

(a) Receive an explanation of the measurement procedures;

(b) Observe all steps related to the measurement of airborne concentrations of benzene performed at the place of exposure; and

(c) Record the results obtained.

(n) Effective date: This section shall become effective May 21, 1977.

(o) *Appendixes.* The information contained in the appendixes is not intended, by itself, to create any additional obligations not otherwise imposed or to detract from any existing obligation.

1. SUBSTANCE IDENTIFICATION

APPENDIX A—SUBSTANCE SAFETY DATA SHEET

BENZENE

A. Substance: Benzene.

B. *Formaldehyde Exposure.* Except as to retail gasoline stations and operations which use liquids containing benzene in amounts greater than 1% by volume, or the benzene vapor released by any such liquids.

1. *Airborne.* 1 part of benzene vapor per million parts of air (1 ppm); time-weighted average (TWA) for an 8-hour workday for a 40-hour week, with a ceiling concentration of 5 ppm.

2. *Dermal.* Eye contact and repeated skin contact with liquid benzene shall be prohibited.

C. *Appearance and odor.* Benzene is a clear, colorless liquid with a pleasant, sweet odor. The odor of benzene does not provide adequate warning of its hazard.

II. HEALTH HAZARD DATA

A. *Ways in which the benzene affects your health.* Benzene can affect your health if you inhale it, or if it comes in contact with your skin or eyes. Benzene may also be harmful if you happen to swallow it.

B. *Effects of overexposure.* 1. *Short-term (acute) overexposure:* If you are overexposed to high concentrations of benzene, well above the levels where its odors are first recognizable, you may feel breathless, irritable, euphoric, or giddy; you may experience irritation in eyes, nose, and respiratory tract. You may develop a headache, feel dizzy, nauseous, or experience unsteadiness in walking. Severe exposures may lead to convulsions.

2. *Long-term (chronic) exposure:* Repeated and prolonged exposure of benzene may cause headache, fatigue, exhaustion, tendency to bleed, nervousness, sleeplessness, shortness of breath, and serious blood disorders, including leukemia.

III. PROTECTIVE CLOTHING AND EQUIPMENT

A. *Respirators.* Respirators are required for those operations in which engineering controls or work practice controls are not available to reduce exposure to the permissible level. If respirators are worn, they must have a National Institute for Occupational Safety and Health (NIOSH) seal of approval. If you experience difficulty breathing while wearing a respirator, tell your employer.

B. *Protective Clothing.* You must wear impervious protective clothing (such as boots, gloves, sleeves, aprons, etc.) over any parts of your body that could be repeatedly exposed to liquid benzene.

C. *Eye and Face Protection.* You must wear splash proof safety goggles if it is possible that benzene may get into your eyes. In addition, you should wear a face shield if your face could be splashed with benzene liquid.

IV. EMERGENCY AND FIRST AID PROCEDURES

A. *Eye and face exposure.* If benzene is splashed in your eyes, wash it out immediately with large amounts of water. Call a doctor as soon as possible.

B. *Skin exposure.* If benzene is spilled on your clothing or skin, remove the contaminated clothing and wash the exposed skin with large amounts of water and soap immediately. Wash contaminated clothing before you wear it again.

C. *Breathing.* If you or any other person breathes in large amounts of benzene, get the exposed person to fresh air at once. Apply artificial respiration if breathing has stopped. Call a doctor as soon as possible.

D. *Swallowing.* If benzene has been swallowed and the patient is conscious, do not induce vomiting. Call a doctor immediately.

V. MEDICAL REQUIREMENTS

If you are exposed to benzene your employer is required to provide the following medical procedures within thirty days of the effective date of this standard, consisting of a medical history and laboratory tests. These tests shall be provided without cost to you.

VII. OBSERVATION OF MONITORING

Your employer is required to perform measurements that are representative of your exposure to benzene and you are entitled to observe the monitoring procedure. You are entitled to receive an explanation of the measurement procedure, observe the steps taken in the measurement procedure, and to record the results obtained. When the monitoring procedure is taking place in an area where respirators or personal protective clothing and equipment are required to be worn, you must also be provided with, and must wear the protective clothing and equipment.

VIII. ACCESS TO RECORDS

You or your representative are entitled to see the records of measurements of your exposure to benzene upon request to your employer. Your medical examination records can be furnished to your physician upon request to your employer.

IX. PRECAUTIONS FOR SAFE USE, HANDLING AND STORAGE

Benzene liquid is highly flammable. It should be stored in tightly closed containers in a cool, well ventilated area. Benzene vapor may form explosive mixtures in air. All sources of ignition must be controlled. You should use non-sparking tools when opening or closing benzene containers. You must ground or bond metal benzene containers. Fire extinguishers, where provided, must be readily available and you should know where they are located and how to operate them. Smoking is prohibited in areas where benzene is used or stored. Ask your supervisor where benzene is used on your work area and for additional plant safety rules.

APPENDIX B—SUBSTANCE TECHNICAL

GUIDELINES

BENZENE

1. PHYSICAL AND CHEMICAL DATA

A. Substance Identification

1. *Synonyms.* Benzol, benzole, coal naphtha, cyclohexatriene, phenol, phenyl hydride, pyrobenzol, (Benzin, petroleum benzin, and benzine, do not contain benzene).

2. *Formula.* C₆H₆ (CAS Registry Number: 000071432)

B. Physical Data

1. *Boiling point* (760 mm Hg): 80.1 C (176F).

2. *Specific Gravity* (water=1): 0.879.

3. *Vapor Density* (air=1): 2.7.

4. *Melting Point:* 5/5 C (42F).

5. *Vapor Pressure at 20 C (68F):* 75 mm Hg.

6. *Solubility in Water:* .08%.

7. *Evaporation Rate* (ether=1): 2.8.

8. *Appearance and Odor:* Clear, colorless liquid with a distinctive sweet odor.

II. FIRE, EXPLOSION AND REACTIVITY HAZARD DATA

A. *Fire.* 1. *Flash Point* (closed cup): -11 C (12F).

2. *Autoignition Temperature:* 680 C (1076F).

3. *Flammable Limits in Air, % by Volume:* Lower: 1.3% Upper: 7.1%.

4. *Extinguishing Media:* Carbon dioxide, dry chemical, or foam.

5. *Special Fire-Fighting Procedures:* Do not use solid stream of water, since stream will scatter and spread fire. Water spray can be used to keep fire exposed containers cool.

6. *Unusual fire and explosion hazards:* Benzene is a flammable liquid. Its vapors can form explosive mixtures. All ignition sources must be controlled when benzene is used, handled, or stored. Where liquid or vapor may be released, such areas shall be considered as hazardous locations. Benzene 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 benzene is handled.

7. Benzene is classified as a 1 B flammable liquid for the purpose of conforming to the requirements of 29 CFR 1910.106. A concentration exceeding 3250 ppm is considered a potential fire or explosion hazard. Locations where benzene may be present in quantities sufficient to produce explosive or ignitable mixtures are considered Class 1 Group D for the purposes of conforming to the requirement of 29 CFR 1910.309.

B. *Reactivity.* 1. *Conditions contributing to instability:* Heat.

2. *Incompatibility:* Heat and oxidizing materials.

3. *Hazardous decomposition products:* Toxic gases and vapors (such as carbon monoxide).

III. SPILL AND LEAK PROCEDURES

A. *Steps to be taken if the material is released or spilled.* Large amounts of water should be used to flush the spills. Do not flush benzene into confined space, such as a sewer, because of explosion danger. Remove all ignition sources. Ventilate enclosed places.

B. *Waste Disposal Method.* Disposal methods must conform to other jurisdictional regulations. If allowed, benzene may be disposed of: (a) By absorbing it in dry sand or earth and disposing in a sanitary land fill; (b) If small quantities, by removing it to a safe location from buildings or other combustible sources, pouring it in dry sand or earth and cautiously igniting it; (c) If large quantities, by atomizing it in a suitable combustion chamber.

IV. MONITORING AND MEASUREMENT PROCEDURES

A. *Normal Monitoring Program:* Measurements taken for the purpose of determining employee exposure are best taken such that the representative average 8-hour exposure may be determined from a single 8-hour sample or two (2) 4-hour samples. Short-time interval samples (or grab samples) may also be used to determine average exposure level if a minimum of five (5) measurements is 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 samples taken on one (1) work shift is an estimate of an employee's average level of exposure for that work shift. NIOSH recommends that samples be collected at a sampling rate of one liter per minute for a minimum of two hours. Air samples should be taken in the employee's breathing zone (air that would nearly represent that inhaled by the employee). Sampling and analysis should be performed by gas absorption tubes with subsequent chemical analysis, by gas chromatography of those areas most likely to represent the highest airborne concentration of benzene where employees are exposed. Methods meeting the prescribed accuracy and precision requirements are available in the "NIOSH Manual of Analytical Methods."

V. MISCELLANEOUS PRECAUTIONS

A. High Exposures to benzene can occur when transferring the liquid from one container to another. Such operations should be well ventilated and good work practices should be established to avoid spills.

B. Non-sparking tools should be used to open benzene containers which should be effectively grounded and bonded prior to opening and pouring.

C. Employers should advise employees of all plant areas and operations where exposure to benzene could occur. A few of the common operations in which high exposures to benzene may be encountered are: manufacture of styrene, phenol, cyclohexane, pesticides, and detergents.

APPENDIX C—MEDICAL SURVEILLANCE GUIDELINES FOR BENZENE

I. ROUTE OF ENTRY

Inhalation; possible skin absorption.

II. TOXICOLOGY

Benzene is primarily an inhalation hazard. Systemic absorption cause depression of the hematopoietic system. Inhalation of high concentrations can affect the central nervous system function. Aspiration of small amounts of liquid benzene immediately causes pulmonary edema and hemorrhage of pulmonary tissue. Skin absorption through intact skin is negligible. However, absorption will be accelerated in the case of injured skin, and benzene may be more readily absorbed if it is present in a mixture or as a contaminant in solvents which are readily absorbed. Defatting action of benzene may produce primary irritation upon repeated or prolonged contact with the skin. High concentrations are irritating to the mucous membranes of the eyes, nose, and respiratory tract.

III. SIGNS AND SYMPTOMS

Benzene is poorly absorbed through the skin, however, direct contact may cause erythema or blistering. Repeated or prolonged contact may result in drying, scaling, dermatitis, or precipitate development of secondary skin infections. Local effects of benzene vapor or liquid on the eye are slight. Only at very high concentrations is there any stinging sensation in the eye. Droplet contamination of the eye by benzene causes a moderate burning sensation, but only slight transient injury of the epithelial cell, with the eye recovering rapidly. Inhalation of high concentrations of benzene may have an initial stimulatory effect on the central nervous system characterized by exhilaration, nervous excitation, and/or giddiness, followed by a period of depression, drowsiness, fatigue, or vertigo. There may be sensation of tightness in the chest accompanied by breathlessness and ultimately the victim may lose consciousness. Convulsions and tremors occur frequently, and death may follow from respiratory paralysis or circulatory collapse in a few minutes to several hours following severe exposures. The insidious and often irreversible effect on the blood-forming system of prolonged exposure to small quantities of benzene vapor is of extreme importance. These effects have been noted to occur at concentrations of benzene which may not cause irritation of mucous membranes, or any unpleasant sensory effects. Early signs and symptoms of benzene morbidity are varied and vague, and not specific for benzene exposure. Subjective complaints of headache, dizziness, and loss of appetite may precede or precede clinical symptomatology. Bleeding from the nose, gums, or mucous membranes and the development of purpuric spots may occur as the condition progresses. Rapid pulse and low blood pressure in addition to a physical appearance of anemia may accompany a subjective complaint of shortness of breath. Clinical evidence of leukopenia and anemia are the most common abnormalities reported, however, macrocytosis and thrombocytopenia are also frequently present. Bone marrow may appear normal, aplastic, or hyperplastic and may not in all situations correlate with peripheral blood findings indicating hypo-hyper-activity of blood forming tissues. There are great variations in the susceptibility to benzene morbidity which prohibits the identification of "typical" blood picture. The effects of prolonged benzene exposure may appear after several weeks or years after the actual exposure has ceased. Development of leukemia also results from exposure to benzene.

IV. TREATMENT

Remove from exposure immediately, give oxygen or artificial resuscitation if indicated. Flush eyes and wash contaminated skin.

Symptoms of non-specific nervous disturbances may persist following severe exposures. Recovery from mild exposures is usually rapid and complete.

V. SURVEILLANCE AND PREVENTIVE CONSIDERATIONS

A. Other considerations. Benzene can cause both acute and chronic effects. It is important that the physician become familiar with the operating conditions in which exposure to benzene 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. Surveillance and screening. Medical histories and laboratory examinations are required for each employee subject to exposure to benzene. The employer must screen employees for history of certain medical conditions (listed below) which might place the employee at increased risk from exposure.

1. Liver disease. The primary site of biotransformation and detoxification of benzene is the liver. Liver dysfunctions likely to inhibit the conjugation reactions will tend to promote the toxic actions of benzene. These precautions should be considered before exposing persons with impaired liver function to benzene vapors.

2. Renal disease. Although benzene is not known as a kidney toxin the importance of the organ in the elimination of toxic substances and metabolites justifies special consideration in those with possible impairment of renal function.

3. Skin disease. Benzene is a defatting agent and can cause dermatitis on prolonged exposure. Persons with preexisting skin disorders may be more susceptible to the effects of benzene.

4. Blood dyscrasias. Benzene is a hematopoietic depressant. Persons with existing blood disorders may be more susceptible to the effects of benzene.

REFERENCES

- Grant, W. Morton: Toxicology of the Eye, (Second Edition), Charles C. Thomas, Illinois, 1974, page 655.
- Browning, Ethel: Toxicity and Metabolism of Industrial Solvents, Elsevier Publishing Company, Amsterdam, 1936, pp. 440-442.
- Petty, F. A.: Industrial Hygiene and Toxicology, Volume II-Toxicology, Interscience Publishers, New York, 1932, pp. 1755-1758.
- Gerrade, H. W.: Toxicology and Biochemistry of Aromatic Hydrocarbons, Elsevier Publishing Company, Amsterdam, 1960, pp. 98-100.

(Secs. 1, 6, 8, & 9 of Bmt. 1603, 1599 (29 U.S.C. 653, 655, 657); Secretary of Labor's Order 8-76 (41 FR 25059); 29 CFR Part 1911.)

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Keep away from heat, sparks, and open flames. In case of fire, use foam, dry chemical, or carbon dioxide fire extinguisher.

Avoid breathing vapor.

Do not get on skin, in eyes or mouth, or on clothing.

Keep containers closed when not in use.

Use only with adequate ventilation.

First Aid: If substance contacts skin, immediately wash affected area with soap and water. In case of eye contact, flush eye with copious amounts of running water. If overexposure should occur, consult a physician.

(b) Work Area

Warning placards shall be affixed in readily visible locations in or near areas of occupational exposure to ketones. The information shall be arranged as in the following examples:

(1) Warning placard for methyl n-butyl ketone:

HAZARDOUS AREA
METHYL n-BUTYL KETONE
(TRADE NAME)
FLAMMABLE
MAY CAUSE NERVE DAMAGE
IF INHALED, SWALLOWED, OR
ABSORBED THROUGH SKIN

Prevent sources of heat, sparks, or open flames.

No smoking permitted. In case of fire use fire extinguishers at (location). Avoid breathing vapor.

Avoid contact with skin, eyes, and clothing.

(2) Warning placard for the other 11 ketones:

HAZARDOUS AREA
NAME OF KETONE
(TRADE NAME)
FLAMMABLE! (or: COMBUSTIBLE!)
HARMFUL IF INHALED, SWALLOWED,
OR ABSORBED THROUGH SKIN

Prevent sources of heat, sparks, or open flames. No smoking or eating. In case of fire, use fire extinguishers at (location). Avoid breathing vapor. Avoid contact with skin, eyes, and clothing.

(3) Respiratory Protection

If respiratory protection is required in accordance with Section 4, the following statement in large letters shall be added to the required sign:

RESPIRATORY PROTECTION REQUIRED IN THIS AREA

Section 4 — Personal Protective Equipment and Clothing

(a) Respiratory Protection

The employer shall use engineering controls when needed to keep concentrations of airborne ketones at or below the recommended environmental limits. Compliance with this standard by the use of respirators is permitted only during installation and testing of engineering controls, during performance of nonroutine maintenance or repair, or during emergencies. When use of a respirator is permitted, it shall be selected and used in accordance with the following requirements:

(1) To determine the type of respirators to be used, the employer shall measure the concentration of airborne ketones in the workplace initially and thereafter whenever control, process, operational, worksite, or climatic changes occur that are likely to increase the concentration of airborne ketones.

(2) The employer shall ensure that no employee is exposed to ketones at concentrations above the recommended limits because of improper respirator selection, fit, use, or maintenance.

(3) A respiratory protection program shall be established. Requirements are found in 29 CFR 1910.134.

(4) The employer shall provide respirators in accordance with Table I-2 and shall ensure that the employees use the respirators properly when they are required. Respiratory protective devices shall be those approved by NIOSH and the Mine Safety and Health Administration.

(5) Respirators specified for use in higher concentrations of a specific airborne ketone may be used in an atmosphere of the same ketone at lower concentrations.

(6) The employer shall ensure that employees are properly instructed in the use of respirators assigned to them and in ways to test for leakage, proper fit, and proper operation.

(b) Protective Clothing

The employer shall provide appropriate protective clothing to employees who may have skin contact with liquid ketones. Protective clothing, including aprons, coats or coveralls, gloves, and boots, shall be made of material resistant to penetration by ketones. The employer shall ensure that personal protective clothing is regularly inspected for defects and that it is worn by employees when necessary to prevent skin contact with liquid ketones.

TABLE I-2

RESPIRATOR SELECTION GUIDE FOR KETONES*

Ketone	Multiples of TWA Concentration Limits				Emergency Entry	Fire-fighting
	Less Than or Equal to			Greater Than		
	10X	50X	100X	100X		
Acetone	CDPH	KL	KL	KL	KL	KL
Methyl n-butyl ketone	AMC	CDPH	KL	KL	KL	KL
Methyl ethyl and methyl n-propyl ketone	B	CDPH KL	KL	KL	KL	KL
Other eight ketones**	B	CDPH	KL	KL	KL	KL

*See Respirator Code on the following page.

**Methyl n-amyl ketone, methyl isobutyl ketone, methyl isobutyl ketone, diisobutyl ketone, cyclohexanone, methyl ethyl ketone, diacetone alcohol, or isophorone.

RESPIRATOR CODE

Code	Respirator Type Approved under Provisions of 33 CFR 11
A	Chemical cartridge respirator with half-mask facepiece and organic vapor cartridge
B	Chemical cartridge respirator with full facepiece and organic vapor cartridge
C	Canister mask with full facepiece and canister-type organic vapor canister
D	Canister mask with full facepiece and back- or front-mounted organic vapor canister
E	Type C supplied-air respirator, with half-mask facepiece, operated in demand (negative pressure) mode
F	Type C supplied-air respirator, with full facepiece, operated in demand (negative pressure) mode
G	Type C supplied-air respirator, with half-mask facepiece, operated in continuous-flow or pressure-demand mode

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Appendix A
Substance Safety Data Sheet: Benzene

I. What is benzene?

- A. Benzene (C_6H_6) - a major organic intermediate and solvent derived from coal or petroleum. It is the simplest member of the aromatic series of hydrocarbons.
- B. Permissible exposure limit.
 - 1. Airborne, 1 part of benzene vapor per million parts of air (1ppm) as a time-weighted average (TWA) for an 8-hour workday with a ceiling concentration of 5ppm, as averaged over any 15-minute period.
 - 2. Dermal, eye contact and repeated skin contact with liquid benzene is prohibited.
- C. Appearance and odor - benzene is a clear, colorless liquid with a pleasant sweet odor. The odor of benzene does not provide adequate warning of its hazard.

II. Health Hazard Data

- A. Ways in which the benzene affects your health. Benzene can affect your health if you inhale it, or it comes in contact with your skin or eyes. Benzene may also be harmful if you swallow it.
- B. Effects of over-exposure: 1. Short-term (acute) overexposure: If you are overexposed to high concentrations of benzene, you may feel breathless, irritable, euphoric (feeling of well-being), or giddy. You may experience irritation in eyes, nose and respiratory tract. You may develop a headache, feel dizzy, nauseous, or experience unsteadiness in walking. Severe exposure may lead to convulsions. 2. Long-term (chronic) exposure: Repeated and prolonged exposure of benzene may cause headache, fatigue, exhaustion, tendency to bleed, nervousness, sleeplessness, shortness of breath, and serious blood disorders, including leukemia (abnormal increase in the number of leukocytes or white cells in the tissues and often in the blood).

III. Protective Clothing and Equipment

- A. Respirators: Respirators are required for those operations in which engineering controls or work practice controls are not available to reduce exposure to the permissible exposure limit. If respirators are worn, they must have a National Institute for Occupational Safety and Health (NIOSH) seal of approval. If you experience difficulty breathing while wearing a respirator, tell your foreman.