NIOSH/OSHA STANDARDS COMPLETION PROGRAM

DRAFT TECHNICAL STANDARD AND SUPPORTING DOCUMENTATION FOR

*** STYRENE ***

NIOSH/OSHA Draft Technical Standard and Supporting Documentation for STYRENE

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 STYRENE.

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.

NIOSH/OSHA Draft Technical Standard
and Supporting Documentation for STYRENE

(a) DEFINITIONS

(1) PERMISSIBLE EXPOSURE - "Permissible Exposure" means inhalation of styrene in concentrations not in excess of 100 parts per million (ppm) averaged over an 8-hour work shift and not in excess of 200 parts per million (ppm) at any time during an 8-hour work shift except that an exposure not in excess of 600 parts per million (ppm) for an aggregate of 5 minutes in any 3 hours shall be permitted as stated in Section 1910.93, Table G-2.

(2) ACTION LEVEL - "Action Level" means one half (1/2) of the time averaged permissible exposure for styrene for an 8-hour work shift.

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

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

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

(c) EXPOSURE MEASUREMENT

(1) INITIAL DETERMINATION - Each employer who has a place of employment in which styrene is released into the workplace air shall determine if any employee may be exposed to airborne concentrations of styrene 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 styrene. 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 styrene;

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

(iii) Any employee complaints of symptoms which may be attributable to exposure to styrene; 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 styrene 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) INDENTIFICATION OF EXPOSED EMPLOYEES - If the exposure measurement taken under paragraph (c)(2) of this section reveals employee exposure to airborne concentrations of styrene 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) 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 styrene 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.

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

(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 the time periods appropriate to the permissible exposure (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 styrene 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 styrene 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 daysy 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 styrene is present in concentrations greater than 2750 ppm, one fourth of the lower flammable limit, the fan rotating element shall be of nonsparking material or the casing shall consist of, or be lined with, nonsparking material. There shall be sufficient clearance between the fan rotating element and the fan casing so as to prevent contact.

(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 employee exposure to at or below the permissible exposure. Where technically feasible engineering and work practice controls are not sufficient to reduce 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),(f) and (g).

TABLE 2. RESPIRATORY PROTECTION FOR STYRENE

Condition	
Vapor Concentrations	
Equal to or Less than 400 ppm	Any chemical cartridge respirator with organic vapor cartridge(s). Any supplied-air respirator. Self-contained breathing apparatus.
Equal to or Less than 1000 ppm	A chemical cartridge respirator with a full facepiece and organic vapor cartridge(s).
Equal to or Less than 5000 ppm	A gas mask with a front or back mounted organic vapor canister. Any self-contained breathing apparatus with a full facepiece. Any supplied-air respirator with a full facepiece.
Equal to or Less than 10 000 ppm	

	mode or with a full facepiece, hoot, or helmet operated in continuous flow mode.
Greater than 10 000 ppm or Entry & Escape from Unknown Concentrations	Self-contained breathing apparatus with a full facepiece supplied-air respirator with a full facepiece operated flow mode and an auxiliary self-contained air supply operated in pressure-demand 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 styrene which is contained in Appendix B in order to ensure the safe handling and use of styrene.

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

(2) Portable fire extinguishers - For the purposes of compliance with section 1910.157, styrene 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 styrene shall be Class I Group D.

(4) Flammable liquids - For the purposes of compliance with section 1910.106, liquid styrene is classified as a Class IC flammable liquid.

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

(6) Storage - Styrene shall be stored so as not to come in contact with oxidizing agents and catalysts for polymerization such as peroxides, strong acids and aluminum chloride. The monomer shall be checked at least weekly to determine inhibitor and polymer content if the material is being stored in excess of 30 days at 90 F.

(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 styrene. Face shields shall comply with section 1910.133(a)(6).

(ii) Employers shall ensure that clothing contaminated with styrene is placed in closed containers. Employers shall provide for the cleaning or disposal of such clothing and if the clothing is to be laundered or otherwise cleaned, shall inform the person performing this operation of the hazardous properties of styrene.

(iii) Employers shall ensure that non-impervious clothing which becomes wet with styrene be removed promptly and not reworn until the styrene is removed from the clothing.

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

(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 styrene may occur.

(h) Spills

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

(2) Liquid styrene 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 styrene promptly wash or shower as necessary to remove any styrene from the skin.

(2) Where skin contamination may occur and showers are required for adequate cleaning of the body, employers shall provide showers as described in section 1910.141(d)(3).

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

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

(2) Medical -

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

(II) Instruct the employees to advise the employer of the development of signs and symptoms of exposure to styrene 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 insure that employees understand the precautions of safe use, emergency procedures, and the correct use of protective equipment relative to styrene.

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

(i) Kidney disease
(ii) Liver disease
(iii) Chronic lung disease
(iv) Skin disease
(v) Central nervous system disorders

(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 styrene.

(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 be exposed to styrene 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 styrene.

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

(i) A copy of this regulation for styrene;
(ii) A description of the employee's duties as they relate to his exposure to styrene;
(iii) A description of any personal protective equipment 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 styrene 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 styrene.

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

(ii) The written opinion shall not reveal medical information unrelated to exposure to styrene.

(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 for at least one year.

(2) Exposure measurements.

(i) The employer shall keep an accurate record of all measurements taken to determine employee exposure to styrene.

(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 styrene 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 for 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 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 for at least one year.

(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 sty

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

(e) A copy of information provided to the physician pursuant to paragraph (K)(9) 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 styrene which is conducted pursuant to this section.

(2) Exercise of opportunity to observe monitoring.

(i) When observation of the monitoring of employee exposure to styrene 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 styrene 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 styrene 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: Styrene

PERMISSIBLE EXPOSURE: 100 parts of styrene vapor per million parts of air (ppm), 8-hour time weighted average, with a ceiling of 200 ppm and a maximum peak concentration of 600 ppm for 5 minutes in any 3 hours.

APPEARANCE AND ODOR: Styrene is a colorless liquid. At low concentrations styrene has a sweet odor but at higher concentrations styrene has a sharp, penetrating disagreeable odor.

II. HEALTH HAZARD DATA

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

B. Effects of Overexposure:

1. Short-Term Effects: Styrene may irritate your eyes, nose, throat and skin. High concentrations may cause you to become sleepy or to become unconscious.
2. Long-Term Effects: Repeated skin contact to styrene may produce a skin rash.
3. Reporting Signs and Symptoms: You should inform your employer if you develop any signs or symptoms associated with styrene exposure.

III. EMERGENCY FIRST AID PROCEDURES

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

B. Skin Exposure: If styrene gets on your non-impervious clothing or skin remove and clean the contaminated clothing and flush the contaminated skin with water when there is skin irritation, get medical attention.

C. Breathing: If you or any other person breathes in large amounts of styrene remove the exposed person to fresh air at once. When breathing is difficult, properly trained personnel may assist the affected person by administering oxygen. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

D. Swallowing: If styrene has been swallowed, do not cause vomiting. 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 styrene. 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.)

If you can smell styrene 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, and other appropriate protective clothing over any parts of your body that could repeatedly be exposed to styrene liquid.

C. EYE PROTECTION: You must wear splash-proof safety goggles if it is possible that styrene may get into your eyes.

V. PRECAUTIONS FOR SAFE USE, HANDLING, AND STORAGE

styrene is a flammable liquid and must be stored in tightly closed containers, in a cool, well-ventilated area away from ignition sources, oxidizing agents, acids, alkalies, and ammonia. You must comply with the manufacturers recommended storage practices to prevent self-reaction. Metal styrene storage containers must be bonded and grounded when transferring liquids and must be opened and closed with non-sparking tools. You must not smoke in areas where styrene is used, stored or handled. If your non-impervious clothing becomes wet with styrene, you must promptly remove the clothing and do not wear it again until the styrene has been removed. If your skin becomes wet with styrene, you must wash or shower promptly. Fire extinguishers, where provided, must be readily available and you should Know where they are and how to operate them. Ask your supervisor where styrene is used in your work area and for any additional plant safety rules.

APPENDIX B

SUBSTANCE TECHNICAL GUIDELINES
STYRENE

I. PHYSICAL AND CHEMICAL DATA

A. Substance Identification

1. Synonyms: Phenylethylene; vinylbenzene; cinnamene; styrene monomer
2. Formula: $C_6H_5CH=CH_2$

B. Physical Data

1. Boiling point (760 mm Hg): 145 C (293 F)
2. Specific gravity (water=1): 0.90
3. Vapor density (air=1): 3.6
4. Melting point: -30.6 C (-23 F)
5. Vapor pressure at 20 C (68 F): 4.5 mm Hg
6. Solubility in water, % by weight at 20 C (68 F): 0.03
7. Evaporation rate (butyl acetate=1): 0.49
8. Appearance and odor: Colorless liquid with sweet aromatic odor at low concentrations. Sharp penetrating and disagreeable at higher concentrations.

II. FIRE, EXPLOSION AND REACTIVITY HAZARD DATA

A. Fire

1. Flash point: 32 C (90 F) (closed cup)
2. Autoignition temperature: 490 C (914 F)
3. Flammable limits in air % by volume: Lower: 1.1; Upper: 6.1
4. Extinguishing media: Dry chemical, foam, or carbon dioxide. Larger fires are best fought with foam.
5. Special fire-fighting procedures: Do not use solid stream of water, since stream will scatter and spread fire. Use water spray to keep containers cool. Firefighters should wear self-contained breathing apparatus. Large fires must be fought from a distance, or from protected locations.
6. Unusual fire and explosion hazards: Styrene is a flammable liquid. Its vapors can easily form explosive mixtures in air. All ignition sources must be controlled when styrene is used, handled, and stored. styrene vapors are heavier than air; thus the vapors may travel along the ground and be ignited by open flames or sparks at locations remote from the site at which the styrene is handled. The vapors are uninhibited and may form polymers in vents or flame arresters of storage containers.
7. For the purposes of complying with 29 CFR 1910.106, styrene is classified as a Class IC flammable liquid. At 2750 ppm,

one-fourth of the lower flammable limit, styrene is considered a potential fire and explosion hazard.

8. For the purposes of complying with 29 CFR 1910.309, the classification of hazardous locations as described in Article 500 of the National Electrical Code for styrene shall be Class I, Group D.

B. Reactivity

1. Conditions contributing to instability: Styrene is stabilized by a polymerization inhibitor (often tert-butylcatechol). If this is not present in adequate concentrations styrene can polymerize and explode its container. The polymerization is also speeded up by temperatures above 66 C (150 F).
2. Incompatibilities: Oxidizing agents and catalysts for vinyl polymerization such as peroxides, strong acids and aluminum chloride.
3. Hazardous decomposition products: Toxic gases and vapors (such as carbon monoxide) may be released in a fire involving styrene fumes from fire are very acrid.
4. Special precautions: Styrene will corrode copper and copper alloys and dissolve rubber.

III. SPILL AND LEAK PROCEDURES

A. If styrene 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) and burn the paper. large quantities, can be collected and atomized in a suitable combustion chamber. Combustion may be improved by mixing with a more flammable liquid.

B. Persons not wearing protective equipment should be restricted from areas of spills or leaks until cleanup has been completed.

C. Waste Disposal Methods:
styrene may be disposed of:

1. By absorbing it in vermiculite, dry sand, earth or a similar material and disposing in a sanitary land fill.
2. By atomizing in a suitable combustion chamber. Combustion may be improved by mixing with a more flammable liquid.

IV. MONITORING AND MEASUREMENT PROCEDURES

a-1. EXPOSURE ABOVE THE ACTION LEVEL (8-hour exposure evaluation): Measurements taken in a fashion such that the average 8-hour exposure may be determined from a single 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).

a-2. EXPOSURE ABOVE THE ACTION LEVEL (Ceiling Evaluation): Measurements taken for the purpose of determining employee exposure under this section must be taken during periods of maximum expected airborne concentrations of styrene. Each measurement should consist of a 15-minute sample or series of consecutive samples totaling fifteen (15) minutes in the employee's breathing zone. A minimum of three measurements should be taken on one work shift and the highest of all measurements taken is a good estimate of the employee's exposure.

a-3. EXPOSURE ABOVE THE ACTION LEVEL (Peak Above Ceiling Evaluation): Measurements taken for the purpose of determining employee exposure under this section must be taken during periods of maximum expected airborne concentrations of styrene. Each measurement should consist of a 5-minute sample or series of consecutive samples totaling five (5) minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three measurements should be taken on one work shift and the highest of all measurements taken is a good estimate of the employee's exposure.

a-4. MONITORING TECHNIQUES: The sampling and analyses under this section may be performed by instruments such as: detector tubes certified by NIOSH under 42 CFR Part 84, portable direct-reading instruments, gas vapor adsorption tubes with subsequent chemical analyses, or dosimeters. The method of measurement must determine the concentration of styrene 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-1. When sampling for peak exposure evaluations, more than three (3) measurements should be taken during the work shift so that increased confidence may be placed in the judgement that the employee has or has not, in fact, been exposed in excess of the permissible limit. 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 styrene to plus or minus 25%. Methods meeting these accuracy requirements are available in the "NIOSH Monitoring Methods Manual".

V. MISCELLANEOUS PRECAUTIONS

A. High exposure to styrene can occur when transferring the liquid from one container to another.

B. Non-sparking tools must be used to open and close styrene containers which must be effectively bonded and grounded prior to pouring.

C. Store styrene in tightly closed containers in a cool well-ventilated area away from ignition sources and polymerization catalysts.

D. Styrene should be stored in a well-ventilated place below 21 C (70 F). If material in storage is above this temperature the inhibitor content specified by the manufacturer should be checked weekly after 30 days.

E. Styrene vapors are not inhibited. They can polymerize and clog tank vents and flame arresters.

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

VI. COMMON OPERATIONS

Some common operations in which high exposures to styrene could occur are in the manufacture of styrene from ethylbenzene and the uses of styrene in the manufacture of synthetic rubber latex, polyester resins (as in glass-reinforced boat hulls), ion-exchange resins, styrenated oil and styrene molding compounds.

APPENDIX C - MEDICAL SURVEILLANCE GUIDELINES

I. Route of Entry

Inhalation; skin absorption.

II. Toxicology

Exposure to concentrations of styrene above 200 ppm causes irritation of the eyes and upper respiratory tract. There is cracking and inflammation of the skin due to defatting. Higher exposures depress the central nervous system. Electroencephalographic changes have been reported. Styrene is excreted fairly rapidly in the urine, largely as hippuric acid.

III. Signs and Symptoms

Irritation of eyes and nose; drowsiness, weakness, unsteady gait; and narcosis; defatting dermatitis.

IV. Special Tests

None in common usage.

V. Treatment

None specific. Remove from exposure, give artificial resuscitation if indicated, and wash eyes and contaminated skin. Recovery is usually rapid and complete.

VI. Surveillance and Preventive Considerations

A. General

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

Routine medical histories and physical examinations 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 styrene exposure. Only those giving a positive history of these conditions must be referred for further medical examinations.

1. Central nervous system disorders -- Since exposure to styrene vapor or liquid on the skin has been observed to result in central nervous system depression and occasional abnormalities in the electroencephalogram, persons with pre-existing neurologic disorders may be unusually susceptible to these effects.

2. Chronic respiratory disease -- In persons with impaired pulmonary function, especially those with obstructive airway diseases, inhalation of styrene vapor might cause exacerbation of symptoms due to its irritant properties or to psychic reflex bronchospasm.

3. Skin disease -- Styrene is a defatting agent and can cause dermatitis on prolonged exposure. Persons with existing skin disorders may be more susceptible to its effects.

4. Renal disease -- Although styrene is not known as a kidney toxin, the importance of the organ in the elimination of toxic substances justifies special consideration in those with possible impairment of renal function.

5. Liver disease -- Although styrene is not commonly considered 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.

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. Dutkiewicz, Tadeusz, and Halina Tyras: Skin Absorption of Toluene, Styrene, and Xylene by Man, British Journal of Industrial Medicine, 25:243, 1968.

2. Zielhuis, R.L.: Systemic Toxicity from Exposure to Epoxy Resins, Hardeners, and Styrene, Journal of Occupational Medicine, 3:25-29, 1961.

3. Browning, Ethel: Toxicity and Metabolism of Industrial Solvents, Elsevier Publishing Company, Amsterdam, 1965, pp. 98-102.

4. Patty, Frank A.: Industrial Hygiene and Toxicology, Vol. II. Toxicology (2d ed. revised), Interscience Publishers, New York, 1963, pp. 1229-1231.

REFERENCES AND SOURCES
STYRENE
1910.93

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

Eye: "Styrene" Hygenic Guide Series, NIOSH
Grant, "Toxicology of the Eye"
Carpenter and Smyth, "Chemical Burns of the Rabbit Cornea," J. Am. Ophth.h, 29, 1363-72 (1946)
Wolf et al., "Toxicological Studies of Certain Alkylated Benzenes and Benzene," Arch. Ind. Hth., 14 (4) 387-98 (1956)
"Styrene," Manufacturing Chemists' Association Chemical Safety Data Sheet

Skin: Browning, "Toxicity and Metabolism of Industrial Solvents"
"Encyclopedia of Occupational Safety and Health, "International Labour Office
Wolf et al., "Toxicological Studies of Certain Alkylated Benzenes and Benzene," Arch. Ind. Hth., 14 (4) 387-98 (1956)
"Styrene," Manufacturing Chemists' Association Chemical Safety Data Sheet

Ingestion: Browning, "Toxicity and Metabolism of Industrial Solvents"
"Styrene," Hygenic Guide Series, NIOSH
"Styrene - PHS - 149 Document
"Encyclopedia of Occupational Safety and Health," International Labour Office
Gleason, "Clinical Toxicology of Commercial Products"
Wolf et al., "Toxicological Studies of Certain Alkylated Benzenes and and Benzene," Arch. Ind. Hth., 14 (4) 387-98 (1956)

COMMENTS

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

The Hygienic Guide Series comments, "liquid (styrene) may produce appreciable irritation and superficial eye burns." They continue, "splash contact with human eyes has resulted in superficial transient disturbances with a return to norm within 48 hours in 29 out of 30 cases." Grant states that "the liquid has been tested by application to rabbit eyes and found to cause moderate hyperemia of the conjuctiva and slight injury of the corneal epithelium with a rapid return to normal." According to Wolf et al., eye contact in rabbits results in an inflammation and slight swelling of the eyelids and a slight transient superficial necrosis in very small areas of the cornea. However, Carpenter and Symth report that styrene "is known to have caused loss of vision or very slowly healing corneal burns in industrial use." They assigned the substance an injury grade of 4 on a scale of 10 after 24 hours which indicates that 0.02 ml of the undiluted chemical causes less than severe injury while 0.1 ml produces severe injury. The MCA reports that "permanent damage to the eyes has not been reported."

Carpenter and Smyth's assertion that the substance causes persistent effects appears to be unsupported. The

substance is therefore assigned a classification of 2.

Skin - Classification: 2
Output statement numbers: 2, 7b, 17g, 21, 17i
Exceptions: 20a deleted

Browning reports that the dermatitis hazard of styrene is especially prominent since it tends to degrease the skin with resulting cracking and inflammation of exposed areas. She also notes it is slowly absorbed by intact skin. The ILO agrees, and notes "styrene is lipid soluble and may enter the body by absorption through the intact skin." It also comments, "animal experiments have shown that styrene-induced skin irritation may be sufficient to cause blistering and tissue necrosis." According to Wolf et al. the repeated cutaneous applictation of styrene to rabbit skin caused definite erythema and the development of a thin layer of devitalized tissue which results in exfoliati The MCA reports: "Styrene monomer may cause some moderate irritation after contact with the skin, similar to that noticed with other aromatic hydrocarbons. Short exposures of skin to styrene should be avoided, particularly when covered by clothing. Long exposures result in irritation and blisters."

Styrene has a flash point of 89.6 degrees F and a vapor pressure of 4.5 mm Hg at 20 degrees C. It is 0.03% soluble in water.

A classification of 2 is concluded to be appropriate to prevent the cited effects. Statement 20a is not used because the amounts of chemical towards which is directed would have innocuous effects, if any.

Ingestion - Classification: 0
Output statement numbers: None
Exceptions: None

Browning comments that "in animals (styrene) has a toxic effect on the central nervous system and neurological disturbances . . . drowsiness, weakness, depression, inert: and unsteadiness . . . have also been described in humans.' The Hygenic Guide Series note styrene "will cause a pronounced irritation of the mouth, esophagus and stomach" and considers it a "moderate hazard" by the oral route. The PHS-149 document lists an oral rat LD50 of 4920 mg/kg. The ILO found "animal experiments have shown that digestive absorption causes symptoms of poisoning similar to those resulting from inhalation." They note acute vapor poisonin results in "narcosis, cramps . . . edema of the brain and lungs, foci of epitheleal necrosis in the renal tubules and hepatic dystrophy . . . and death due to respiratory-centre paralysis." For chronic vapor exposure, "an increase in deep reflexes, irritation of the upper respiratory tract and haematological disorders - leukopenia and lymphoatosis" were reported. Gleason notes that "renal and hepatic damage are said to occur after ingestion but if aspiration occurs the chief hazard is probably chemical pneumonitis."

According to Wolf et al., six-month rat studies of 132 feedings caused no effects at daily does of 66.7 and 133 mg/Kg but at the level of 400 mg/Kg daily there was a slight effect on growth depression and on liver and kidney weight and at 667 mg/Kg/day there was a moderate effect on growth depression and liver weight and a slight effect on kidney weight. They list an oral rat LD50 of 5 g/Kg.

The low acute oral toxicity of the substance and the repeated feeding data indicate that ingestion of styrene should not, in the context of this standard, present a hazard in the industrial environment.

RESPIRATOR TABLE DOCUMENTATION

SUBSTANCE: Styrene

D. O. L. STANDARD: 100 ppm, where 200 ppm shall not be exceeded except that a peak is permitted of 600 ppm for 5 minutes in any 3 hours.

WARNING PROPERTIES:

Odor Threshold: Staub reports that the odor threshold of styrene is 0.08 ppm.

Eye Irritation Level: The AIHA Hygienic Guides report that "styrene vapor at concentrations of 200 to 400 ppm was found to have transient irritant effect on the eyes."

Other Information: The Manufacturing Chemists' Association reports that styrene is a moderate irritant to the . . . respiratory tract at concentrations above 400 ppm.

Evaluation of Warning Properties: Since the odor threshold of styrene is below the permissible exposure limit, styrene is treated as a material with adequate warning properties. Gas sorbent respiratory equipment is permitted.

IDLH: 5000 ppm

Basis for IDLH Value: This IDLH is based upon the report in Patty that animals exposed to 5000 ppm styrene become unconscious within one hour.

Other Toxicological Information: Browning reports that "styrene is principally an irritant of skin and mucous membranes, but in animals it has a toxic effect on the central nervous system, and neurological disturbances have been described in human beings."

Patty states that "under ordinary room conditions styrene does not vaporize sufficiently to reach vapor concentrations that kill animals (rats and guinea pigs) in a few minutes; 10,000 ppm was dangerous to life in 30 - 60 minutes, 2500 ppm was dangerous to life in 8 hours, while 1300 ppm was the highest amount causing no serious systemic disturbance in 8 hours. All animals exposed to these concentrations had evidence of eye and nasal irritation. Animals exposed to 2500 ppm or greater showed varying degrees of weakness and stupor, followed by incoordination, tremors, and unconsciousness. Unconsciousness occurred in 10 hours with 2500 ppm, in 1 hour wi 5000 ppm, and in a few minutes at 10,000 ppm."

The Hygienic Guides report similar information to that found in Patty.

LFL: 11,000 ppm
VAPOR PRESSURE AT 20 C: 4.5 mm Hg
SATURATED CONCENTRATION AT 20 C: 5920 ppm

NIOSH/OSHA Draft Technical Standard
and Supporting Documentation for STYRENE

USE/EXPOSURE AND CONTROL DOCUMENT
STYRENE

	Use/Exposure	Principal Route of Entry	Currently Used Control Methods
1.	Inhalation of vapor during spray-up manufacture of glass fiber reinforced styrene-polyester articles (storage tanks, boats, auto bodies, etc.)	A,B	Local exhaust ventilatio general dilution ventila personal protective equi (gloves, aprons, barrier creams)
2.	Inhalation of vapor and skin contact with liquid during spray application of styrene-polyester surface coatings	A,B	Process enclosure; local exhaust ventilation; per protective equipment (gl barrier creams)
3.	Inhalation of vapor and skin contact with liquid during hand lay-up of glass fiber reinforced styrene-polyester articles (storage tanks, boats, etc.)	A,B	Local exhaust ventilatio general dilution ventila personal protective equi (gloves, aprons, barrier creams)
4.	Inhalation of vapor and skin contact with liquid during molding of articles or potting electrical components with polystyrene	A,B	General dilution ventila personal protective equi (gloves, aprons, barrier creams)
5.	Inhalation of vapor and skin contact with liquid during manufacture of tires and other rubber goods using styrene-butadiene elastomers (SBR)	A,B	General dilution ventila
6.	Inhalation of vapor and skin contact with liquid during use of styrene containing concretes	A,B	General dilution ventila personal protective equi (gloves)
7.	Inhalation of vapor and skin contact with liquid during bag lay-up manufacture of glass fiber reinforced styrene-polyester articles (storage tanks)	A,B	Local exhaust ventilatio process enclosure; perso protective equipment (gl aprons, barrier creams)
8.	Inhalation of vapor and skin		

	contact with liquid during use of surface coatings containing styrene-butadiene copolymer resins (paper and textile coatings, cement and mortar additives, waterbase paints, and floor polishes)		general dilution ventila personal protective equi (gloves, goggles, aprons
9.	Inhalation of vapor during die molding of articles made from styrene-polyester resins	A,B	Local exhaust ventilatio general dilution ventila personal protective equi (gloves, barrier creams)
10.	Inhalation of vapor during brush application of styrene-polyester surface coatings	A,B	Local exhaust ventilatio general dilution ventila personal protective equi (gloves, barrier creams)
11.	Inhalation of vapor and skin contact with liquid in process operations for production of styrene	A,B	Local exhaust ventilatio personal protective equi (gloves, goggles, barrie creams)
12.	Inhalation of vapor and skin contact with liquid in process operations for production of polystyrene	A,B	Local exhaust ventilatio personal protective equi (gloves, goggles, barrie creams)
13.	Inhalation of vapor and skin contact with liquid in process operations for production of styrene-butadiene rubber (SBR)	A,B	General dilution ventila personal protective equi (gloves, aprons)
14.	Inhalation of vapor and skin contact with liquid in process operations for manufacture of acrylonitrile-butadiene-styrene (ABS), styrene-acrylonitrile (SAN), and styrene-butadiene copolymers	A,B	Local exhaust ventilatio personal protective equi (gloves, aprons)
15.	Inhalation of vpaor and skin contact with liquid during manufacture of surface coatings containing styrene	A,B	Local exhaust ventilatio personal protective equi (goggles, gloves)
16.	Inhalation of vapor and skin contact with liquid in miscellaneous processes	A,B	Local exhaust ventilatio personal protective equi (gloves, goggles, barrie

	using styrene as an elastomer, intermediate, or starting material		creams)
17.	Inhalation of vapor and skin contact with liquid during subdivision of large quantities and handling of styrene monomer	A,B	Local exhaust ventilatio personal protective equi (gloves, goggles)
18.	Inhalation of vapor and skin contact with liquid during manufacture of ion exchange resins (styrene-divinylbenzene copolymer)	A,B	Local exhaust ventilatio personal protective equi (goggles, gloves, aprons

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

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

1,285 CARDS READ

0 SYSOUT PRINT RECORDS

0 SYSOUT PUNCH RECORDS

0.00 MINUTES EXECUTION TIME

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