

ARSENIC AND ITS INORGANIC COMPOUNDS

This data sheet was prepared by the Industrial Department of the National Safety Council, 425 North Michigan Avenue, Chicago 60611, and is published by the Council.

THIS DATA SHEET is intended to guide employers, plant safety engineers, personnel managers, and supervisors to safe practices in processing and handling all forms of arsenic and its inorganic compounds. A plant engineer who desires additional information should consult a competent industrial hygienist. Such an adviser, if not available within one's own company, may be obtained from an insurance carrier, private consultant, or state health or labor agency.

2. The medical, personnel, and engineering controls described here primarily apply to full-time operations. For intermittent handling of arsenic or its compounds and alloys, modification of these controls may be advisable, depending on the nature, frequency, and duration of the operations.

3. Arsenic and its inorganic compounds fall into three major groups:

- Elemental arsenic.
- Arsenicals, which comprise white arsenic (As_2O_3), the arsenate salts, and the arsenite salts.
- Gaseous arsenic or arsine (AsH_3). Arsenic in the form of arsenic trioxide (As_2O_3) has been known for centuries as an odorless and tasteless poison. Elemental arsenic, however, is seldom responsible for fatal or disabling industrial poisoning. The effects of its fumes and dusts may be cumulative, though, and continued exposure may cause severe symptoms. Arsine, a colorless gas formed when nascent hydrogen is generated in the presence of com-

pounds containing arsenic, is extremely poisonous and can be fatal if inhaled in appreciable quantity. (See paragraphs 50 and 51.)

Properties

4. Although arsenic is stable in dry air, it oxidizes slowly in the presence of moisture to form a greyish mixture of arsenious and arsenic oxides. When heated, it ignites, burns with a bluish flame, and produces dense, garlic-odored fumes of arsenious oxide.

5. The strong inorganic acids vary in their manner of reaction

with arsenic. (a) With strong nitric acid, arsenic undergoes oxidation, ultimately to the pentoxide. This reaction is utilized industrially. (b) Cold dilute sulfuric acid produces no effect, but arsenic is attacked and dissolved by the concentrated acid, with liberation of sulfur dioxide. (c) Hydrochloric acid alone has only a feeble action but, as aqua regia, attacks and dissolves the arsenic.

6. Arsenic reacts directly with the halogens to ignite spontaneously in an atmosphere of chlorine and to combine, when heated, with bromine

Table I

Per Cent Arsenic in Certain of Its Compounds

Compound	Formula	Per Cent
Arsenic trichloride	AsCl_3	42
Arsenic trioxide	As_2O_3	76
Arsenic trisulfide	As_2S_3	61
Arsenic pentoxide	As_2O_5	65
Calcium arsenate	$\text{Ca}_3(\text{AsO}_4)_2$	38
Copper arsenite	CuHAsO_3	40
Lead arsenate	$\text{Pb}_3(\text{AsO}_4)_2$	16.5
Potassium arsenate	KH_2AsO_4	43.5
Copper acetoarsenite	$(\text{CuOAs}_2\text{O}_3)_3 \cdot \text{Cu}(\text{C}_2\text{H}_3\text{O}_2)_2$	44

The time-weighted average atmospheric concentrations believed safe for continuous exposure during an average work day are based on the per cent arsenic in the compound. This value (called the TLV) is 0.5 milligram of arsenic per cubic meter of air. See paragraph 51.

Compound	Formula	Physical State	Color	Melting Point	Boiling Point	Specific Gravity	Solubility
Arsenic (metallic)	As	Brittle, crystalline metal	Silver gray; turns black in air	814 C (1,497 F) @ 35 atmospheres. Sublimes @ 615 C (1,139 F). Appreciably volatile @ 100 C (212 F).		5.6 to 5.9	Soluble in nitric acid; insoluble in water.
Arsenic trichloride Also known as { Arsenic chloride Arsenious chloride Butter of arsenic Caustic arsenic chloride Fuming liquid arsenic	AsCl ₃	Oily liquid	Colorless or pale yellow	-18 C (-0.4 F)	130.5 C (267 F)	2.163	Soluble in concentrated HCl and most organic liquids; decomposed by H ₂ O; fumes in moist air.
Arsenic trioxide Also known as { Arsenious acid White arsenic Arsenious oxide Arsenious arsenic oxide Arsenous anhydride	As ₂ O ₃	Amorphous powder or Vitreous Lumps	White	Sublimes @ 193 C (379 F) Melts 315 C (599 F)		3.738	Soluble in glycerine, acids, and alkalis; slightly soluble in H ₂ O.
Arsenic trisulfide Also known as { Arsenious sulfide Arsenous sulfide Arsenic tersulfide	As ₂ S ₃	Crystals or powder	Yellow; changes to red @ 170 C (338 F)	300 C (572 F)	707 C (1301 F)	3.43	Soluble in HNO ₃ and alkaline solutions; insoluble in H ₂ O and HCl.
Arsenic pentoxide Also known as { Arsenic anhydride	As ₂ O ₅	Amorphous powder	White	Decomposes @ 315 C (599 F)		4.086	Soluble in water, alkalis and ethyl alcohol.
Arsine Also known as { Arsenic hydride Arseniuretted hydrogen	AsH ₃	Gas	None	-113.5 C (-172 F)	-55 C (-67 F)	2.695*	Soluble in H ₂ O; slightly soluble in alcohol and alkalis.
Calcium arsenate	Ca ₃ (AsO ₄) ₂	Amorphous powder	White				Slightly soluble in cold water; insoluble in hot water; soluble in dilute acids.
Copper arsenite Also known as { Cupric arsenite Copper ortho-arsenite Sheele's green.	CuHAsO ₃ or Cu ₃ (AsO ₃) ₂ • 3H ₂ O	Fine powder	Light green	Decomposes			Soluble in acids; insoluble in H ₂ O and alcohol.
Lead arsenate	Pb ₃ (AsO ₄) ₂	Crystalline	White	1,012 C (1,908 F)**		7.30	Soluble in HNO ₃ ; insoluble in H ₂ O.
Potassium arsenate (monobasic)	KH ₂ AsO ₄	Crystals	Colorless or white	288 C (550 F)		2.867	Soluble in water; insoluble in alcohol.
Copper acetoarsenite (CuOAs ₂ O ₃) ₃ • Cu(C ₂ H ₃ O ₂) ₂ Also known as { Cupric acetoarsenite Paris green Schweinfurth green Imperial green King's green Emerald green New green Pat green Moss green Mitis green Vienna green Parrot green		Powder	Emerald green				Soluble in acids; insoluble in alcohol and water.

* Specific gravity with reference to air = 1

** Slightly decomposes at 1,000 C (1,812 F)

with sulfur.

7. Arsenic trioxide is the most important commercial compound of arsenic, and is usually referred to as white arsenic or simply "arsenic." It is an amphoteric compound, its acidic properties predominating. It is soluble both in hydrochloric acid to yield arsenic trichloride, and in alkalis to form arsenites. In water, it is slightly soluble—arsenious acid HAsO_2 , being formed. Exposure to oxidizing agents such as ozone, hydrogen peroxide, or nitric acid readily brings about conversion to the pentavalent state; exposure to reducing agents reduce arsenic trioxide to arsenic and arsine.

8. Some of the properties of arsenic and several of its compounds are given in Table II.

Uses

9. Elemental arsenic is utilized in the production of various alloys. It increases the resistance of copper to corrosion, improves its machinability, and raises the annealing temperature.

10. Arsenic trioxide is used in the production of pesticides, such as lead arsenate, calcium arsenate, and copper acetoarsenite (Paris green), and in wood preservatives, such as Wolman salts, which contain 25 per cent sodium arsenate. It is also employed in the manufacture of pharmaceuticals, glass, cattle and sheep dips, hide preservatives, poisoned bait, and weed killers. Arsenicals have been used in the manufacture of dyestuffs, in the production of chemical warfare gases, and as debarking agents in the paper industry.

11. Arsine is employed in the synthesis of organic compounds.

Hazards

12. Occupational poisoning from pure metallic arsenic is rare. Arsenic trioxide taken internally is poisonous and can be fatal, but few cases of general poisoning have occurred from industrial exposure to this chemical. Dermatitis and perforation of the nasal septum are common problems associated with arsenic trioxide, either because of direct contact with the compound in powder form, or exposure to it as air-borne particulate matter.

13. Careful handling and reason-

cient to control dust dispersion in the bagging and handling of nonvolatile arsenic compounds. Where arsenic fumes may be present, such as in the sintering and roasting of arsenic-bearing ores, complete enclosure and exhaust ventilation of the operation is needed. If respirators are required for protection against arsenic and its compounds, a respirator approved by the U.S. Bureau of Mines for protection against fumes not significantly more toxic than lead or a similarly approved air line respirator should be used. Handling arsenic trichloride requires complete enclosure because it has a vapor pressure of approximately 11 mm at 25 C, which could result in an air concentration of the order of 14,000 ppm (parts per million).

- Direct contact with the skin must be prevented, particularly contact with the vesicants. Clothing contaminated with dust or liquid must be cleaned before it is worn again.
- Eye protection is needed where arsenicals are handled. Potential dust exposures must be controlled to prevent eye irritation.
- Good washing facilities and appropriate eating and smoking regulations and enforcement of them will prevent the possibility of ingestion.

14. At high temperatures, arsenic and its solid compounds become volatile and produce poisonous fumes. Even though these compounds are noncombustible, their volatility at higher temperatures makes the use of self-contained breathing apparatus mandatory for anyone fighting a fire where they are present.

15. Arsine gas constitutes a serious industrial hazard. In fact, the highest incidence of injury involving arsenic is caused by accidental poisoning from inhalation of arsine, which releases the hemoglobin from the red blood cells and can easily be fatal. Instances of chronic poisoning from arsine have also been recorded. Arsine may be formed when hydrogen is generated in the presence of a material containing arsenic. Consequently, concentrates, intermetallic compounds, and drosses containing arsenic should be handled with care.

- In the smelting and refining industry, impurities in a molten metal

one of the more common impurities and, along with others such as antimony and sulfur, will combine with the aluminum and concentrate in the dross. Wetting this dross may cause one of several reactions or a combination of them. If nascent hydrogen is released, it could react with even minute amounts of arsenic to form arsine. If aluminum arsenide is formed in the dross, it could react with water to form arsine. These combinations of events have resulted in a number of fatal arsine poisonings.

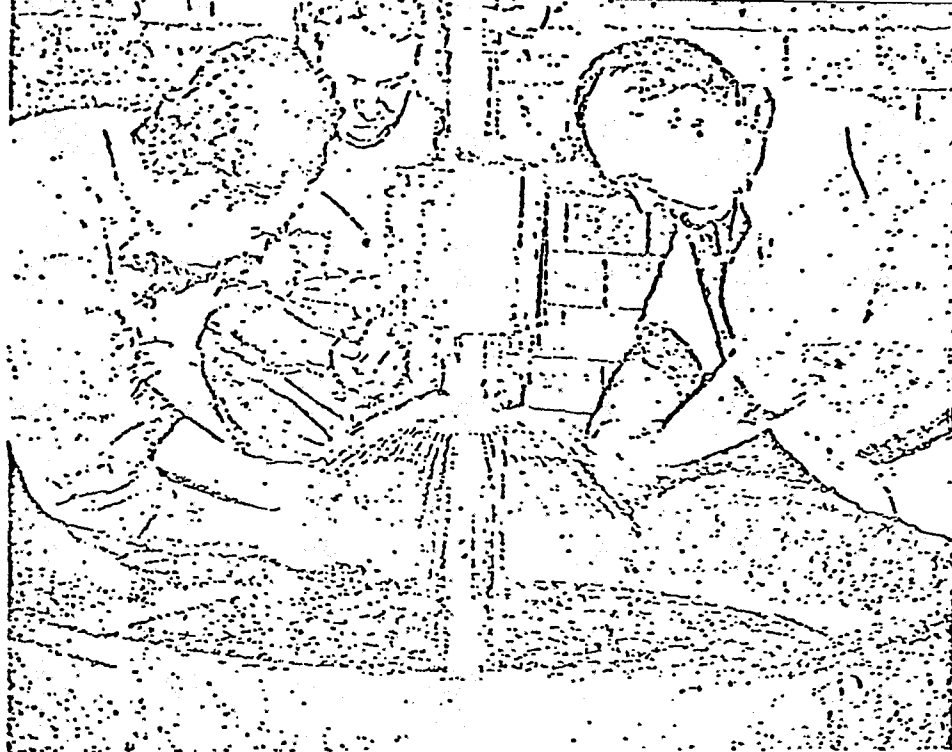
- The recommended procedure for handling the dross is to convert it to a granular, dusty black form by the addition of sawdust. It is then roasted for at least one hour at 1,800 F, a procedure which effectively stabilizes it to prevent liberation of arsine in the event of future wetting of the dross.
- Certain important industrial metals such as zinc often contain enough arsenic to create a hazardous situation in the presence of an acid. Hydrogen may be produced by the reaction between the zinc and the acid and combine with the arsenic to form arsine. Only a trace of arsenic is required to create a problem. The metallurgical industry is particularly susceptible because acid treatment of arsenic-bearing metals is common.

Containers and shipping regulations

16. Containers and shipping requirements for arsenic and its compounds are specified by Interstate Commerce Commission regulations.* All these compounds are Class B poisons and must carry the poison label. Each container should also carry a printed or stenciled label identifying the contents.

17. Metallic arsenic may be

*Agent T. C. George's Tariff No. 15, Publishing Interstate Commerce Commission Regulations for Transportation of Explosives and Other Dangerous Articles by Land and Water in Rail Freight, Express and Baggage Services and by Motor Vehicle (Highway) and Water, including Specifications for Shipping Containers. Issued by T. C. George, Agent, 63 Vesey St., New York City 10007.



Every employee who handles arsenic or its compounds should wash before eating or smoking. At the end of each workday, he should shower, change his shoes and work clothes. Clothes (including underwear) should be laundered before they are worn again.

shipped in 500-pound barrels or 100-pound casks.

18. Arsenic trichloride may be shipped in 20- or 55-gallon drums or in 5-gallon boxed glass carboys.

19. Arsenic trioxide may be shipped in 5- to 50-gallon drums or in tight wood (oak) barrels of no more than 700-pound gross capacity. Crepe-paper bag liners must be used unless the barrels are constructed with tongue and groove staves. This compound may also be shipped in hopper or bottom-outlet cars equipped with waterproof and dustproof covers. These cars should be used only for delivery to plants with private sidings.

20. Arsine is shipped in steel cylinders; copper arsenite in 1-pound bottles, wood kegs, or fiber drums. Lead arsenate in powder form is shipped in sacks and 100-pound barrels; in paste form, in cases, tins, 100-pound kegs, or 300- and 600-pound barrels.

21. Arsenic trisulfide is shipped in 50-pound multiwall paper bags. Copper acetoarsenite is shipped in 1-pound bottles, wood kegs, or fiber drums.

Storage

22. Arsenic and its compounds should be stored in areas removed from food or food products and from combustible materials. Those capable of sifting should be stored in containers of sift-proof construction. Hoppers and silos made of mild steel are acceptable.

23. Containers that have held arsenic or its compounds should not be cleaned with mineral acids because of the possibility of evolution of arsine.

Handling

24. Arsenic and its compounds require intelligent handling. Employees must be completely familiar with the potentially hazardous nature of such materials. Employee training must include thorough indoctrination in the use of personal protective equipment.

25. The possibility of the formation of arsine should be considered in processes and in areas where arsenic or its compounds are handled. Adequate general ventilation and local exhaust removal must be provided, unless the work is done

plant.

26. Spills of arsenic trioxide or other powdered compounds of arsenic should be removed by a vacuum cleaner with a fabric filter, never by use of a broom. Personnel who empty the vacuum cleaner should be thoroughly trained in handling procedures.

27. General handling precautions that should be followed are:

- Do not permit arsenic or its compounds to come in contact with the skin, eyes, nose, mouth, or clothing.
- Do not eat or smoke in areas where contamination by arsenic or its compounds is possible.
- Wash the hands and face before eating. Wash the hands before smoking. Make every effort to prevent ingestion of or contact with arsenic and its compounds.

Employee training

28. All employees working with arsenic should be trained to work in a hygienic manner. Such training or indoctrination should stress the following points, details of which are covered elsewhere in this data sheet:

- Indoctrination in the toxicity and hazard of inhalation and dermatitis-producing effects of arsenic and its water-soluble compounds.
- Training in safe handling techniques.
- Training on the proper fit, use, and limitations of prescribed respiratory protective equipment.
- Teaching the absolute necessity of assuring that ventilation equipment is in operation at all times when work is being performed.
- Teaching the value of promptness and proper equipment in cleaning up spills. (See "Handling.")
- Explaining the necessity of preventing transfer of arsenic compounds from the plant into the home, which is the basis for clothing changes at each work shift.
- Promoting personal cleanliness depending upon the type of operations involved. Showers may be required. Employees should be encouraged to report all cuts, scratches, or other injuries to supervision so that proper medical attention can be obtained.

arsenic or its compounds should put on clean work clothes daily, including cotton underwear and socks and a coverall.

30. At the end of each workday, the employee should thoroughly clean his work shoes, take a shower, and make a complete change of clothing. Work clothes should be laundered before they are worn again.

31. Calamine lotion and zinc oxide powder can be used on the hands and other skin areas before work. If gloves made of rubber or other protective material are worn, they must be cleaned inside and out after each use.

32. Local exhaust should be adequate to remove dust or arsine. Dust respirators approved by the U.S. Bureau of Mines should be available for emergency use. If the presence of arsine is suspected, complete respiratory protection approved by the Bureau of Mines for the specific hazard is required.

33. Safety showers and eyewash fountains should be available, and they should be checked frequently to see that they operate properly.

Isolation

34. Various methods of controlling arsenic dusts and fumes are available. Where possible, an operation should be completely enclosed. This either completely prevents the contaminant from entering the workroom atmosphere or limits to safe levels the amounts that do escape. In addition, this method is generally the least expensive.

35. Many states and municipalities have dust control codes or ordinances with which employers must comply. In a few states, for instance, written approval of plans must be obtained before a local exhaust system is installed. Each employer should therefore know his state and municipal dust control requirements.

36. A local exhaust system for the control of an industrial dust or fume traps the air contaminant near its source so that an operator standing at the process is not exposed to harmful concentrations, if the system cannot be enclosed completely. Local exhaust usually is preferred to general ventilation.

the air-borne arsenical contaminant is drawn.

- b. Ducts, to carry the contaminated air to a central point.
 - c. Dust and fume collectors, to clean the air before it is discharged.
 - d. A fan and motor to keep the air moving through the system.
- While each of these parts should be designed and installed to perform its required function with respect to the entire system, design of the exhaust hood demands the greatest care. The degree of control of dust at the point of generation or dispersion is determined by (a) the shape of the hood or degree of enclosure, (b) the location of the hood and its distance from the dust source, and (c) the rate of air-flow into the hood. A poorly designed hood can make an exhaust system ineffective.

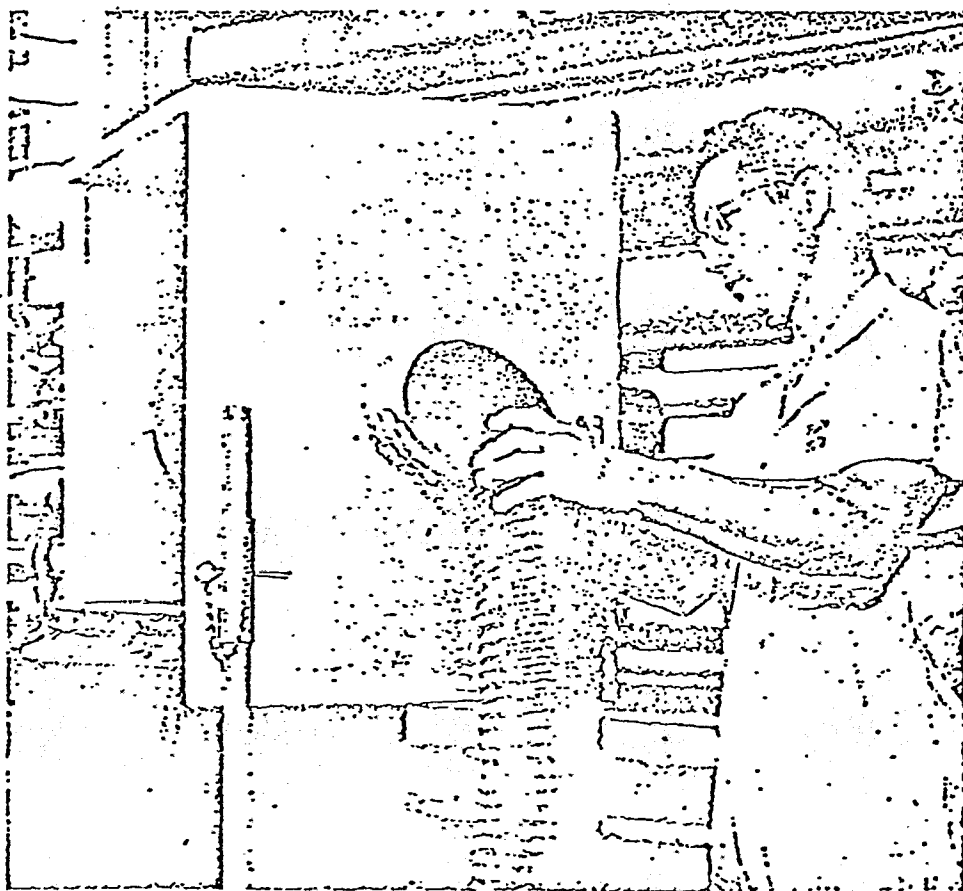
37. There is no standard hood design. In every case, the hood must be designed to fit the specific operation and to make the exhaust effective without interfering with the operation. Among the factors to be

- The hood should be shaped to conform to the shape of the area of dust production so as to secure reasonably uniform air velocity over this area. A hood which does not enclose the process should be placed with its opening as close as possible to the point of generation of the dust or fume because the velocity of the air drops off sharply.
- Air movement must always be past the employee, then over the dust source and directly into the face of the hood.

38. The fan should be of sufficient capacity to maintain the required air capture velocity at the point of generation of the dust. Internal baffles should be installed to guide the air flow where it is most needed. Flanges should be provided wherever possible to reduce the air flow from areas where no dust is produced; that is, air-flow contours should be controlled.

39. When control at the source is not possible, other methods may have to be considered. Any one or a combination of the following types

Portable exhaust hood is used over portable mixer. Air contaminant should be trapped near its source so that those near the process are not exposed to harmful concentrations. If the operation cannot be completely enclosed, local exhaust is next-best method.



limit the exposure.

- The dusty operation may be enclosed, with or without a local exhaust system. An enclosed operation generating large quantities of dust usually needs to be exhausted, or the dust will leak into the surrounding atmosphere.
- The dusty work may be performed in a separate building or may be isolated by partitions to reduce the number of employees exposed to the dust. The employees who are still being exposed should be protected by respiratory protective equipment.
- Keeping the materials moist may be a practical means of control.
- General room ventilation can be used to dilute the dust by adding large quantities of air and thus preventing build-up of dust concentrations. Examples of this method are roof fans and roof monitor windows. But it generally is inefficient and expensive to attempt to control contaminants by dilution.
- The dusty work may be performed at night or on week-ends to reduce the number of employees exposed.
- Cleaning dust accumulations from overhead beams, for instance, is preferably done during a weekend. The employees who are exposed should use appropriate respiratory protective equipment.

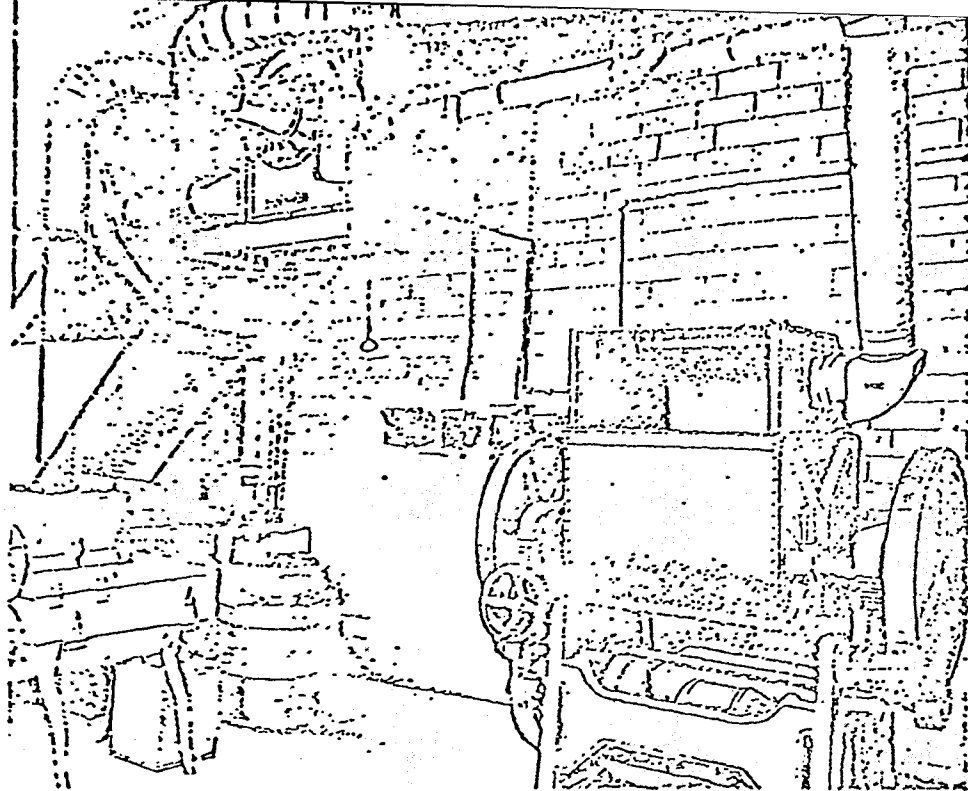
Symptoms of poisoning

40. Employees should be familiar with the symptoms of poisoning and should immediately report to the medical department if these symptoms occur.

41. Symptoms of poisoning by arsine are severe nausea, severe headache, abdominal pain (usually cramps), and numbness and tingling of hands, feet, and face.

42. Some literature on the subject states that arsine can be recognized by its garlic-like odor. However, a number of victims have stated that they smelled nothing unusual at the time of exposure. Those receiving less than the lethal dose usually recover without serious after-effects although permanent injury may occur if exposure has been chronic.

43. Arsenic trioxide, if swallowed in even very small amounts (1 or 2 grains), can cause acute poisoning. Symptoms are severe abdominal pain, difficulty in swallow-



Exhaust hoods over dry mixing machines have flanges to reduce air flow from areas where no dust is produced. Fan should be of sufficient capacity to capture the dust and pull it through the ductwork.

ing, tight feeling in the throat, vomiting, inability to urinate, cold and damp skin, rapid weak pulse, shallow breathing, and sometimes convulsions.

44. Symptoms of poisoning from arsenic trichloride may be intense irritation, itching, or ulceration of the skin and mucous membranes, multiple neuritis (inflammation of the spinal nerves) with sensory and motor disturbances, loss of hair, sweating of palms and soles.

45. Symptoms of poisoning from copper arsenite and copper acetoarsenite are similar to those from arsenic poisoning. Lead arsenate has a "double-barreled" effect because both lead and arsenic are highly poisonous (although, individually, arsenic is a more powerful poison than lead). Symptoms of chronic poisoning from lead arsenate are similar to those caused by lead; they include loss of appetite, metallic taste, constipation, severe abdominal cramps, facial pallor, mild jaundice, and anemia.

46. The effects of chronic poisoning by arsenic or arsenic compounds first show themselves on the skin, on the mucous membranes

of the eyes, and upper air passages, in the gastrointestinal tract, and in the nervous system. Often symptoms such as weakness, loss of appetite, and occasional nausea develop slowly, with the eyes, skin, and respiratory system being affected later.

47. Dusts on the skin, especially where there are folds, as around the mouth, or where the surfaces are moist, as in the armpits, set up an eruption or eczematous condition which, if not treated, will lead to extensive ulceration. Inhalation of excessive amounts of dust will lead to perforation of the nasal septum.

First aid

48. If an acute exposure occurs during the handling of vesicant arsenicals, take the victim to a clean area, remove contaminated clothing under a shower, flush exposed skin thoroughly with water, and call a physician.

49. If arsenic or one of its compounds has been swallowed, vomiting should be induced as soon as possible. The victim should be given a glassful of warm water in which a tablespoon of common salt has been dissolved. This remedy should be repeated until the vomited

and keep warm while awaiting medical assistance.

50. For a case of acute arsine poisoning, there is no specific first-aid measure other than immediate removal of the victim from the exposure. Medical attention should be secured promptly. A worker exposed to appreciable concentrations of arsine should be hospitalized at once.

Threshold limit values

51. The threshold limit values (TLV)—the time-weighted average atmospheric concentrations believed safe for continuous exposure during a normal work day—established by the American Conference of Governmental-Industrial Hygienists are:

Arsenic and compounds, based on the per cent arsenic in the compound (see Table I).	0.5 Mg/M ³
Arsine	0.05 ppm or 0.2 Mg/M ³
Calcium Arsenate	1.0 Mg/M ³
Lead Arsenate	0.15 Mg/M ³

52. The calculated limit value for arsenic trichloride would be 1.2 mg per cubic meter of air or 0.07 ppm, based on its arsenic content. However, due to the irritant and vesicant nature of arsenic trichloride, it would be advisable to set a limit well below this figure.

Medical examinations

53. Workers who handle arsenic or its compounds should be given thorough preplacement physical examinations and annual examinations thereafter.

54. People subject to chronic or recurrent skin conditions or to intestinal or nervous disorders should not be assigned to jobs in which they may be exposed to arsenic or its compounds. Since these conditions are also symptoms of arsenic poisoning, diagnostic difficulties

may arise if they were working with these substances.

Waste disposal

55. Waste materials containing arsenic or its compounds should be buried in an isolated area. (Check the rules and regulations of the state health department and other regulatory bodies in the particular area involved.) This area should be fenced and restricted. No trespassing or animal grazing is to be allowed. The site selected should be so located that there will be no possibility of arsenic leaching out or being carried by surface drainage to streams, ponds, or private or public water supplies.

56. Combustible containers that have been used for arsenic or its compounds should be burned in small quantities when there is enough wind to disperse fumes. The area downwind from the burning site should be unoccupied for a distance that will allow safe dilution of fumes that may be generated.

REFERENCES

Accident Prevention Manual for Industrial Operations, National Safety Council, 425 North Michigan Avenue, Chicago.

Arsenic and Its Compounds, Ohio State Department of Health, Columbus, Ohio 1940.

Arsenic Trioxide, Chemical Safety Data Sheet SD-60, Manufacturing Chemists' Association Inc., 1825 Connecticut Avenue, NW., Washington, D.C. 1956.

Arsine and Arsenic and Compounds, Hygienic Guide Series, American Industrial Hygiene Association, 14125 Prevoist, Detroit, Mich.

The Condensed Chemical Dictionary, 5th Edition, Reinhold Publishing Corporation, 330 West 42nd Street, New York City.

Dinman, B. D., "Arsenic: Chronic Human Intoxication," *Journal of Occupational Medicine*, 2:137-141 (March 1960).

pany, Baltimore, Md. 1957.
Fleming, A. J., D'Alonzo, C. A., and Zapp, S. A., *Modern Occupational Medicine*, Lea and Febiger, Philadelphia, Pa. 1954.

Gleason, M. N., Gosselin, R. E., and Hodge, H. C. *Clinical Toxicology of Commercial Products*, The Williams and Wilkins Company, Baltimore, Md. 1963.

Harrison, Joseph W. E., Packman, E. W., and Abbott, D. D., "Acute Oral Toxicity and Chemical and Physical Properties of Arsenic Trioxide," *AMA Archives of Industrial Health*, 17:118-123 (February 1958).

Mayers, M. R., "Occupational Arsenic Poisoning," *AMA Archives of Industrial Hygiene and Occupational Medicine*, 9:384-8 (May 1954).

McKinstry, W. J., and Hicks, J. M., "Emergency: Arsine Poisoning," *AMA Archives of Industrial Health*, 16:32-41 (July 1957).

Morse, K. M., and Setterlund, A. N., "Arsine Poisoning in the Smelting and Refining Industry," *AMA Archives of Industrial Hygiene and Occupational Medicine*, 2:148 (August 1950).

Patty, Frank A., editor, *Industrial Hygiene and Toxicology*, Vol. II, Interscience Publishers, Inc., 215 Fourth Avenue, New York City 1963.

Schrenk, H. H., "Industrial Hygiene Information on Arsenic Trioxide," *Industrial and Engineering Chemistry* (December 1953).

Spolyar, L. W., and Harger, R. N., "Arsine Poisoning," *AMA Archives of Industrial Hygiene and Occupational Medicine*, 1:419 (April 1950).

Vallee, B. L., Ulmer, D. D., and Wacker, W. E. C., "Arsenic Toxicology and Biochemistry," *AMA Archives of Industrial Health*, 21:132-151 (February 1966).

ACKNOWLEDGMENT

This data sheet was prepared by the staff of the Industrial Department, National Safety Council. It has been extensively reviewed by members of the National Safety Council and by representatives of chapters of the American Society of Safety Engineers. It has been approved for publication by the Publications Committee of the Industrial Conference of the Council.