

Occupational Health Guideline for Pentaborane

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: B₅H₉
- Synonyms: Stable pentaborane, pentaboron anhydride
- Appearance and odor: Colorless liquid with a strong, pungent odor.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for pentaborane is 0.005 part of pentaborane per million parts of air (ppm) averaged over an eight-hour work shift. This may also be expressed as 0.01 milligram of pentaborane per cubic meter of air (mg/m³).

HEALTH HAZARD INFORMATION

• Routes of exposure

Pentaborane can affect the body if it is inhaled, if it comes in contact with the eyes or skin, or if it is swallowed. It may enter the body through the skin.

• Effects of overexposure

1. Short-term Exposure: Exposure to low concentrations of pentaborane may cause lightheadedness, drowsiness, nervousness, lack of coordination, and tremors. The onset of these symptoms may be delayed as long as 48 hours. After exposure to higher concentrations, the onset of symptoms may be prompt and may include the above symptoms plus spasms of the face, neck, arms, legs, and abdomen. After severe exposure, convulsions may occur. In animals impairment of liver and kidney function has been reported. Also, in animals, the vapor

has caused severe irritation of the eyes and the liquid has caused inflammation of the skin.

2. Long-term Exposure: Prolonged exposure to low concentrations of pentaborane may cause headache, fatigue, drowsiness, the inability to concentrate, and the lack of coordination.

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 pentaborane.

• Recommended medical surveillance

The following medical procedures should be made available to each employee who is exposed to pentaborane 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. Persons with a history of convulsive disorders would be expected to be at increased risk from exposure. Examination of the nervous system, liver, and kidneys should be stressed. The skin and eyes should be examined for evidence of chronic disorders.

2. Periodic Medical Examination: The aforementioned medical examinations should be repeated on an annual basis.

• Summary of toxicology

Pentaborane vapor affects the nervous system and causes signs of both hyperexcitability and narcosis. Exposure of rats to 10 ppm for 2 hours was fatal; effects included weakness, incoordination, corneal opacities, tremors, and convulsions; other animal studies have indicated that kidney and liver damage may occur. In humans, the onset of symptoms may be delayed up to 48 hours after exposure; dizziness, headache, and drowsiness are common; other symptoms include fatigue, incoordination, and tremor. After exposure to higher concentrations, the onset of symptoms may be prompt and include tonic spasms of the muscles of the face,

These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

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neck, abdomen, and extremities; after severe exposures, convulsive seizures may occur. The results of exposure to animals for 60 minutes are: 8 ppm, some decrement in performance of learned tasks and slight signs of toxicity; 15 ppm, convulsions; 30 ppm, convulsions and death. Severe irritation and corneal opacity of the eyes of test animals occurred from exposure to the vapor; the liquid on the skin of animals caused acute inflammation.

CHEMICAL AND PHYSICAL PROPERTIES

• Physical data

1. Molecular weight: 63.1
2. Boiling point (760 mm Hg): 58.4 C (137 F)
3. Specific gravity (water = 1): 0.63
4. Vapor density (air = 1 at boiling point of pentaborane): 2.2
5. Melting point: -47 C (-52 F)
6. Vapor pressure at 20 C (68 F): 171 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): Reacts slowly to form hydrogen gas
8. Evaporation rate (butyl acetate = 1): Data not available

• Reactivity

1. Conditions contributing to instability: Temperatures above 150 C (302 F) cause decomposition and pressure buildup in containers.

2. Incompatibilities: Pentaborane reacts with oxidizers to form highly explosive mixtures. Contact with halogens or halogenated compounds may cause explosions.

3. Hazardous decomposition products: Toxic gases and vapors (such as boron acids) may be released in a fire involving pentaborane.

4. Special precautions: Pentaborane will attack some forms of plastics, rubber, and coatings.

• Flammability

1. Flash point: 30 C (86 F) (closed cup when pure); impure material ignites spontaneously in air

2. Autoignition temperature: 35 C (95 F) (impure material ignites at lower temperatures)

3. Flammable limits in air, % by volume: Lower: 0.42; Upper: Not obtainable

4. Extinguishant: Let small fires burn. Water spray, foam, dry chemical, and carbon dioxide will decrease intensity of large fires. Do not use halogenated extinguishing fluids.

• Warning properties

1. Odor Threshold: The AIHA *Hygienic Guide* states that pentaborane has a characteristic odor, but that it is "not a reliable index of exposure." According to a technical bulletin from Callery Chemical Company, the median detectable concentration of pentaborane by odor is 2.5 mg/m³, which is many times greater than the permissible exposure limit.

2. Eye Irritation Level: Pentaborane vapor is not known to be an eye irritant.

3. Evaluation of Warning Properties: Since the odor threshold is many times greater than the permissible

exposure limit of pentaborane, and since there is no other quantitative information relating warning properties to air concentrations of pentaborane, this substance is treated as a material with poor 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

At the time of publication of this guideline, no measurement method for pentaborane had been published by NIOSH.

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 skin contact with liquid pentaborane, where skin contact may occur.

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

- Where exposure of an employee's body to liquid pentaborane may occur, facilities for quick drenching of the body should be provided within the immediate work area for emergency use.
- Any clothing which becomes wet with liquid pentaborane should be removed immediately and not reworn until the pentaborane is removed from the clothing.
- Employees should be provided with and required to use splash-proof safety goggles where there is any possibility of liquid pentaborane contacting the eyes.
- Where there is any possibility that employees' eyes may be exposed to liquid pentaborane, an eye-wash fountain should be provided within the immediate work area for emergency use.

SANITATION

- Skin that becomes wet with liquid pentaborane should be immediately washed or showered with soap or mild detergent and water to remove any pentaborane.

COMMON OPERATIONS AND CONTROLS

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

Operation	Controls
Use in chemical research as jet and rocket fuels, catalysts, corrosion inhibitor-fluxing agents, and oxygen scavengers	Process enclosure; local exhaust ventilation; personal protective equipment
Use as a chemical intermediate (higher boranes, alkyl boranes— ethyl pentaborane and various hydrides); these are not industrial chemicals	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 pentaborane or strong concentrations of pentaborane vapor get into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. If irritation is present after washing, get medical attention promptly. Contact lenses should not be worn when working with this chemical.

• Skin Exposure

If liquid pentaborane or strong concentrations of pentaborane vapor get on the skin, immediately wash the contaminated skin using soap or mild detergent and

water. If liquid pentaborane or strong concentrations of pentaborane vapor penetrate through the clothing, remove the clothing immediately and wash the skin using soap or mild detergent and water. If irritation persists after washing, get medical attention.

• Breathing

If a person breathes in large amounts of pentaborane, 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 pentaborane 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 pentaborane is spilled or leaked, the following steps should be taken:

1. Remove all ignition sources.
2. Ventilate area of spill or leak.
3. For small quantities, absorb on paper towels. Evaporate in a safe place (such as a fume hood). Allow sufficient time for evaporating vapors to completely clear the hood ductwork. Burn the paper in a suitable location away from combustible materials. Large quantities can be reclaimed or collected and atomized in a suitable combustion chamber equipped with an appropriate effluent gas cleaning device. Pentaborane should not be allowed to enter a confined space, such as a sewer, because of the possibility of an explosion. Sewers designed to preclude the formation of explosive concentrations of pentaborane vapors are permitted.

- Waste disposal method:

Pentaborane may be disposed of by atomizing in a suitable combustion chamber equipped with an appropriate effluent gas cleaning device.

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RESPIRATORY PROTECTION FOR PENTABORANE

Condition	Minimum Respiratory Protection* Required Above 0.005 ppm
Vapor Concentration	
0.05 ppm or less	Any supplied-air respirator. Any self-contained breathing apparatus.
0.25 ppm or less	Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
3 ppm or less	A Type C supplied-air respirator operated in pressure-demand or other positive pressure or continuous-flow mode.
Greater than 3 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 pentaborane. Any escape self-contained breathing apparatus.

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