

OCCUPATIONAL SAFETY AND HEALTH GUIDELINE FOR ARSINE POTENTIAL HUMAN CARCINOGEN

INTRODUCTION

This guideline summarizes pertinent information about arsine for workers, employers, and occupational safety and health professionals who may need such information to conduct effective occupational safety and health programs. Recommendations may be superseded by new developments in these fields; therefore, readers are advised to regard these recommendations as general guidelines. For information on other arsenic compounds, see guideline for inorganic arsenic.

SUBSTANCE IDENTIFICATION

- **Formula:** AsH₃
- **Synonyms:** Arsenic hydride, arsenic trihydride, hydrogen arsenide
- **Identifiers:** CAS 7784-42-1; RTECS CG6475000; DOT 2188, label required: "Poison, Flammable Gas"
- **Appearance and odor:** Colorless gas with a faint odor like garlic

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**
 1. Molecular weight: 77.95
 2. Boiling point (at 760 mmHg): -62.5°C (-80.5°F)
 3. Vapor density (air = 1 at boiling point of arsine): 2.69
 4. Melting point: -116°C (-177°F)
 5. Vapor pressure at 20°C (68°F): >1 atm
 6. Solubility in water, g/100 g water at 20°C (68°F): 0.07
 7. Ionization potential: 10.03 eV
- **Reactivity**
 1. Incompatibilities: Arsine reacts with strong oxidizers, especially chlorine and nitric acid. Arsine decomposes at temperatures above 300°C (572°F) to form elemental arsenic and hydrogen. In the presence of moisture, decomposition may be triggered by light.
 2. Hazardous decomposition products: Toxic fumes may be released in a fire involving arsine.

- **Flammability**

Flammable gas

- **Warning properties**

1. Odor threshold: 0.5 ppm
2. Evaluation of warning properties for respirator selection: Warning properties are not considered in recommending respirators for use with carcinogens.

EXPOSURE LIMITS

The current Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for arsine is 0.05 parts of arsine per million parts of air (ppm) [0.2 milligrams of arsine per cubic meter of air (mg/m³)] as a time-weighted average (TWA) concentration over an 8-hour workshift. The National Institute for Occupational Safety and Health (NIOSH) recommends that arsenic and all its inorganic compounds including arsine be regarded as potential human carcinogens in the workplace and that exposure be minimized to the lowest feasible limit. The NIOSH recommended exposure limit (REL) for arsine is 0.002 mg/m³ (as arsenic) as a ceiling concentration determined in any 15-minute sampling period. The American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit value (TLV[®]) is 0.05 ppm (0.2 mg/m³) for a normal 8-hour workday and a 40-hour workweek (Table 1).

Table 1.—Occupational exposure limits for arsine

	Exposure limits	
	ppm	mg/m ³
OSHA PEL TWA	0.05	0.2
NIOSH REL (as arsenic) ceiling (15 min) (Ca)*	—	0.002
ACGIH TLV [®] TWA	0.05	0.2

* (Ca): NIOSH recommends treating as a potential human carcinogen.

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health
Division of Standards Development and Technology Transfer

HEALTH HAZARD INFORMATION

• Routes of exposure

Arsine may cause adverse health effects following exposure via inhalation.

• Summary of toxicology

Effects on humans: Acute inhalation of arsine has caused the breakdown of red blood cells and hemoglobin, impairment of kidney function, damage to the liver and heart, electroencephalogram abnormality (elevation of T-waves), hemolytic anemia, and death due to kidney or heart failure. The human carcinogenic potential of arsine itself has not been determined; however, inorganic arsenic, a recognized human carcinogen in the workplace, is used in the production of arsine.

• Signs and symptoms of exposure

Short-term (acute): Exposure to arsine can cause the delayed onset of headache, malaise, weakness, dizziness, breathing difficulty (dyspnea), abdominal pain, nausea, vomiting, jaundice, bloody urine followed by absence of urination, pulmonary edema, and coma.

RECOMMENDED MEDICAL PRACTICES

• Medical surveillance program

Workers with potential exposures to chemical hazards should be monitored in a systematic program of medical surveillance intended to prevent or control occupational injury and disease. The program should include education of employers and workers about work-related hazards, placement of workers in jobs that do not jeopardize their safety and health, earliest possible detection of adverse health effects, and referral of workers for diagnostic confirmation and treatment. The occurrence of disease (a "sentinel health event," SHE) or other work-related adverse health effects should prompt immediate evaluation of primary preventive measures (e.g., industrial hygiene monitoring, engineering controls, and personal protective equipment). A medical surveillance program is intended to supplement, not replace, such measures.

A medical surveillance program should include systematic collection and epidemiologic analysis of relevant environmental and biologic monitoring, medical screening, morbidity, and mortality data. This analysis may provide information about the relatedness of adverse health effects and occupational exposure that cannot be discerned from results in individual workers. Sensitivity, specificity, and predictive values of biologic monitoring and medical screening tests should be evaluated on an industry-wide basis prior to application in any given worker group. Intrinsic to a surveillance program is the dissemination of summary data to those who need to know, including employers, occupational health professionals, potentially exposed workers, and regulatory and public health agencies.

• Preplacement medical evaluation

Prior to placing a worker in a job with a potential for exposure to arsine, the physician should evaluate and document the worker's baseline health status with thorough medical,

environmental, and occupational histories, a physical examination, and physiological and laboratory tests appropriate for the anticipated occupational risks. These should concentrate on the function and integrity of the skin, liver, kidneys, and lymphatic and hematopoietic (blood cell forming), respiratory, and peripheral nervous systems. A complete blood count with a reticulocyte count should be performed. Medical surveillance for respiratory disease should be conducted by using the principles and methods recommended by NIOSH and the American Thoracic Society (ATS).

A preplacement medical evaluation is recommended in order to detect and assess preexisting or concurrent conditions which may be aggravated or result in increased risk when a worker is exposed to arsine at or below the NIOSH REL. The examining physician should consider the probable frequency, intensity, and duration of exposure, as well as the nature and degree of the condition, in placing such a worker. Such conditions, which should not be regarded as absolute contraindications to job placement, include concurrent dermatitis or peripheral neuropathy, a history and other findings consistent with chronic disease of the skin or nervous system, and significant breathing impairment due to pre-existing chronic lung disease.

• Periodic medical screening and/or biologic monitoring

Occupational health interviews and physical examinations should be performed at regular intervals. Additional examinations may be necessary should a worker develop symptoms that may be attributed to exposure to arsine. The interviews, examinations, and appropriate medical screening and/or biologic monitoring tests should be directed at identifying an excessive decrease or adverse trend in the physiologic function of the skin, liver, kidneys, and hematopoietic, lymphatic, respiratory, and peripheral nervous systems as compared to the baseline status of the individual worker or to expected values for a suitable reference population. The following tests should be used and interpreted according to standardized procedures and evaluation criteria recommended by NIOSH and ATS: standardized questionnaires and tests of lung function.

• Medical practices recommended at the time of job transfer or termination

The medical, environmental, and occupational history interviews, the physical examination, and selected physiologic and laboratory tests which were conducted at the time of placement should be repeated at the time of job transfer or termination. Any changes in the worker's health status should be compared to those expected for a suitable reference population. Because occupational exposure to arsine may cause diseases of prolonged induction-latency, the need for medical surveillance may extend well beyond termination of employment.

• Sentinel health events

1. Acute SHE's include: Non-autoimmune hemolytic anemia and acute renal (kidney) failure
2. Delayed-onset SHE's include: Chronic renal (kidney) failure (see also SHE's for inorganic arsenic and its compounds)

MONITORING AND MEASUREMENT PROCEDURES

• Ceiling concentration evaluation

Measurements to determine worker exposure should be taken during periods of maximum expected airborne concentrations of arsine. Each measurement to determine the NIOSH REL (ceiling exposure) in the worker's breathing zone (air that most nearly represents that inhaled by workers) should consist of a 15-minute sample or a series of consecutive samples that total 15 minutes. A minimum of three measurements should be taken during one workshift, and the highest of all measurements taken is an estimate of the worker's exposure. If the periods of maximum exposure are not clearly defined, a statistical procedure which can be used as a peak exposure detection strategy is given in the *Occupational Exposure Sampling Strategy Manual*.

• Method

Sampling and analysis may be performed by collecting arsine using charcoal tubes with prefilters to capture particulates followed by desorption with nitric acid and analysis by atomic absorption spectrophotometry with heated graphite atomization. Direct-reading devices calibrated to measure arsine may also be used if available. A detailed sampling and analytical method for arsine may be found in the *NIOSH Manual of Analytical Methods* (method number 6001).

PERSONAL PROTECTIVE EQUIPMENT

Chemical protective clothing (CPC) should be selected after utilizing available performance data, consulting with the manufacturer, and then evaluating the clothing under actual use conditions.

Workers should be provided with and required to use CPC, gloves, and other appropriate clothing necessary to prevent skin contact with arsine.

SANITATION

Clothing which is contaminated with arsine should be removed immediately and placed in sealed containers for storage until it can be discarded or until provision is made for the removal of arsine from the clothing. If the clothing is to be laundered or cleaned, the person performing the operation should be informed of arsine's hazardous properties. Reusable clothing and equipment should be checked for residual contamination before reuse or storage.

A change room with showers, washing facilities, and lockers that permit separation of street and work clothes should be provided.

Workers should be required to shower following a workshift and prior to putting on street clothes. Clean work clothes should be provided daily.

The storage, preparation, dispensing, or consumption of food or beverages, the storage or smoking of tobacco or other

smoking materials, and the storage or use of products for chewing should be prohibited in work areas.

Workers who handle arsine should wash their faces, hands, and forearms thoroughly with soap and water before eating, smoking, or using toilet facilities.

Contact lenses should not be worn when there is a potential for exposure to arsine.

COMMON OPERATIONS AND CONTROLS

Common operations in which exposure to arsine may occur and control methods which may be effective in each case are listed in Table 2.

Table 2.—Operations and methods of control for arsine

Operations	Controls
During the manufacture of electrical semi-conductors and gallium arsenide; during the manufacture, storage, and distribution of arsine	Process enclosure, local exhaust ventilation, personal protective equipment
During the refining of metal ores that may contain arsenic	Local exhaust ventilation, personal protective equipment
During cleaning of metal equipment, electroplating of metals, metallic pickling, soldering and etching, photo-duplication, and use of photographic emulsions	Process enclosure, local exhaust ventilation, personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, remove the victim from further exposure, send for medical assistance, and initiate emergency procedures.

• Rescue

If a worker has been incapacitated, move the affected worker from the hazardous exposure. 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.

SPILLS AND LEAKS

Workers not wearing protective equipment and clothing should be restricted from areas of leaks until cleanup has been completed.

If arsine is leaked, the following steps should be taken:

1. Stop the flow of arsine gas. If the source of the leak is a cylinder and the leak cannot be stopped in place, remove the leaking cylinder to an area with local exhaust ventilation and repair the leak or allow the cylinder to empty.
2. Ventilate area of leak.

WASTE REMOVAL AND DISPOSAL

U.S. Environmental Protection Agency, Department of Transportation, and/or state and local regulations shall be followed to assure that removal, transport, and disposal are done in accordance with existing regulations.

RESPIRATORY PROTECTION

It must be stressed that the use of respirators is the least preferred method of controlling worker exposure and should not normally be used as the only means of preventing or minimizing exposure during routine operations. However, there are some exceptions for which respirators may be used to control exposure: when engineering and work practice controls are not technically feasible, when engineering controls are in the process of being installed, or during emergencies and certain maintenance operations including those requiring confined-space entry (Table 3).

In addition to respirator selection, a complete respiratory protection program should be instituted which as a minimum complies with the requirements found in the OSHA Safety and Health Standards 29 CFR 1910.134. A respiratory protection program should include as a minimum an evaluation of the worker's ability to perform the work while wearing a respirator, the regular training of personnel, fit testing, periodic environmental monitoring, maintenance, inspection, and cleaning.

The implementation of an adequate respiratory protection program, including selection of the correct respirators, requires that a knowledgeable person be in charge of the program and that the program be evaluated regularly.

Only respirators that have been approved by the Mine Safety and Health Administration (MSHA, formerly Mining Enforcement and Safety Administration) and by NIOSH should be used. **Remember! Air-purifying respirators will not protect from oxygen-deficient atmospheres.**

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Table 3.—Respiratory protection for arsine

Condition	Minimum respiratory protection*
Any detectable concentration	Any self-contained breathing apparatus with a full facepiece and operated in a pressure-demand or other positive pressure mode Any supplied-air respirator with a full facepiece and operated in a pressure-demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in a pressure-demand or other positive pressure mode
Planned or emergency entry into environments containing unknown or any detectable concentration	Any self-contained breathing apparatus with a full facepiece and operated in a pressure-demand or other positive pressure mode Any supplied-air respirator with a full facepiece and operated in a pressure-demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in a pressure-demand or other positive pressure mode
Firefighting	Any self-contained breathing apparatus with a full facepiece and operated in a pressure-demand or other positive pressure mode
Escape only	Any air-purifying full facepiece respirator (gas mask) with a chin-style or front- or back-mounted canister providing protection against the compound of concern Any appropriate escape-type self-contained breathing apparatus

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

