Occupational Health Guideline for Nitrobenzene

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: $C_6H_5NO_2$
- Synonyms: Nitrobenzol; oil of mirbane
- Appearance and odor: Pale yellow to dark brown, oily liquid with an odor like black paste shoe polish. It can be a solid at temperatures below 5.1 C (41 F).

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for nitrobenzene is 1 part of nitrobenzene per million parts of air (ppm) averaged over an eight-hour work shift. This may also be expressed as 5 milligrams of nitrobenzene per cubic meter of air (mg/m^3).

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Nitrobenzene can affect the body if it is inhaled, comes in contact with the eyes or skin, or is swallowed. It is readily absorbed through the skin, either as liquid or vapor. Even a small amount absorbed from clothes or shoes may cause toxic symptoms.

- **Effects of overexposure**

1. Short-term Exposure: Nitrobenzene affects the ability of blood to carry oxygen. A bluish discoloration of the skin may occur with headache, irritability, dizziness, weakness, nausea, vomiting, shortness of breath, drowsiness, and unconsciousness. If treatment is not given promptly, death may occur. The onset of symptoms may be delayed. Direct contact with the eyes or skin may cause mild irritation. Ingestion of alcohol may cause aggravation of symptoms.

2. Long-term Exposure: Repeated or prolonged exposure to nitrobenzene may cause anemia. An allergic skin rash may occur.

3. Reporting Signs and Symptoms: A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to nitrobenzene.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to nitrobenzene at potentially hazardous levels:

1. Initial Medical Examination:

—A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Examination of the blood, liver, kidneys, and cardiovascular system should be stressed. The skin should be examined for evidence of chronic disorders.

—A complete blood count: Nitrobenzene has been shown to cause methemoglobinemia and may cause anemia. Those with blood disorders may be at increased risk from exposure. A complete blood count should be performed including a red cell count, a white cell count, a differential count of a stained smear, as well as hemoglobin and hematocrit. Observe for Heinz bodies.

—Urinalysis: The presence of p-nitrophenol and p-aminophenol in the urine is an indication of exposure to nitrobenzene.

2. Periodic Medical Examination: The aforementioned medical examinations should be repeated on an annual basis. Methemoglobin determinations should be performed at any time overexposure is suspected or signs and symptoms of toxicity occur.

- **Summary of toxicology**

Nitrobenzene absorption, whether from inhalation of the vapor or absorption of the liquid through skin, causes anoxia due to the formation of methemoglobin; chronic exposure produces anemia. In rabbits given

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subcutaneous injections of 0.75 g of nitrobenzene there was methemoglobin, sulfhemoglobin, Heinz body formation in erythrocytes, a marked decrease in hematocrit and hemoglobin levels, reticulocytosis, and mild damage to the liver and kidney. Vapor concentrations near 40 ppm resulted in intoxication of workers; exposure to vapor concentrations averaging 6 ppm caused headache and vertigo; small amounts of methemoglobin and sulfhemoglobin and some Heinz bodies were found in the blood. Signs and symptoms of overexposure are due to the loss of oxygen-carrying capacity of the blood. Rapid absorption through the intact skin is frequently the main route of entry. The onset of symptoms of methemoglobinemia is often insidious and may be delayed for up to 4 hours; headache is commonly the first symptom and may become quite intense as the severity of methemoglobinemia progresses. Cyanosis develops early in the course of intoxication, first in the lips, the nose, and the ear lobes, often recognized by fellow workers. Cyanosis often occurs when the methemogoblin concentration is 15% or more. The individual may feel well, have no complaints, and may insist that nothing is wrong until the methemoglobin concentration approaches approximately 40%. At methemoglobin concentrations of over 40% there usually is weakness and dizziness; at up to 70% concentration there may be ataxia, dyspnea on mild exertion, tachycardia, nausea, vomiting, and drowsiness. Ingestion of alcohol aggravates the toxic effects of nitrobenzene. p-Nitrophenol and p-aminophenol are metabolites of nitrobenzene, and their presence in the urine is an indication of exposure. Nitrobenzene is mildly irritating to the eyes; it may produce dermatitis due to primary irritation or sensitization.

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**
  1. Molecular weight: 123.1
  2. Boiling point (760 mm Hg): 211 C (412 F)
  3. Specific gravity (water = 1): 1.2
  4. Vapor density (air = 1 at boiling point of nitrobenzene): 4.3
  5. Melting point: 5.1 C (41 F)
  6. Vapor pressure at 20 C (68 F): Much less than 1 mm Hg
  7. Solubility in water, g/100 g water at 20 C (68 F): 0.19
  8. Evaporation rate (butyl acetate = 1): Not applicable
- **Reactivity**
  1. Conditions contributing to instability: None
  2. Incompatibilities: Contact with concentrated nitric acid or nitrogen tetroxide may cause fires and explosions. Contact with caustics and chemically active metals such as tin and zinc can cause evolution of much heat and fumes.
  3. Hazardous decomposition products: Toxic gases and vapors (such as oxides of nitrogen and carbon monoxide) may be released in a fire involving nitrobenzene.
  4. Special precautions: Liquid nitrobenzene will attack some forms of plastics, rubber, and coatings.
- **Flammability**
  1. Flash point: 88 C (190 F) (closed cup)
  2. Autoignition temperature: 482 C (900 F)
  3. Flammable limits in air, % by volume: Lower: 1.8
  4. Extinguishant: Dry chemical, foam, carbon dioxide
- **Warning properties**
  1. Odor Threshold: Both Stern and May report that the odor threshold of nitrobenzene is 1.9 ppm.
  2. Eye Irritation Level: Browning states that nitrobenzene causes "only slight transient (eye) irritation." Grant states that "the most reliably established ocular effects are secondary to discoloration of the blood from methemoglobinemia, and consist of brown discoloration of the vessels of the fundus and the conjunctiva."
  3. Evaluation of Warning Properties: Since the odor threshold of nitrobenzene is within twice the permissible exposure limits, nitrobenzene is treated as a material with good warning properties.

MONITORING AND MEASUREMENT PROCEDURES

- **General**

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

- **Method**

Sampling and analyses may be performed by collection of nitrobenzene in an adsorption tube containing silica gel, followed by desorption with methanol, and gas chromatographic analysis. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure nitrobenzene may be used. An analytical method for nitrobenzene is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 3, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00261-4).

RESPIRATORS

- Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to

be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.

• In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

• Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent any possibility of skin contact with liquid nitrobenzene.

• If employees' clothing has had any possibility of being contaminated with liquid nitrobenzene, employees should change into uncontaminated clothing before leaving the work premises.

• Clothing which has had any possibility of being contaminated with liquid nitrobenzene should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of nitrobenzene from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the nitrobenzene, the person performing the operation should be informed of nitrobenzene's hazardous properties.

• Where there is any possibility of exposure of an employee's body to liquid nitrobenzene, facilities for quick drenching of the body should be provided within the immediate work area for emergency use.

• Non-impervious clothing which becomes contaminated with nitrobenzene should be removed immediately and not reworn until the nitrobenzene is removed from the clothing.

• Employees should be provided with and required to use splash-proof safety goggles where liquid nitrobenzene may contact the eyes.

SANITATION

• Skin that becomes contaminated with nitrobenzene should be immediately washed or showered with soap or mild detergent and water to remove any nitrobenzene.

• Workers subject to skin contact with liquid nitrobenzene should wash with soap or mild detergent and water any areas of the body which may have contacted nitrobenzene at the end of each work day.

• Eating and smoking should not be permitted in areas where liquid nitrobenzene is handled, processed, or stored.

• Employees who handle liquid nitrobenzene should wash their hands thoroughly with soap or mild detergent and water before eating, smoking, or using toilet facilities.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to nitrobenzene may occur and control methods which may be effective in each case:

Operation	Controls
Use in production of chemical intermediates	Process enclosure; local exhaust ventilation; personal protective equipment
Use in solvent refining of lubricating oils; use in production of intermediates in synthesis of rubber chemicals, photographic chemicals, explosives, liquid propellants, and pharmaceuticals	Process enclosure; local exhaust ventilation; personal protective equipment
Use as a solvent in specialized surface coatings; use as a solvent in organic synthesis	Process enclosure; local exhaust ventilation; personal protective equipment
Use as perfume in manufacture of toilet and household soaps; use in synthesis of insecticides and germicides	Process enclosure; local exhaust ventilation; personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

• **Eye Exposure**

If liquid nitrobenzene gets into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. If irritation persists after washing, get medical attention. Contact lenses should not be worn when working with this chemical.

• **Skin Exposure**

If liquid nitrobenzene gets on the skin, immediately wash the contaminated skin using soap or mild detergent and water. If liquid nitrobenzene soaks through the clothing, remove the clothing immediately and wash the skin using soap or mild detergent and water. Get medical attention immediately.

• **Breathing**

If a person breathes in large amounts of nitrobenzene, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration.

Keep the affected person warm and at rest. Get medical attention as soon as possible.

• **Swallowing**

When liquid nitrobenzene has been swallowed and the person is conscious, give the person large quantities of water immediately. After the water has been swallowed, try to get the person to vomit by having him touch the back of his throat with his finger. Do not make an unconscious person vomit. Get medical attention immediately.

• **Rescue**

Move the 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. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL, LEAK, AND DISPOSAL PROCEDURES

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

• If liquid or solid nitrobenzene is spilled or leaked, the following steps should be taken:

1. Ventilate area of spill or leak.
2. If in the liquid form, for small quantities, absorb on paper towels. Evaporate in a safe place (such as a fume hood). Allow sufficient time for evaporating vapors to completely clear the hood ductwork. Burn the paper in a suitable location away from combustible materials. Large quantities can be collected and atomized in a suitable combustion chamber equipped with an appropriate effluent gas cleaning device.
3. If in the solid form, allow to melt and handle as indicated in (2) above.

• Waste disposal methods:

Nitrobenzene may be disposed of:

1. By absorbing it in vermiculite, dry sand, earth or a similar material and disposing in sealed containers in a secured sanitary landfill.
2. By atomizing in a suitable combustion chamber equipped with an appropriate effluent gas cleaning device.

REFERENCES

• American Conference of Governmental Industrial Hygienists: "Nitrobenzene," *Documentation of the Threshold Limit Values for Substances in Workroom Air* (3rd ed., 2nd printing), Cincinnati, 1974.

• American Industrial Hygiene Association: "Nitrobenzene," *Hygienic Guide Series*, Detroit, Michigan, 1959.

• Browning, E.: *Toxicity and Metabolism of Industrial Solvents*, Elsevier, New York, 1965.

• Chambers, J. V., and O'Neill, F. J.: "Nitrobenzene Poisoning," *British Journal of Industrial Medicine*, 3:22, p. 102, 1946.

• Christensen, H. E., and Luginbyhl, T. L. (eds.): *NIOSH Toxic Substances List*, 1974 Edition, HEW Publication No. 74-134, 1974.

• Fairhall, L. T.: *Industrial Toxicology* (2nd ed.), Williams and Wilkins, Baltimore, 1957.

• Gleason, M. N., Gosselin, R. E., Hodge, H. C., and Smith, R. P.: *Clinical Toxicology of Commercial Products* (3rd ed.), Williams and Wilkins, Baltimore, 1969.

1969.

• Grant, W. M.: *Toxicology of the Eye* (2nd ed.), C. C. Thomas, Springfield, Illinois, 1974.

• Ikeda, M., and Kita, A.: "Excretion of p-Nitrophenol and p-Aminophenol in the Urine of a Patient Exposed to Nitrobenzene," *British Journal of Industrial Medicine*, 21:210-213, 1964.

• International Labour Office: *Encyclopedia of Occupational Health and Safety*, McGraw-Hill, New York, 1971.

• Johnstone, R. T., and Miller, S. E.: *Occupational Disease and Industrial Medicine*, Saunders, Philadelphia, 1960.

• Linch, A. L.: "Biological Monitoring for Industrial Exposure to Cyanogenic Aromatic Nitro and Amino Compounds," *American Industrial Hygiene Association Journal*, 35:426-432, 1974.

• Mangelsdorff, A. F.: "Treatment of Methemoglobinemia," *A.M.A. Archives of Industrial Health*, 14:148-153

• Manufacturing Chemists Association, Inc.: *Chemical Safety Data Sheet SD-21, Nitrobenzene*, Washington, D.C., 1967.

• May, J.: "Solvent Odor Thresholds for the Evaluation of Solvent Odors in the Atmosphere," *Staub-Reinhalt*, 26:9, 385-389, 1966.

• Patty, F. A. (ed.): *Toxicology*, Vol. II of *Industrial Hygiene and Toxicology* (2nd ed. rev.), Interscience, New York, 1963.

• Sax, N. I.: *Dangerous Properties of Industrial Materials* (3rd ed.), Van Nostrand Reinhold, New York, 1968.

• Spector, W. S. (Vols. I, II), Negherbon, W. O. (Vol. III), Grebe, R. M. (Vol. IV), and Dittmer, D. S. (Vol. V) (eds.): *Handbook of Toxicology*, Saunders, Philadelphia, 1956-1959.

• Stern, A. C. (ed.): *Air Pollution* (2nd ed.), Academic Press, New York, 1968.

• Thienes, C. H., and Haley, T. J.: *Clinical Toxicology* (5th ed.), Lea and Febiger, Philadelphia, 1972.

• von Oettingen, W. F.: *Poisoning: A Guide to Clinical Diagnosis and Treatment* (2nd ed.), Saunders, Philadelphia, 1958.

RESPIRATORY PROTECTION FOR NITROBENZENE

Condition	Minimum Respiratory Protection* Required Above 1 ppm
Vapor Concentration	
10 ppm or less	Any chemical cartridge respirator with an organic vapor cartridge(s). Any supplied-air respirator. Any self-contained breathing apparatus.
50 ppm or less	A chemical cartridge respirator with a full facepiece and an organic vapor cartridge(s). A gas mask with a chin-style or a front- or back-mounted organic vapor canister. Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
200 ppm or less	A Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure mode or with a full facepiece, helmet, or hood operated in continuous-flow mode.
Greater than 200 ppm** or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
Escape	Any gas mask providing protection against organic vapors. Any escape self-contained breathing apparatus.

*Only NIOSH-approved or MSHA-approved equipment should be used.

**Use of supplied-air suits may be necessary to prevent skin contact while providing respiratory protection from airborne concentrations of nitrobenzene; however, this equipment should be selected, used, and maintained under the immediate supervision of trained personnel. Where supplied-air suits are used above a concentration of 200 ppm, an auxiliary self-contained breathing apparatus operated in positive pressure mode should also be worn.