NIOSH/OSHA STANDARDS COMPLETION PROGRAM

DRAFT TECHNICAL STANDARD AND SUPPORTING DOCUMENTATION FOR

*** TETRAHYDROFURAN ***

NIOSH/OSHA Draft Technical Standard and Supporting Documentation for TETRAHYDROFURAN

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 TETRAHYDROFURAN.

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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and Supporting Documentation for TETRAHYDROFURAN

(a) DEFINITIONS

(1) PERMISSIBLE EXPOSURE - "Permissible Exposure" means inhalation of tetrahydrofuran in concentrations not in excess of 200 parts per million (ppm) (590 milligrams per cubic meter, mg/cu.m.) averaged over an eight hour work shift, as stated in section 1910.93, Table G-1.

(2) ACTION LEVEL - "Action Level" means one half (1/2) of the permissible exposure for tetrahydrofuran.

(b) EMPLOYEE INFORMATION - Each employer who has a workplace in which tetrahydrofuran is present shall:

(1) STANDARD AVAILABILITY - Keep a copy of this section with its appendices A, B and C, at the workplace. This material shall be made readily available to affected employees; and

(2) PRESENCE OF TETRAHYDROFURAN - Inform affected employees of the quantity, location, and manner of use or storage of tetrahydrofuran.

(c) EXPOSURE MEASUREMENT

(1) INITIAL DETERMINATION - Each employer who has a place of employment in which tetrahydrofuran is released into the workplace air shall determine if any employee may be exposed to airborne concentrations of tetrahydrofuran 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 tetrahydrofuran. A written determination shall be made and it shall contain at least the following information:

(i) Any information, observations, or calculations which would indicate employee exposure to tetrahydrofuran;

(ii) Any measurements of airborne concentrations of tetrahydrofuran taken;

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

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

(2) INITIAL EXPOSURE MEASUREMENT - If the employer determines that any employee may be exposed to airborne concentrations of tetrahydrofuran at or above the action level, the exposure of the employee believed to have the greatest exposure shall be measured. The exposure measurement shall be representative of the maximum exposure of the employee.

(3) IDENTIFICATION OF EXPOSED EMPLOYEES - If the exposure measurement taken under paragraph (c)(2) of this section reveals employee exposure to airborne concentrations of tetrahydrofuran 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.

(4) EXPOSURE ABOVE THE ACTION LEVEL - If an employee exposure measurement reveals that an employee is exposed to airborne concentrations of tetrahydrofuran 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.

(5) EXPOSURE ABOVE THE PERMISSIBLE EXPOSURE - If an employee exposure measurement reveals that an employee is exposed to airborne concentrations of tetrahydrofuran above the permissible exposure, the employer shall:

(i) Inform the employee of the exposure as required by paragraph (N)(1) of this section; and

(ii) Measure the exposure of the employee at least monthly; and

(iii) Institute control measures as required by paragraph (E) of this section.

(6) TERMINATION OF EXPOSURE MEASUREMENT - If two consecutive employee exposure measurements taken at least one week apart reveal that the employee is exposed to airborne concentrations of tetrahydrofuran below the action level, the employer may terminate measurement for the employee. For purposes of this subparagraph, use of respirators shall not constitute reduction of employee exposure below the action level.

(d) METHODS OF MEASUREMENT - 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 (Appendix B (iv)). The method of measurement shall have an accuracy, to a confidence level of 95%, of not less than that given in Table 1 below.

Table 1

Concentration	Required Accuracy
Above permissible exposure	Plus or Minus 25%
At or below permissible exposure and above the action level	Plus or Minus 35%
At or below the action level	Plus or Minus 50%

(e) Methods of Compliance

(1) Engineering controls - No employee shall be exposed to tetrahydrofuran above the permissible limit as defined in paragraph (a)(1) of this section. Engineering and work practice controls shall be used to reduce exposure to tetrahydrofuran to at or below the permissible exposure.

(i) When mechanical ventilation is used to control exposure, measurements which demonstrate system efficiency (for example: air velocity, static pressure, or air volume) shall be made at least every three months. Measurements of system efficiency shall also be made within five work days of any change in production, process or control which might result in a reduction in control.

(ii) Where a fan is located in duct work and where tetrahydrofuran is present in concentrations greater than 5000 ppm, one fourth of the lower flammable limit, the fan rotating element 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.

(iii) In the design of open surface tank ventilation for the purposes of section 1910.94 (d), operations involving tetrahydrofuran shall be classified as B-1 at 70 F.

(2) Respirators

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

(a) During the time period necessary to install engineering controls; or
(b) In work situations in which engineering controls are technically not feasible; or
(c) In work situations in which feasible engineering and work practice controls are insufficient to reduce employees exposure to at or below permissible exposure, they shall be used to reduce exposure to the lowest level feasible; or
(d) For operations not exceeding 40 hours per year; or
(e) In emergencies.

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

(iii) Employers shall select and provide the appropriate respirator from Table 2 and shall ensure that the employee uses the respirator provided.

(iv) Employers shall institute a respiratory protection program in accordance with sections 1910.134(b),(d),(e) and (f).

TABLE 2. RESPIRATORY PROTECTION FOR TETRAHYDROFURAN

Condition	
Vapor Concentration	
Equal to or less than 1000 ppm	organic vapor cartridge(s).
Equal to or less than 5000 ppm	
Equal to or less than 10 000 ppm	Any supplied-air respirator wtih a full facepiece. Any self-contained breathing apparatus with a full face-piece.
Greater than 10,000 ppm, or Entry & Escape from UnKnown Concentrations	Self-contained breathing apparatus with a full facepiece
	air respirator with a full facepiece operated in pressure-
	auxiliary self-contained air supply operated in pressure-demand or other positive pressure mode.

Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand (positive pressure) mode.
Escape	Any gas mask providing protection against organic vapors. Any escape self-contained breathing apparatus.

(f) Fire and Safety

Employers shall familiarize themselves with the information contained in the Substance Technical Guidelines for tetrahydrofuran which is contained in Appendix B in order to ensure the safe handling and use of tetrahydrofuran.

(1) Electrical - For the purposes of compliance with section 1910.309, locations classified as hazardous locations due to the presence of tetrahydrofuran shall be Class I Group C.

(2) Portable fire extinguishers - For the purposes of compliance with section 1910.157, tetrahydrofuran is classified as a Class B fire hazard.

(3) Powered industrial trucks - For the purposes of compliance with section 1910.178, locations classified as hazardous locations due to the presence of tetrahydrofuran shall be Class I Group C.

(4) Flammable liquids - For the purposes of compliance with section 1910.106, liquid tetrahydrofuran is classified as a Class IB flammable liquid. Spray finishing operations shall be performed in accordance with sections 1910.107 and 1910.94 (c). Dip tank operations shall be performed in accordance with sections 1910.108 and 1910.94 (d).

(5) Sources of ignition - Sources of ignition such as smoking or open flames are prohibited where tetrahydrofuran is handled, used or stored in a manner so as to create a potential fire or explosion hazard.

(6) Storage - Tetrahydrofuran shall be stored so as not to come in contact with strong oxidizers and shall be stored away from heat and sunlight. Stored lots of tetrahydrofuran shall be checked for the presence of explosive peroxides. Tetrahydrofuran containing peroxides may not be distilled to dryness.

(g) Personal Protective Equipment

(1) Skin Contact

(i) Employers shall provide, and require employees to use, impervious clothing, gloves, face shields (8-inch minimum) and other appropriate protective clothing necessary to prevent repeated or prolonged skin contact to liquid tetrahydrofuran. Face shields shall comply with section 1910.133(a)(6).

(ii) Employers shall ensure that clothing which becomes wet with liquid tetrahydrofuran be removed immediately and not reworn until the tetrahydrofuran is removed from the clothing.

(iii) Employers shall ensure that clothing wet with liquid tetrahydrofuran is placed in closed containers for storage

until it can be discarded or until the employer provides for the removal of tetrahydrofuran from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the tetrahydrofuran, the employer shall inform the person performing the operation of the hazardous properties of tetrahydrofuran.

(2) Eye Contact

(i) Employers shall provide, and require employees to use, splash-proof safety goggles (cup-cover type dust and splash safety goggles), which comply with section 1910.133 (a)(6), where eye contact to liquid tetrahydrofuran may occur.

(h) Spills

(1) Spills of tetrahydrofuran shall be cleaned up immediately after eliminating potential sources of ignition and utilizing available ventilation.

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

(i) Sanitation

(1) Employers shall ensure that employees whose skin becomes wet with liquid tetrahydrofuran, promptly wash or shower to remove any tetrahydrofuran from the skin.

(j) Training and Information - Each employer who has employees exposed to tetrahydrofuran in excess of the action level, or employees who may have skin or eye contact with liquid tetrahydrofuran, or employees who work where accidental release, spill, fire, or explosion of tetrahydrofuran may occur, shall annually:

(1) Substance Safety Data Sheet - Inform each employee of the information contained in the Substance Safety Data Sheet for tetrahydrofuran, which is contained in Appendix A; and

(2) Medical -

(I) Advise employees as to the signs and symptoms of exposure to tetrahydrofuran.

(II) Instruct the employees to advise the employer of the development of signs and symptoms of exposure to tetrahydrofuran which are listed in Appendix A.

(III) Instruct the employees to inform the employer if they develop any of the medical conditions listed in (k)(2) of this section; and

(3) Procedures -

(I) Provide training to ensure that employees understand the precautions of safe use, emergency procedures, and the correct use of protective equipment relative to tetrahydrofuran.

(II) The procedures required by (j)(1), (2), and (3)(I) shall be provided to employees at the expense of the employer during the employee's normal working hours.

(k) Medical Surveillance

(1) The employer shall provide medical procedures as required by paragraph (k). These procedures shall be provided at no cost to the employee.

(2) Preplacement Questionnaire - The employer shall obtain from each employee who will be exposed to liquid tetrahydrofuran, or airborne

concentrations of tetrahydrofuran at or above the action level, a written statement as to whether such employee has a history of any of the following:

(I) Skin disease
(II) Kidney disease
(III) Chronic lung disease
(IV) Liver disease

(3) Preplacement Medical Examination - The employer shall provide a medical examination for an employee if the employee provides a history of any of the conditions named in paragraph (k)(2).

(4) Results of Preplacement Examination - The employer shall obtain a physician's written opinion based on the medical examination pursuant to paragraph (k)(3).

(5) Periodic Medical Examinations - The employer shall provide a medical examination for an employee if the employee advises the employer of the development of:

(I) Any of the medical conditions listed in (k)(2).
(II) Signs and symptoms listed in Appendix A which the employee suspects may be caused by exposure to tetrahydrofuran.

(6) Results of Periodic Examinations - The employer shall obtain a physician's written opinion based on the medical examination pursuant to paragraph (k)(5).

(7) Exclusion or Removal from Exposure - No employee shall continue to be exposed to tetrahydrofuran if such exposure could place the employee at increased risk of material impairment of his health.

(8) Emergency Procedures - The employer shall provide emergency and follow-up medical examinations and treatment for any employee injured through exposure to tetrahydrofuran.

(9) Informing the Physician - The employer shall provide to the examining physician the following information:

(I) A copy of this section with its Appendices A, B, and C;
(II) A description of the employee's duties as they relate to his exposure to tetrahydrofuran;
(III) A description of any personal protective equipment, including respirators, required to be used;
(IV) The results of any employee's exposure measurement, if available;
(V) The employee's anticipated exposure level; and
(VI) Upon request of the physician, information from previous medical examination of the employee.

(10) Physician's Written Opinion

(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 conditions which could be directly or indirectly aggravated by exposure to tetrahydrofuran or which could significantly interfere with the ability of the employee to follow recommended or required procedures for protecting himself from unusual or emergency

exposure.

(B) Any recommended limitations upon the employee's exposure to tetrahydrofuran.

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

(II) The written opinion shall not reveal medical information unrelated to exposure to tetrahydrofuran.

(11) Refusal to be Medically Examined - 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.

(l) RecordKeeping.

(1) Initial determination.

(i) The employer shall keep an accurate record of all initial determinations required to be made pursuant to paragraph (c)(1) of this section.

(ii) The record shall include the written determination and any supporting documentation as required in paragraph (c)(1) 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 tetrahydrofuran.

(ii) This record shall include:

(a) The date of measurement;

(b) A reference to the subparagraph of this regulation which required the measurement, if any;

(c) Operations involving exposure to tetrahydrofuran which are being monitored;

(d) Sampling and analytical methods used and evidence of their accuracy;

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

(f) 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 a record of measurements demonstrating the effectiveness of such ventilation as required by paragraph (e)(1)(i) of this section.

(ii) This record shall include:

(a) Date of measurement;

(b) Type of measurement taken;

(c) Result of measurement.

(iii) This record shall be maintained for at least one year.

(4) Training and information.

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

(ii) The record shall include:

(a) Date of training;

(b) Name and Social Security number of employees trained;

(c) Substance of training provided.

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

(5) Medical records.

(i) The employer shall keep an accurate medical record for each employee.

(ii) The record shall include:

(a) Physician's written opinion;

(b) Preplacement questionnaire;

(c) Any employee medical complaints relative to exposure to tet

(d) A signed statement of any refusal to be examined;

(e) A copy of information provided to the physician pursuant to paragraph (k)(9)(ii) through (vi) of this section.

(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 and the Director.

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

(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.

(m) Observation of monitoring.

(1) Duty.

The employer shall give affected employees or their representatives an opportunity to observe any monitoring of employee exposure to tetrahydrofuran which is conducted pursuant to this section.

(2) Exercise of opportunity to observe monitoring.

(i) When observation of the monitoring of employee exposure to tetrahydrofuran requires entry into an area where the use of personal protective devices is required, the observer shall use such equipment and comply with all other applicable safety procedures.

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

(a) Receive an explanation of the measurement procedures;

(b) Visually observe all steps related to the measurement of exposure to tetrahydrofuran that are being performed at the place of exposure.

(c) Record the results obtained.

(n) Employee notification.

(1) The employer shall notify in writing, within five work days, every employee who is found to be exposed to tetrahydrofuran above the permissible exposure. The employee shall also be notified of the level of his exposure and the corrective action being taken to reduce the exposure to at or below the permissible exposure.

(2) Pursuant to paragraph (k) of this Section, when an employee is medically examined the employer shall provide the employee with a copy of the physician's written opinion.

APPENDIX A

SUBSTANCE SAFETY DATA SHEET

I. SUBSTANCE IDENTIFICATION

SUBSTANCE: Tetrahydrofuran

PERMISSIBLE EXPOSURE: 200 parts of tetrahydrofuran per million parts of air (ppm) or 590 milligrams of tetrahydrofuran per cubic meter of air (mg/cu m)

APPEARANCE AND ODOR: Colorless liquid with an ether-like odor.

II. HEALTH HAZARD DATA

A. Ways in Which the Chemical Affects Your Body: Tetrahydrofuran can affect your body if you inhale it, swallow it, or if it comes into contact with your eyes or skin.

B. Effects of Overexposure:

1. Short-Term Overexposure: Overexposure to tetrahydrofuran may cause irritation of the eyes and nose, nausea, dizziness, and headache.

2. Long-Term Overexposure: Prolonged or repeated exposure to tetrahydrofuran may cause drying of the skin.

3. Reporting Signs and Symptoms: You should inform your employer if you develop any signs or symptoms associated with tetrahydrofuran exposure.

III. EMERGENCY FIRST AID PROCEDURES

A. Eye Exposure: If tetrahydrofuran gets into your eyes, wash the eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. If irritation persists, get medical attention. Contact lenses should not be worn when working with this chemical.

B. Skin Exposure: If tetrahydrofuran gets on your skin, wash the contaminated skin with water promptly. If tetrahydrofuran soaks through your clothing, remove the clothing immediately and flush the skin with water. If irritation persists, get medical attention. Do not wear the clothing again until the tetrahydrofuran has been removed. Replace or repair impervious clothing that has developed leaks.

C. Breathing: If you or any other person breathes in large amounts of tetrahydrofuran remove 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 tetrahydrofuran has been swallowed get medical attention immediately. If medical attention is not immediately available get the affected person to vomit by having him touch the back of the throat with his finger or by giving him large amounts (one pint or more) of warm salt water (two tablespoons of salt per pint of water). Do not make an unconscious person vomit.

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 tetrahydrofuran. You can only be required to wear them for routine use if your employer is in the process of installing controls or other 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)/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 should not be loosened or removed in work situations where there use is required. If you can smell tetrahydrofuran 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 repeated or prolonged skin contact with liquid tetrahydrofuran.

C. EYE PROTECTION: You must wear splash-proof safety goggles (cup-cover type dust and splash safety goggles) where eye contact to liquid tetrahydrofuran may occur.

V. PRECAUTIONS FOR SAFE USE, HANDLING AND STORAGE

Tetrahydrofuran is a flammable liquid and its vapors easily form explosive mixtures with air. It must be stored in tightly closed containers in a cool, well-ventilated area away from heat, sparks, flames and strong oxidizers. Sources of ignition such as smoking and open flames are prohibited wherever tetrahydrofuran is handled, used or stored in a manner that could create a potential fire or explosion hazard. You must use non-sparking tools when opening or closing metal containers of tetrahydrofuran, and containers must be bonded and grounded when pouring or transferring liquid tetrahydrofuran. If your skin becomes wet with liquid tetrahydrofuran, you must promptly wash or shower to remove any tetrohydrofuran from your skin. You must immediately remove any clothing that becomes wet with liquid tetrahydrofuran and this clothing must not be reworn until the tetrahydrofuran is removed from the clothing. Fire extinguishers, where provided, must be readily available and you should

Know where they are and how to operate them. Ask your supervisor where tetrahydrofuran is used in your work area and for any additional plant safety and health rules.

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APPENDIX B

SUBSTANCE TECHNICAL GUIDELINES
TETRAHYDROFURAN

I. PHYSICAL AND CHEMICAL DATA

A. Substance Identification

1. Synonyms: Diethylene oxide; tetramethylene oxide; THF
2. Formula: C4H8O
3. Molecular weight: 72

B. Physical Data

1. Boiling point (760 mm Hg): 66 C (151 F)
2. Specific gravity (water=1): 0.9
3. Vapor density (air=1 at boiling point of tetrahydrofuran): 2.5
4. Melting point: -108 C (-163 F)
5. Vapor pressure at 20 C (68 F): 145 mm Hg
6. Solubility in water, % by weight at 20 C (68 F): Miscible in all proportions
7. Evaporation rate (butyl acetate=1): 14.5
8. Appearance and odor: Colorless liquid with an ether-like odor.

II. FIRE, EXPLOSION AND REACTIVITY HAZARD DATA

A. Fire

1. Flash point: -14.5 C (6 F) (closed cup)
2. Autoignition temperature: 321 C (610 F)
3. Flammable limits in air, % by volume: Lower: 2; Upper: 11.8
4. Extinguishing media: Dry chemical, alcohol foam, carbon dioxide
5. Special fire-fighting procedures: Do not use a solid stream of water since the stream will scatter and spread the fire. Use water spray to cool containers exposed to a fire.
6. Unusual fire and explosion hazards: Tetrahydrofuran is a flammable liquid. Its vapors can easily form explosive mixtures with air. All ignition sources must be controlled where tetrahydrofuran is handled, used or stored. Tetrahydrofuran 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 tetrahydrofuran is handled.
7. For purposes of conforming with the requirements of 29 CFR 1910.106, tetrahydrofuran is classified as a Class IB flammable liquid. At 5000 ppm, one-fourth of the lower flammable limit, tetrahydrofuran 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 tetrahydrofuran shall be Class I Group C.

B. Reactivity

1. Conditions contributing to instability: Heat and sunlight
2. Incompatibilities: Contact with strong oxidizing agents may cause fire and explosions.
3. Hazardous decomposition products: Toxic gases and vapors (such as carbon monoxide) may be released in a fire involving tetrahydrofuran.
4. Special precautions: Tetrahydrofuran will attack some forms of plastics, rubber and coatings. Storage in the presence of air and light causes the formation of explosive peroxides that remain dissolved in tetrahydrofuran. These containers may explode when their caps or stoppers are removed.

III. SPILL, LEAK AND DISPOSAL PROCEDURES

A. If tetrahydrofuran 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 the hood ductwork, then burn the paper. Large quantities can be collected, dissolved in alcohol of greater molecular weight than butyl alcohol, and atomized in a suitable combustion chamber. Tetrahydrofuran 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:
Tetrahydrofuran may be disposed of by dissolving in alcohol of greater molecular weight than butyl alcohol and 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 8-hour sample or two (2) 4-hour samples. Short term interval samples (up to 30 minutes) may also be used to determine average exposure level if a minimum of five (5) measurements are taken in a random manner over the 8-hour work shift. Random sampling means that any portion of the work shift has the same chance of being sampled as any other. The arithmetic average of all such random equal duration samples taken on one (1) work shift is an estimate of an employee's average level of exposure for that work shift. 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 performed by instruments such as detector tubes certified by NIOSH under 42 CFR Part 84, portable direct-reading instruments, gas and vapor adsorption tubes with subsequent chemical analyses or dosimeters. The method of measurement must determine the concentration of tetrahydrofuran to plus or minus 35%.

b. EXPOSURE ABOVE THE PERMISSIBLE EXPOSURE: The monitoring 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 (AIHA). The method of measurement must determine the concentration of tetrahydrofuran to plus or minus 25%. Methods meeting these accuracy requirements are available from NIOSH.

V. MISCELLANEOUS PRECAUTIONS

A. Store tetrahydrofuran in tightly closed containers in a cool, well-ventilated area.

B. High exposures to tetrahydrofuran can occur when transferring the liquid from one container to another.

C. Non-sparking tools must be used to open and close metal tetrahydrofuran containers. These containers must be effectively grounded and bonded prior to pouring.

D. Stored tetrahydrofuran must be checked for the presence of explosive peroxides and for proper inhibitor concentration.

E. Employers must advise employees of all plant areas and operations where exposure to tetrahydrofuran could occur.

VI. COMMON OPERATIONS

Common operations in which exposure to tetrahydrofuran is likely to occur are: during its production; its use as a solvent in the preparation of inks, lacquers, coatings and for polyvinyl chloride and other plastics; and as a special solvent for chemical reactions in the synthesis of pharmaceuticals, motor fuel, vitamins, hormones, perfumes, organometallic compounds and insecticides; and as an intermediate in the production of adipic acid, butadiene and acrylic acid.

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APPENDIX C - MEDICAL SURVEILLANCE GUIDELINES

I. ROUTE OF ENTRY

Inhalation.

II. TOXICOLOGY

Tetrahydrofuran is an anesthetic agent and a mild upper respiratory tract irritant. Exposure of animals to vapor above 3,000 ppm for 8 hours daily for 20 days produced irritation of the upper respiratory tract. Some injury to the liver and kidneys was observed which was possibly due to impurities since other studies have not confirmed these findings. Concentrations above 25,000 ppm produced anesthesia, with a small margin of safety between anesthesia and death. Severe headaches were noted among technicians performing this experiment. Daily 6 hour exposures of dogs for 3 to 4 weeks at 200 ppm produced only a slight change in pulse pressure, but no other signs were noted even when continued for a total of 9 weeks, followed by an additional 3 weeks exposure at nearly 400 ppm. This substance was irritating to the skin of rabbits when applied in aqueous solutions exceeding 20% concentration, although it has not been observed to be a significant skin irritant or sensitizer in industrial practice. No chronic systemic effects have been reported in humans, although nausea, dizziness and headaches are said to occur with overexposure and are readily reversible in fresh air.

III. SIGNS AND SYMPTOMS

Irritation of the eyes and upper respiratory tract; nausea, dizziness and headache may occur at high levels.

IV. SPECIAL TESTS

None in common usage.

V. TREATMENT

Remove from exposures. Flush eyes and skin with water. If swallowed and the person is conscious, induce vomiting. Recovery is usually rapid and complete.

VI. SURVEILLANCE AND PREVENTIVE CONSIDERATIONS

A. GENERAL

Most reported effects of tetrahydrofuran are caused by its irritant properties. It is important that the physician becomes familiar with plant operating conditions in which exposure to tetrahydrofuran 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.

Protective eye equipment should be worn by all persons exposed to liquid tetrahydrofuran.

B. PREPLACEMENT

Routine medical histories and physical examination are not required. However, the employer must screen employees for history of certain medical conditions (listed below) which might place the employee at increased risk from tetrahydrofuran exposure. Only those giving a positive history of these conditions must be referred for further medical examinations.

1. Skin disease -- Tetrahydrofuran can cause dermatitis on prolonged exposure. Persons with preexisting skin disorders may be more susceptible to the effects of this agent.

2. Liver disease -- Although tetrahydrofuran is not known as a liver toxin in humans, the importance of this organ in the biotransformation and detoxification of foreign substances should be considered before exposing persons with impaired liver function.

3. Kidney disease -- Although tetrahydrofuran is not known as a kidney toxin in humans, the importance of this organ in the elimination of toxic substances justifies special consideration in those with impaired renal function.

4. Chronic respiratory disease -- In persons with impaired pulmonary function, especially those with obstructive airway diseases, the breathing of tetrahydrofuran might cause exacerbation of symptoms due to its irritant properties.

C. PERIODIC EXAMINATIONS

Routine periodic examinations are not required. However, if the employer becomes aware of an employee with the above listed conditions, he must refer such employee for further medical examination.

References

1. American Conference of Governmental Industrial Hygienists: "Tetrahydrofuran," (3d ed., 2d printing), Documentation of the Threshold Limit Values for Substances in Workroom Air, Cincinnati, 1974, p. 252-253.

2. Hygienic Guide Series: "Tetrahydrofuran," American Industrial Hygiene Association Journal, 20:250-251, 1959.

REFERENCES AND SOURCES
TETRAHYDROFURAN
1910.93

(d) Methods of Compliance - Open surface tank classification based on a relati evaporation rate of 0.99 hour.

(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. 20.

(f) Personal Protective Equipment, and (h) Sanitation

Eye: Sax, "Dangerous Properties of Ind. Materials;" AIHA Hyg. Guides; Quaker Oats MSDS

Skin: Documentation of TLV's; Browning, "Toxicity and Metabolism of Ind. Solvent Chemicals;" Quaker Oats MSDS

Ingestion: NIOSH Toxic Substances List (1974); Sax, "Dangerous Properties of Ind. Materials;" Browning, "Toxicity and Metabolism of Ind. Solve

COMMENTS

Eye - Classification: 2
Output statement numbers: 10
Exceptions: None

Sax states that the vapors are irritating to the eyes. AIHA only states "in case of eye contact, irrigate immediately with la quantities of water," and that "eye protection is advisable when handling liquid solvent." Quaker Oats MSDS states "it is an irri in contact with the eyes."

No specific data on the effects of eye contact could be four in the literature. By analogy with ethylene oxide and other orga solvents, it is concluded that any injury caused is reversible.

Skin - Classification: 2
Output statement numbers: 2, 7b, 16i, 21
Exceptions: None

Documentation of TLV's states it "was irritating to the skin rabbits when applied in aqueous solutions exceeding 20% concentra It goes on to say about subsequent experimentation that "in contr to literature reports, tetrahydrofuran was found not to irritate or be a skin sensitizer. Greater validity is believed for these results than those previosyly reported because of the greater number of individuals tested." Deichmann and Gerarde state "liqu THF applied to the skin of 196 persons was found to be essentiall non-irritating. Repeated exposure will dehydrate and delipidize the skin and cause dermatitis." Quaker Oats MSDS states that "repeated contact with skin will cause defatting."

Tetrahydrofuran has a vapor pressure of 145 mm Hg at 20 degr It is miscible in all proportions with water and has a flash poin of 6 degrees F.

A classification of 2 is concluded to be appropriate to prevent the cited effects.

Ingestion - Classification: 0
Output statement numbers: None
Exceptions: None
The Toxic Substances List gives an oral rat LD50 of 3 g/kg.

Sax considers the acute local effects of ingestion be severe because it has been reported as causing injury to liver and kidne Browning agrees with effects given and gives a lethal dose by ora administration for rabbits of 2.5 g/kg of a 20 per cent solution.

Though there is reason to believe that repeated ingestion of small quantities of this substance may be harmful, its volatility is such that it is concluded that, in the context of this standar ingestion would not present a hazard in the industrial environmer

SUBSTANCE TECHNICAL GUIDELINES
TETRAHYDROFURAN

I. PHYSICAL AND CHEMICAL DATA

A. Substance Identification

1. Synonyms: Diethylene oxide; tetramethylene oxide; THF
2. Formula: C4H8O
3. Molecular weight: 72

B. Physical Data

1. Boiling point (760 mm Hg): 66 C (151 F)
2. Specific gravity (water=1): 0.9
3. Vapor density (air=1 at boiling point of tetrahydrofuran): 2.5
4. Melting point: -108 C (-163 F)
5. Vapor pressure at 20 C (68 F): 145 mm Hg
6. Solubility in water, % by weight at 20 C (68 F): Miscible in all proportions
7. Evaporation rate (butyl acetate=1): 14.5
8. Appearance and odor: Colorless liquid with an ether-like odor.

II. FIRE, EXPLOSION AND REACTIVITY HAZARD DATA

A. Fire

1. Flash point: -14.5 C (6 F) (closed cup)
2. Autoignition temperature: 321 C (610 F)
3. Flammable limits in air, % by volume: Lower: 2; Upper: 11.8
4. Extinguishing media: Dry chemical, alcohol foam, carbon dioxide
5. Special fire-fighting procedures: Do not use a solid stream of water since the stream will scatter and spread the fire. Use water spray to cool containers exposed to a fire.
6. Unusual fire and explosion hazards: Tetrahydrofuran is a flammable liquid. Its vapors can easily form explosive mixtures with air. All ignition sources must be controlled where tetrahydrofuran is handled, used or stored in a manner that could create a potential fire or explosion hazard. Tetrahydrofuran 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 tetrahydrofuran is handled.
7. For purposes of conforming with the requirements of 29 CFR 1910.106, tetrahydrofuran is classified as a Class IB flammable liquid. For example, 5000 ppm, approximately one-fourth of the lower flammable limit, is one situation in

which tetrahydrofuran 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 tetrahydrofuran shall be Class I Group C.

B. Reactivity

1. Conditions contributing to instability: Heat and sunlight.
2. Incompatibilities: Contact with strong oxidizing agents may cause fire and explosions.
3. Hazardous decomposition products: Toxic gases and vapors (such as carbon monoxide) may be released in a fire involving tetrahydrofuran.
4. Special precautions: Tetrahydrofuran will attack some forms of plastics,rubber and coatings. Storage in the presence of air and light causes the formation of explosive peroxides that remain dissolved in tetrahydrofuran. These containers may explode when their caps or stoppers are removed.

III. SPILL, LEAK AND DISPOSAL PROCEDURES

A. If tetrahydrofuran 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 the hood ductwork, then burn the paper. Large quantities can be collected and atomized in a suitable combustion chamber. Tetrahydrofuran 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: Tetrahydrofuran may be disposed of 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 8-hour sample or two (2) 4-hour samples. Short term interval samples (up to 30 minutes) may also be used to determine average exposure level if a minimum of five (5) measurements are taken in a random manner over the 8-hour work shift. Random sampling means that any portion of the work shift has the same chance of being sampled as any other. The arithmetic average of all such random equal duration samples taken on one (1) work shift is an estimate of an employee's average level of exposure for that work shift. 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 performed by instruments such as detector tubes certified by NIOSH under 42 CFR Part 84, portable direct-reading instruments, gas and vapor adsorption tubes with subsequent chemical

analyses or dosimeters. The method of measurement must determine the concentration of tetrahydrofuran to plus or minus 35%.

b. EXPOSURE ABOVE THE PERMISSIBLE EXPOSURE: The monitoring 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 (AIHA). The method of measurement must determine the concentration of tetrahydrofuran to plus or minus 25%. Methods meeting these accuracy requirements are available from NIOSH.

V. MISCELLANEOUS PRECAUTIONS

A. Store tetrahydrofuran in tightly closed containers in a cool, well-ventilated area.

B. High exposures to tetrahydrofuran can occur when transferring the liquid from one container to another.

C. Non-sparking tools must be used to open and close metal tetrahydrofuran containers. These containers must be effectively grounded and bonded prior to pouring.

D. Stored tetrahydrofuran must be checked for the presence of explosive peroxides and for proper inhibitor concentration.

E. Employers should advise employees of all plant areas and operations where exposure to tetrahydrofuran could occur.

VI. COMMON OPERATIONS

Common operations in which exposure to tetrahydrofuran is likely to occur are: during its production; its use as a solvent in the preparation of inks, lacquers, coatings and for polyvinyl chloride and other plastics; and as a special solvent for chemical reactions in the synthesis of pharmaceuticals, motor fuel, vitamins, hormones, perfumes, organometallic compounds and insecticides; and as an intermediate in the production of adipic acid, butadiene and acrylic acid.

RESPIRATOR TABLE DOCUMENTATION

SUBSTANCE: Tetrahydrofuran

D. O. L. STANDARD: 200 ppm

WARNING PROPERTIES:

Odor Threshold: Staub and Summer both report an odor threshold for tetrahydrofuran of 30 ppm.

Eye Irritation Level: Sax reports that tetrahydrofuran is an eye irritant, and Stetcher, Browning, and the ILO indicate that it is a mucous membrane irritant, but the concentrations which produce irritation are not given. The Handbook of Organic Industrial Solvents reports that tetrahydrofuran "may cause irritation to mucuous membranes at concentrations higher than the threshold limit," but no quantitative information is available concerning the threshold of eye irritation. Therefore, only full facepiece respirators are permitted.

Other Information: "The TLV of 200 ppm is recommended to protect against irritative effects and has a wide margin of safety for narcotic and systemic effects," according to the Documentation of TLV's.

Evaluation of Warning Properties: Since the odor threshold of tetrahydrofuran is well below the permissible exposure limit, tetrahydrofuran is treated as a material with good warning properties.

Gas sorbent respiratory equipment is permitted.

IDLH: 20,000 ppm

Basis for IDLH Value: The AIHA Hygienic Guides state that exposure to "25,000 ppm will cause anesthesia. Concentrations of 17,000 ppm appear to be safe for three hours." Therefore, since 20,000 ppm is the lower flammable limit of tetrahydrofuran, this has been chosen as the IDLH concentration.

Other Toxicological Information: The Documentation of TLV's states that "Stoughton and Robbins found concentrations greater than 25,000 ppm were required to produce anesthesia which had a delayed induction period and recovery with poor relaxation; this was accompanied by a fall in blood pressure and strong respiratory stimulation. There was a small margin of safety between anesthesia and death in dogs and in mice. Severe headaches were noted among the technicians performing the experiments. . .

"Aettel exposed cats, rabbits, rats and mice to tetrahydrofuran at concentrations ranging from 3400 to 60,000 ppm for periods up to six hours duration. Aften ten three-hour to thirty six-hour exposures ranging from 3400 to 17,000 ppm, there was no evidence of kidney damage and changes in the livers of cats and rabbits. The action of tetrahydrofuran was compared with that of ethyl ether."

The AIHA Hygienic Guides state that exposure to "25,000 ppm will cause anesthesia. Concentrations of 17,000 ppm appear to be safe for three hours."

Browning gives the following narcotic doses by inhalation for experimental animals: "for mice, 6.7 vol % in 5 min; 1.1 vol % in 43 min; for dogs, 5.7 vol % (oxygen mixture) for 2 h.

LFL: 20,000 ppm

VAPOR PRESSURE AT 20 C: 145 mm Hg

SATURATED CONCENTRATION AT 20 C: Approximately 190,800 ppm

NIOSH/OSHA Draft Technical Standard
and Supporting Documentation for TETRAHYDROFURAN

USE/EXPOSURE AND CONTROL DOCUMENT
TETRAHYDROFURAN

	Use/Exposure	Principal Route of Entry	Currently Used Control Methods
1.	Inhalation of vapor and skin contact with vapor and liquid during use as a solvent in the preparation of printing inks, adhesives, lacquers, and other coatings	A,B	General dilution ventilation; personal protective devices (rubber gloves, goggles, respiratory protective devices)
2.	Inhalation of vapor and skin contact with liquid during use as a Grignard reagent in the syntheses of motor fuels, vitamins, hormones, pharmaceuticals, synthetic perfumes, organometallic compounds and insecticides	A,B	General dilution ventilation; process enclosure; personal protective devices (rubber gloves, goggles)
3.	Inhalation of vapor and skin contact with liquid during use as an intermediate in the preparation of various chemicals, including adipic acid, butadiene, polytetramethylene, and acrylic acid	A,B	General dilution ventilation; process enclosure; personal protective devices (rubber gloves, goggles)
4.	Inhalation of vapor and skin sKin contact with liquid during manufacture of tetrahydrofuran	A,B	General dilution ventilation; process enclosure; personal protective devices (rubber gloves, goggles)

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

------ JES2 JOB STATISTICS ------

1,243 CARDS READ

0 SYSOUT PRINT RECORDS

0 SYSOUT PUNCH RECORDS

0.00 MINUTES EXECUTION TIME

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