep an accurate record of employee medical surveillance required by paragraph (j) of this section.

(ii) This record shall include:

(A) Results of tests required by paragraph (j)(2) and (j)(4) of this section:

(B) Any employee medical complaints relative to exposure to 2-hexanone;

(C) A copy of information provided to the physician pursuant to paragraph (j)(6)(ii), (iii), (iv), (v), and (vi) of this section.

(D) Physician's written opinion; and

(E) A signed statement of any refusal to be examined.

(iii) This record shall be maintained for the duration of the employment of the affected employee.

(6) Access to records. (i) All records required to be maintained by this section shall be made available upon request to authorized representatives of the Assistant Secretary of Labor for Occupational Safety and Health and the Director of the National Institute for Occupational Safety and Health.

(ii) Employee exposure determination and exposure measurement records required to be maintained by this section shall be made available to employees and former employees and their designated representatives.

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(iii) Employee medical records required to be maintained by this section shall be made available upon written request to a physician designated by the employee or former employee.

(1) Employee observation of measurement. (1) The employer shall give affected employees or their representatives an opportunity to observe any measurement of employee exposure to 2-hexanone which is conducted pursuant to this section.

(2) When observation of measurement of employee exposure to 2-hexanone requires entry into an area where the use of personal protective devices, including respirators, is required, the observer shall be provided with and required to use such equipment and comply with all other applicable safety procedures.

(3) Without interfering with the measurement, observers shall be entitled to:

(i) Receive an explanation of the measurement procedure.

(ii) Visually observe all steps related to the measurement of the airborne concentration of 2-hexanone that are being performed at the place of exposure; and

(iii) Record the results obtained.

NOTE: The information contained in the following appendixes is advisory in nature and is not intended, by itself, to create any additional obligations not otherwise imposed or detract from any existing obligation.

APPENDIX A

SUBSTANCE SAFETY DATA SHEET
FOR 2-HEXANONE

I. SUBSTANCE IDENTIFICATION

A. Substance: 2-Hexanone

B. Permissible Exposure: 100 parts of 2-hexanone per million parts of air (ppm) (410 milligrams of 2-hexanone per cubic meter of air (mg/M3)), averaged over an eight-hour work shift.

C. Appearance and Odor: Colorless liquid with a characteristic odor

II. HEALTH HAZARD DATA

A. Ways in which the chemical affects your body: 2-Hexanone can affect your body if you inhale it or if it comes in contact with your eyes or skin, or if you swallow it. It may enter your body through your skin.

B. Effects of Overexposure:

1. Short-term Exposure: 2-Hexanone causes irritation of the eyes, nose and throat. It may cause headaches or

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drowsiness. At very high concentrations it may cause unconsciousness.

2. Long-term Exposure: Repeated or prolonged exposure to 2-hexanone may cause weakness, numbness and tingling of your arms and legs. This may become so severe that you have difficulty in using your arms and legs. Prolonged or repeated exposure of the skin may cause drying and cracking.
3. Reporting Signs and Symptoms: You should inform your employer if you develop any signs or symptoms and suspect that they are caused by exposure to 2-hexanone.

III. EMERGENCY FIRST AID PROCEDURES

- A. Eye Exposure: If 2-hexanone gets into your eyes, wash your eyes immediately with copious amounts of water, lifting the lower and upper lids occasionally. If irritation persists after washing, get medical attention. Contact lenses should not be worn when working with this chemical.
- B. Skin Exposure: If 2-hexanone gets on your skin, immediately wash the contaminated skin using soap or mild detergent and water. If 2-hexanone soaks through your clothing remove the clothing immediately and wash the skin using soap or mild detergent and water. Get medical attention promptly.
- C. Breathing: If you or any other person breathes in large amounts of 2-hexanone move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.
- D. Swallowing: When 2-hexanone has been swallowed, give the person large quantities of water immediately. After the water has been swallowed, try to get the person to vomit by having him touch the back of his throat with his finger. Do not make an unconscious person vomit. Get medical attention immediately.
- E. Rescue: Move affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty yourself. Understand your emergency rescue procedures and know the locations of the equipment before the need arises.

IV. RESPIRATORS AND PROTECTIVE CLOTHING

- A. Respirators: Respirators are not the best way to control exposure to 2-hexanone. You can only be required to wear them for routine use if your employer is in the process of installing controls or control measures prove inadequate. You may be required to wear respirators for non-routine activities or in emergencies. If respirators are worn, they must have a Mining Enforcement and Safety Administration (MESA) or National Institute for Occupational Safety and Health (NIOSH) approval label. (Older respirators may have a Bureau of Mines approval label.) For effective protection, respirators must fit your face and head snugly. Respirators

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should not be loosened or removed in work situations where there use is required. If you can smell 2-hexanone while wearing a respirator, the respirator is not working correctly; go immediately to fresh air. If you experience difficulty breathing while wearing a respirator, tell your employer.

- B. Protective Clothing: You must wear impervious clothing, gloves, face shield or other appropriate protective clothing to prevent skin contact with liquid 2-hexanone where skin contact may occur. Replace or repair impervious clothing that has developed leaks.
- C. Eye Protection: You must wear splash-proof safety goggles where liquid 2-hexanone may contact your eyes.

V. PRECAUTIONS FOR SAFE USE, HANDLING AND STORAGE

- A. 2-Hexanone is a flammable liquid and its vapors can easily form explosive mixtures in air.
- B. 2-Hexanone must be stored in tightly closed containers in a cool, well-ventilated area away from heat, and strong oxidizers.
- C. Sources of ignition such as smoking and open flames are prohibited wherever 2-hexanone is handled, used or stored in a manner that could create a potential fire or explosion hazard.
- D. You must use non-sparking tools when opening or closing metal containers of 2-hexanone, and containers must be bonded and grounded when pouring or transferring liquid 2-hexanone.
- E. You must promptly remove any non-impervious clothing that becomes contaminated with 2-hexanone and this clothing must not be reworn until the 2-hexanone is removed from the clothing.
- F. Clothing wet with liquid 2-hexanone can be easily ignited. You must immediately remove this clothing and it must not be reworn until the 2-hexanone is removed from the clothing.
- G. If your skin becomes contaminated with 2-hexanone, you must promptly wash or shower with soap or mild detergent to remove the 2-hexanone from your skin.
- H. Fire extinguishers, where provided, must be readily available and you should know where they are and how to operate them.
- I. Ask your supervisor where 2-hexanone is used in your work area and for any additional plant safety and health rules.

VI. ACCESS TO INFORMATION

- A. Each year your employer is required to inform you of the information contained in this Substance Safety Data Sheet for 2-hexanone. In addition, your employer must instruct you in the safe use of 2-hexanone, emergency procedures, and the correct use of protective equipment.
- B. Your employer is required to determine whether you are being exposed to 2-hexanone. You or your representative have the right to observe employee exposure measurements and to record the results obtained. If your employer determines that you are being overexposed, he is required to inform you of the

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exposure and of the actions which are being taken to reduce your exposure.

- C. Your employer is required to keep records of exposure determinations, exposure measurements, and medical surveillance. Your employer is required to make records of exposure determinations and your exposure measurements available to you or your representative upon your request. Your employer is required to release your medical records to your physician upon your written request.

APPENDIX B

SUBSTANCE TECHNICAL GUIDELINES
FOR 2-HEXANONE

I. PHYSICAL AND CHEMICAL DATA

A. Substance Identification

1. Synonyms: Methyl butyl ketone; MBK; Butyl methyl ketone; Methyl n-butyl ketone
2. Formula: $\text{CH}_3\text{CO}(\text{CH}_2)_3\text{CH}_3$
3. Molecular weight: 100

B. Physical Data

1. Boiling point (760 mm Hg): 127.8 C (262 F)
2. Specific gravity (water = 1): 0.8
3. Vapor density (air = 1 at boiling point of 2-hexanone): 3.5
4. Melting point: -57 C (-71 F)
5. Vapor pressure at 20 C (68 F): 3 mm Hg
6. Solubility in water, % by weight at 20 C (68 F): 1.4
7. Evaporation rate (butyl acetate = 1): approximately 1
8. Appearance and odor: Colorless liquid with a characteristic odor

II. FIRE, EXPLOSION AND REACTIVITY HAZARD DATA

A. Fire

1. Flash point: 25 C (77 F) (closed cup)
2. Autoignition temperature: 424 C (795 F)
3. Flammable limits in air, % by volume: Lower: 1.2; Upper: 8
4. Extinguishing media: Dry chemical, carbon dioxide, alcohol foam
5. Special fire-fighting procedures: Do not use a solid stream of water since a stream will scatter and spread the fire. Use water spray to cool containers exposed to a fire.
6. Unusual fire and explosion hazards: 2-Hexanone is a flammable liquid. Its vapors can easily form explosive mixtures with air. All ignition sources must be controlled where 2-hexanone is used, handled or stored in a manner that could create a potential fire or

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explosion hazard. 2-Hexanone vapors are heavier than air and may travel along the ground and be ignited by open flames or sparks at locations remote from the site at which 2-hexanone is handled.

7. For purposes of conforming with the requirements of 29 CFR 1910.106, 2-hexanone is classified as a Class IC flammable liquid. For example, 3000 ppm, approximately one-fourth of the lower flammable limit, is one situation in which 2-hexanone is considered to be a potential fire and explosion hazard.
8. For purposes of complying with 29 CFR 1910.309, the classification of hazardous locations as described in Article 500 of the National Electrical Code for 2-hexanone shall be Class I Group D.

B. Reactivity

1. Conditions contributing to instability: Heat.
2. Incompatibilities: Contact with strong oxidizers may cause fires and explosions.
3. Hazardous decomposition products: Toxic gases and vapors (such as carbon monoxide) may be released in a fire involving 2-hexanone.
4. Special precautions: Liquid 2-hexanone will attack some forms of plastics, rubber and coatings.

III. SPILL, LEAK, AND DISPOSAL PROCEDURES

- A. If 2-hexanone 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, absorb on paper towels. Evaporate in a safe place (such as a fume hood). Allow sufficient time for vapors to completely clear hood ductwork, then burn the paper. Large quantities can be collected and atomized in a suitable combustion chamber. 2-Hexanone may not be allowed to enter a confined space, such as a sewer, because of the possibility of an explosion.
- B. Persons not wearing protective equipment should be restricted from areas of spills or leaks until cleanup has been completed.
- C. Waste disposal methods: 2-Hexanone may be disposed of:
 1. By absorbing in vermiculite, dry sand, earth or similar material and disposing in a secured sanitary landfill.
 2. By atomizing in a suitable combustion chamber.

IV. MONITORING AND MEASUREMENT PROCEDURES

- A. EXPOSURE ABOVE THE ACTION LEVEL: Measurements taken for the purpose of determining employee exposure under this section are best taken such that the average 8-hour exposure may be determined from a single eight-hour sample or two (2) 4-hour samples. Several short time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). Sampling and analyses may be

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performed by instruments such as detector tubes certified by NIOSH under 42 CFR part 84, portable direct-reading instruments, dosimeters, or gas and vapor adsorption tubes with subsequent chemical analyses. The method of measurement must determine the concentration of 2-hexanone to plus or minus 35%.

- B. EXPOSURE ABOVE THE PERMISSIBLE EXPOSURE: The monitoring and measurements under this section should be essentially the same as described under paragraph IV. A. Laboratories performing chemical analyses should be accredited in Industrial Hygiene Chemistry by the American Industrial Hygiene Association. The method of measurement must determine the concentration of 2-hexanone to plus or minus 25%.
- C. METHODS: Methods meeting these accuracy requirements are available from the National Technical Information Service, U. S. Department of Commerce, Springfield, Virginia 22161 under the title "NIOSH Analytical Methods for Set M" (Order number XXXXXXXXXX).
- D. QUALIFIED PERSONS: Since many of the duties relating to employee protection are dependent on the results of monitoring and measuring procedures, employers should assure that the evaluation of employee exposures is performed by a competent industrial hygienist or other technically qualified person.

V. MISCELLANEOUS PRECAUTIONS

- A. Store 2-hexanone in tightly closed containers in a cool, well ventilated area.
- B. High exposures to 2-hexanone can occur when transferring the liquid from one container to another.
- C. Non-sparking tools must be used to open and close metal 2-hexanone containers. These containers must be effectively grounded and bonded prior to pouring.
- D. Employers should advise employees of all areas and operations where exposure to 2-hexanone could occur.

VI. COMMON OPERATIONS

Common operations in which exposure to 2-hexanone is likely to occur are: during its production and its use as a solvent for coatings, lacquers and resins, oils, waxes; and as an extraction solvent.

APPENDIX C - MEDICAL SURVEILLANCE GUIDELINES

I. ROUTE OF ENTRY

Inhalation; skin absorption.

—II. TOXICOLOGY

2-Hexanone causes peripheral neuropathy; at high concentrations it is irritating to ocular and nasal mucous membranes, and causes narcosis. Guinea pigs exposed to 6000 ppm showed signs of narcosis after 30 minutes, and deep anesthesia after 1 hour; deaths occurred after

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approximately 6 1/2 hours. Animals exposed 24 hours a day to concentrations between 100 and 600 ppm developed signs of peripheral neuropathy after 4 to 8 weeks; in cats, the conduction velocity of the ulnar nerve was less than one half of normal after exposure for 7 to 9 weeks. In these animals histologic examination revealed focal denudation of myelin from nerve fibers with or without axonal swelling. 2,5-hexanedione was a major metabolite of 2-hexanone in several animal species; peripheral neuropathy occurred in rats after daily subcutaneous injection of 2, 5-hexanedione at a dose of 340 mg/kg, 5 days a week for 19 weeks. Human volunteers exposed to vapor concentration of 1000 ppm for several minutes developed moderate eye and nasal irritation. Workers exposed to vapors of 2-hexanone and methyl ethyl ketone at probable mean concentrations of from 6 to 36 ppm for 12 months with peaks as high as 150 ppm with extensive skin exposures developed peripheral neuropathy. The neurological pattern was one of a distal motor and sensory disorder with minimal loss of tendon reflexes. In those with prominent motor involvement, initial symptoms included slowly developing weakness of the hands, with difficulty in pincer movements on the grasping of heavy objects, or weakness of the ankle extensors, resulting in a slapping gait. In other cases, the initial symptoms were intermittent tingling and paresthesias in the hands or feet. In some cases, the condition progressed slowly for several months after cessation of exposure; in moderate to severe cases improvement occurred over a period of up to 8 months. In the rabbit eye, 2-hexanone is a mild irritant. Repeated or prolonged skin contact will result in absorption of 2-hexanone and defatting of the skin and primary irritation.

III. SIGNS AND SYMPTOMS

Irritation of eyes and nose; signs of peripheral neuropathy including slow development of weakness and paresthesias; dermatitis.

IV. SPECIAL TESTS

Electromyography of the extremities may be of value in determining incipient or minor impairments of neurologic functions.

V. TREATMENT

Remove from exposure. Flush eyes with water and wash skin with soap or mild detergent and water. If swallowed and the person is conscious, immediately administer salt water orally and induce vomiting. Give artificial resuscitation if indicated. Recovery is usually complete.

VI. SURVEILLANCE AND PREVENTIVE CONSIDERATIONS

A. GENERAL

In workers exposed to low concentrations of mixtures of 2-hexanone and methyl ethyl ketone for long periods, the onset of peripheral neuropathy has been insidious. At high concentrations in animals, 2-hexanone has caused narcosis and death. Skin absorption is

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thought to be a major route of entry into the body. It is important that the physician become familiar with plant operating conditions in which exposure to 2-hexanone occurs. Those with skin disease may not tolerate the wearing of protective clothing and those with chronic respiratory disease may not tolerate the wearing of negative pressure respirators.

B. PREPLACEMENT

The following medical procedures must be made available to each employee who is exposed to 2-hexanone:

1. A complete history and physical examination -- The purpose is to detect preexisting conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Persons with a history of neurologic disorders such as diabetic neuropathy would be expected to be at increased risk from exposure. Examination of the nervous system, eyes and respiratory system should be stressed. The skin should be examined for evidence of chronic disorders.

C. PERIODIC EXAMINATIONS

The above medical examinations are to be repeated on an annual basis.

VII. REFERENCES

1. American Conference of Governmental Industrial Hygienists: "2-Hexanone (Methyl 2-butyl ketone)," Documentation of the Threshold Limit Values for Substances in Workroom Air (3d ed., 2d printing), Cincinnati, 1974, p. 126.
2. Hygienic Guide Series: "2-Hexanone," American Industrial Hygiene Association Journal, 29:618-620, 1968.
3. Patty, Frank A.: Industrial Hygiene and Toxicology, Vol. II - Toxicology (2d ed. revised), Interscience Publishing Company, New York, 1963, pp. 1735-1737.
4. Browning, Ethel: Toxicity and Metabolism of Industrial Solvents, Elsevier Publishing Company, Amsterdam, 1965, pp. 428-429.
5. Gilchrist, M.A., et al: "Toxic Peripheral Polyneuropathy," Morbidity and Mortality Weekly Report, 23:9-10, 1974.
6. Mendell, J.R., et al: "Toxic Polyneuropathy Produced by Methyl N-Butyl Ketone," Science, 185:787-789, 1974.
7. Duckett, S., et al: "Peripheral Neuropathy Associated with Inhalation of Methyl-n-Butyl Ketone," Experientia, 30:1283-1284, 1974.

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8. Billmaier, D., et al: "Peripheral Neuropathy in a Coated Fabrics Plant," Journal of Occupational Medicine, 16:665-671, 1974.

9. Allen, N., et al: "Toxic Polyneuropathy due to Methyl n-Butyl Ketone," Archives of Neurology, 32:209-218, 1975.

10. Raleigh, R.L., et al: "Methyl N-Butyl Ketone," Journal of Occupational Medicine, 17:286, 1975.

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REFERENCES AND SOURCES
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- (d) Compliance - Open surface tank classification based on relative evaporation rate of 12 hours (from Doolittle)
- (e) Fire and Safety
- (1) Electrical - Classification based on "Fire Hazard Classification of Chemical Vapors Relative to Explosion-proof Electrical Equipment," H. Carhart et al., National Academy of Sciences, 1973, report to U. S. Coast Guard, report no. CG-D-92-74, p. 31 (ketone family)
- (f) Personal Protective Equipment, and, (h) Sanitation
- Eye: Patty, "Industrial Hygiene and Toxicology;" Henson, Edward, "Toxicology of Some Aliphatic Ketones," J. of Occup. Med., 1, p. 607, November 1959; Grant, "Toxicology of the Eye"
- Skin: "2-Hexanone," Hygienic Guide Series; Patty, "Industrial Hygiene and Toxicology;" Henson, Edward, "Toxicology of Some Aliphatic Ketones," J. of Occup. Med., 1, p. 607, November 1959; Billmaier, Donald, "Peripheral Neuropathy in a Coated Fabrics Plant", J. of Occup. Med., 16:10:665-671, October, 1974.
- Ingestion: Patty, "Industrial Hygiene and Toxicology;" Browning, "Toxicity and Metabolism of Industrial Solvents;" Henson, Edward, "Toxicology of Some Aliphatic Ketones," J. of Occup. Med., 1, p. 607, November 1959

COMMENTS

Eye - Classification: 2

Output statement numbers: 10

Exceptions: None

Patty, quoting the work of Smyth et al., reports that eye contact may result in "mild irritation and possibly some transient minor corneal injury." Henson notes that in rabbits, eye contact with 2-hexanone caused squinting, lachrymation and rubbing of the eyes. As reported in Grant, Smyth and Carpenter assigned the substance an injury grade of 3 on a scale of 10 after 24 hours. This indicates that 0.1 ml of the undiluted chemical causes less than severe injury while 0.5 ml produces severe injury. Since Grant notes in general for fat solvents that only the epithelium is damaged and "it generally regenerates in a few days without residual permanent damage," the substance is assigned a classification of 2.

Skin - Classification: 2

Output statement numbers: 2, 7b, 17g, 21, 17i

Exceptions: 20a deleted; 2 modified

According to Henson, because of 2-hexanone's solvent properties, it tends to extract the lipids of the skin resulting in a drying and cracking, thus increasing the skin's susceptibility to infection and the "detrimental action of other agents."

The Hygienic Guide Series notes, "covered application to rats for a period of 24 hours followed by a 14 day observation period resulted in an LD50 by skin absorption of 6 ml/kg."

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Patty states that 2-hexanone should cause essentially no irritation to the skin unless contact is repeated or prolonged. Citing the work of Smyth et al., Patty notes absorption through the skin can occur but that it is low in toxicity by this route; a rabbit skin absorption LD50 of 5.99 ml/kg is given. Recent work, however, by NIOSH and other (Billmaier) has shown that MBK (2-hexanone) can produce peripheral neuropathy in laboratory animals and that exposure to MBK was responsible for an outbreak of peripheral neuropathy in a coated fabrics plant. It was recommended that skin exposure be prevented, consequently statement 2 has been modified to prevent skin contact where it may occur.

The substance is 1.4% soluble in water, has a flash point of 77 degrees F, and a vapor pressure of 3 mm Hg at 20 degrees C.

A classification of 2 is concluded to be appropriate. Statement 20a is not used because of the strong odor of the substance and the requirement that contaminated skin (hands) be promptly washed.

Ingestion - Classification: 0

Output statement numbers: None

Exceptions: None

Patty reports that 2-hexanone is low in single dose oral toxicity . . and adds "this chemical should not present a hazard from swallowing in industrial handling. . . but some systemic injury might result, however, if large amounts were swallowed accidentally (sic)." Henson lists an oral rat LD50 2.59 g/kg and notes fatalities were usually due to a state of narcosis. He also observed a depression of rectal temperature, respiratory rate and heart rate. Browning states that "congestion was the chief sign of injury - congestion and haemorrhaging of the lungs, moderate congestion of the liver and kidneys and a slight congestion of the brain."

The moderate toxicity of the substance, its vapor pressure, and the requirement that contaminated skin be promptly washed lead to the conclusion that ingestion, in the context of this standard, should not present a significant hazard in the industrial environment.

SUBSTANCE TECHNICAL GUIDELINES

The references cited for this document include:

National Fire Protection Association, "Fire Protection Guide on Hazardous Materials," 5th edition, 1973 (NFPA)

Eastman Kodak Co., Technical Bulletin M-162 and Material Safety Data Sheet (East)

"Handbook of Chemistry and Physics," Chemical Rubber Co. (CRC)

Sources of data items used:

- I. A. 1. Synonyms: NFPA-325M; East
- 2. Formula: East
- 3. Molecular weight: ADL
- B. 1. Boiling point: NFPA-325M; East
- 2. Specific gravity: NFPA-325M; East
- 3. Vapor density: NFPA-325M; East

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- 4. Melting point: East
- 5. Vapor pressure: CRC
- 6. Solubility in water: East
- 7. Evaporation rate: East
- 8. Appearance and odor: East
- II. A. 1. Flash point: East
- 2. Autoignition temperature: East
- 3. Flammable limits: NFPA-325M; East
- 4. Extinguishing media: East
- 5. Special fire fighting procedures: NFPA-325M; East
- 6. Unusual fire and explosion hazards: ADL
- B. 1. Conditions contributing to instability: ADL
- 2. Incompatibilities: ADL
- 3. Hazardous decomposition products: ADL
- 4. Special precautions: ADL
- III. A. Steps if released or spilled: ADL
- C. Waste disposal method: ADL
- V. Miscellaneous precautions: ADL

USE/EXPOSURE AND CONTROL DOCUMENT

References used in the preparation of this document include:

- "Chemical Abstracts," American Chemical Society, 70:100216, 1969;
70:100217, 1969; 68:116169, 1968; 71:74778, 1969; 76:37062, 1972 (CA)
"2-Hexanone," American Industrial Hygiene Association, Hygienic Guide
Series, November - December 1968 (Hygienic Guide)
International Labour Office, "Encyclopedia of Occupational Health and
Safety," 1972 (ILO)
Mattiello, J., "Protective and Decorative Coatings," Vol. II, 1943 (Mattiello)
Mendell, J. R. et al., "Toxic Polyneuropathy Produced by Methyl-n-butyl
Ketone," Science, 185:787 - 89, 1974 (Science)
"Methyl-n-butyl Ketone," Material Safety Data Sheet, Eastman Kodak Company,
October 26, 1973 (MSDS)
"Solvents," Methyl-n-butyl Ketone, Eastman Kodak Company, 1972 (Solvents)

References for Specific Use/Exposure

- 1. CA, Hygienic Guide, Mattiello, Science, Solvents
- 2. CA
- 3. ILO
- 4. MSDS

References for Specific Control Methods

MSDS was the reference used in all of the Specific Control Methods.

RESPIRATOR TABLE DOCUMENTATION

SUBSTANCE: 2-Hexanone

D. O. L. STANDARD: 100 ppm

WARNING PROPERTIES:

Odor Threshold: According to the Documentation of TLV's, at 1000 ppm the odor of 2-hexanone is strong. No quantitative information is available concerning the odor threshold, however.

Eye Irritation Level: The AIHA Hygienic Guides state that humans exposed to 1000 ppm 2-hexanone experience eye irritation. The Hygienic Guides state that half facepiece respirators should be allowed up to 1000 ppm.

Other Information: The Hygienic Guides state that humans exposed to 1000 ppm 2-hexanone experience nasal irritation.

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According to the Documentation of TLV's, the "recommended TLV of 100 ppm should provide protection against irritation and, by a large margin, against initiation of narcosis."

Evaluation of Warning Properties: At a concentration 10 times the TLV, 2-hexanone can be detected through its odor and irritant effects. Although 2-hexanone could be treated as a material with poor warning properties, for the purposes of this standard, it is not. Since the TLV has been established primarily to prevent irritant effects, 2-hexanone is treated as a substance with good warning properties. The available toxicological information indicates that the effects are reversible and there are no acute toxic effects at concentrations of this magnitude (1000 ppm).

Gas sorbent respiratory equipment is permitted. Both Patty and the Hygienic Guides remark that 2-hexanone has good warning properties.

IDLH: 5000 ppm

Basis for IDLH Value: This IDLH is based upon the report in the Hygienic Guides that "guinea pigs exposed to a vapor concentration of 6000 ppm showed signs of beginning narcosis at 30 minutes and deep anesthesia at the end of one hour." Death did not occur for 6 1/2 hours at this concentration. A concentration of 8000 ppm killed all rats during a 4 hour exposure. The IDLH value is reduced to 5000 ppm based on protection factors.

Other Toxicological Information: Patty reports that inhalation is the principal hazard in the industrial use of 2-hexanone. "The inhalation of the vapors of this material may result in eye and upper respiratory tract irritation followed by narcosis if the concentration is high. . . Only the effects of single exposures to rats and guinea pigs as well as to man have been studied." Smyth et al. reported that "in exposure to saturated atmospheres, more than 30 minutes were required to cause the death of rats. Exposures to concentrations of 4000 ppm caused no deaths in rats exposed for 4 hours, whereas exposure to concentrations of 8000 ppm for 4 hours resulted in the death of all the rats exposed."

Patty gives the following table which Schrenk and coworkers developed based on their guinea pig studies:

	Concentration (ppm)
Kills in a few minutes	Greater than 20,000
Dangerous to life in 30 - 60 min.	10,000 to 20,000
Dangerous to life after several hours	4,000 to 6,000
Maximum concentration for 60 min without serious disturbances	3,000
Maximum concentration for several hours without serious disturbances	1,500
Maximum concentration for several hours resulting in only slight or no symptoms	1,000

The Hygienic Guides report that Specht and coworkers found that "Guinea pigs exposed to a vapor concentration of 6000 ppm showed signs of beginning narcosis at 30 minutes and deep anesthesia at the end of one hour. Deaths occurred in approximately six and one-half

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hours."

LFL: 12,000 ppm

VAPOR PRESSURE AT 20 C: 15 mm Hg

SATURATED CONCENTRATION AT 20 C: 19,700 ppm

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Use/Exposure	Principal Route of Entry	Currently Used Control Methods
1. Inhalation of vapor and skin contact with liquid during use as a commercial solvent for nitro-cellulose, natural and synthetic resins, oils, fats, waxes, vinyl polymers and copolymers, cellulose acetates (coated fabrics, varnish removers, vinyl lacquers, nitrate wood lacquers)	A,B,D	Local exhaust ventilation; general dilution ventilation; personal protective equipment (gloves, goggles)
2. Inhalation of vapor and skin contact with liquid during use as an extraction solvent (extraction of paraffin wax from hydrocarbon oils, separation and purification of certain metals)	A,B,D	Local exhaust ventilation; general dilution ventilation; personal protective equipment (gloves, goggles)
3. Inhalation of vapor and skin contact with liquid during manufacture and processing of 2-hexanone (catalytic reaction of acetic acid and acetone under pressure)	A,B,D	Process enclosure; local exhaust ventilation; general dilution ventilation; personal protective equipment (gloves, goggles)
4. Inhalation of vapor and skin contact with liquid during cleaning and maintenance of storage vessels and during clean up of accidental spills	A,B,D	Local exhaust ventilation; general dilution ventilation; personal protective equipment (gloves, goggles, respiratory protective devices)

- A -- Inhalation
- B -- Skin and eye contact resulting in localized irritation
- C -- Ingestion
- D -- Skin contact resulting in absorption and subsequent systemic poisoning

Note: Recent findings linking exposures to 2-hexanone with the occurrence of peripheral neuropathy should result in reduced utilization of this solvent.