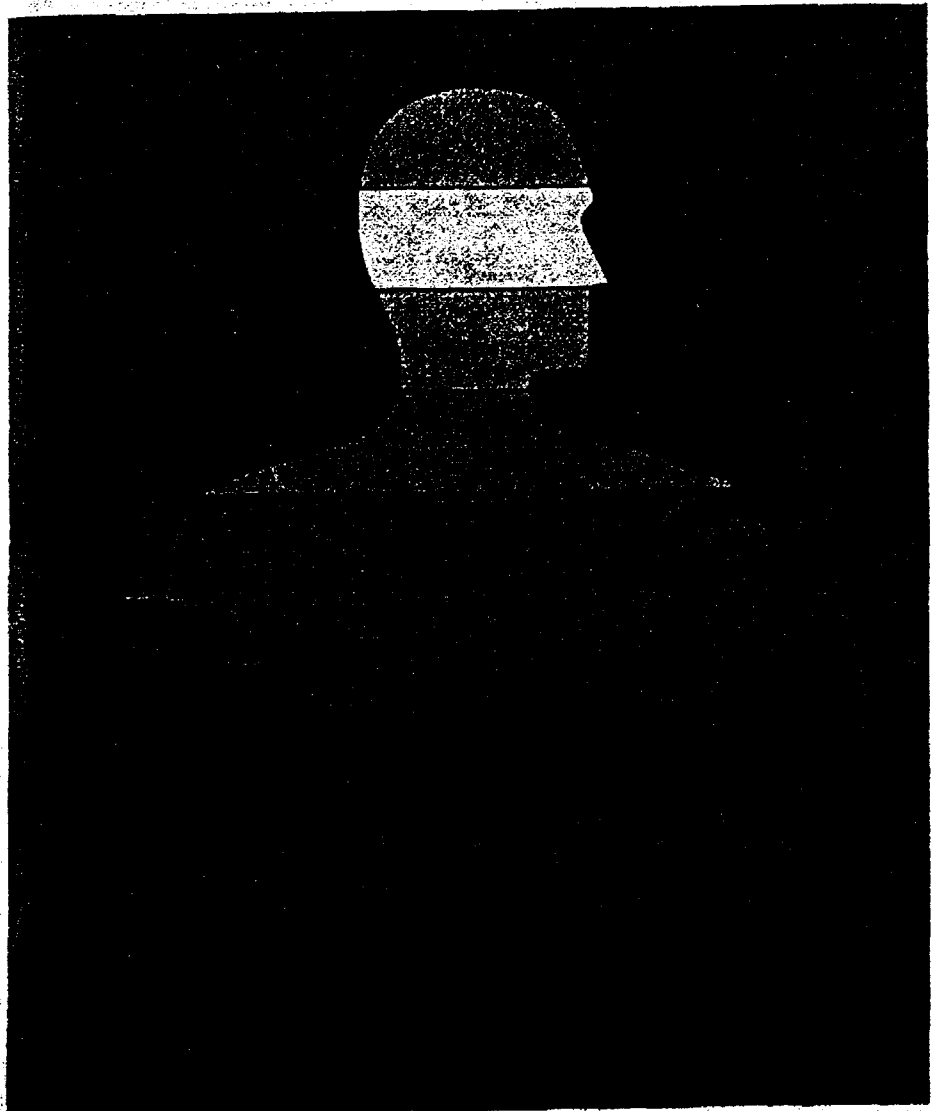


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Fundamentals of Industrial Hygiene



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Fundamentals of Industrial Hygiene

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and
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National Safety Council
Chicago, Ill. 60611

that flammable liquids are in particular care. Posters and signs effectively. No SMOKING signs in areas where smoking is prohibited.

Pneumoconiosis-Producing Dusts

by Fred Cook, M.S.

Pneumoconiosis is a tongue-twisting term of Greek derivation, meaning "lung" and "dust." As such, it may be applied to everyone because all the air we breathe contains some dust, and some dust is retained in every person's lungs. More specifically, pneumoconiosis is taken to mean a *fibrous hardening of the lungs caused by the irritation created from the inhalation of dust.*

All dust, smoke, fumes, vapors, and gases cause some irritation; and some fibrosis is present in every lung. With this in mind then, the lungs of older people might reasonably be expected to exhibit a greater degree of fibrosis due to these causes than the lungs of youngsters. This is frequently the case.

It follows that increased exposure to dust of any kind will increase the amount of pneumoconiosis in any individual's lungs; and it is also true that at some point, pneumoconiosis reduces the lungs' efficiency.

One of the first symptoms of its presence is shortness of breath. Unfortunately shortness of breath is also a symptom of aging (which may be accentuated by many causes), and a simple diagnosis of pneumoconiosis does not in itself mean that shortness of breath or any other symptoms must be ascribed to this cause.

One of the pneumoconioses that involves additional specific lung changes and is often associated with disability is silicosis.

Silicosis may also be present to a degree without producing symptoms or inconvenience. This disease is caused by the inhalation of finely divided free silica dust.

3-PNEUMOCONIOSIS-PRODUCING DUSTS

Free silica is the term commonly applied to crystallized silicon dioxide (SiO_2), which most commonly occurs as sand, but is also widely distributed in hard rocks and minerals. The percentage of crystalline SiO_2 in a mineral dust mixture is the usual basis for evaluating the hazards associated with the breathing of the mixture. See Table 3-A.

TABLE 3-A
CRYSTALLINE SiO_2 IN VARIOUS MATERIALS

Material	Normal Range Crystalline SiO_2 —%
Foundry molding sand	50-90
Pottery ware body	15-25
Brick and tile compositions	10-35
Buffing wheel dressings	0-60
Road rock	0-80
Limestone (agricultural)	0-3
Feldspar	12-25
Clay	0-40
Mica	0-10
Talc	0-5
Slate and shale	5-15

Another kind of pneumoconiosis, involving specific lung changes, is called *asbestosis* caused by the inhalation of asbestos dust.

There are several other lung diseases caused by specific mineral dusts, but they occur rarely because exposure to the offending dust is uncommon. Long exposure to very high concentrations of mineral dusts that do not produce specific lung changes can still be expected to result in some degree of pneumoconiosis even though symptoms may not be noticed.

Those responsible for the protection of the health and safety of workmen employed in the dusty trades must first find a means of evaluating the dust exposures, and must then apply the best available control measures to keep exposures within acceptable recommended safe limits. The solution of each of these parts of the problem frequently requires the assistance of specialists.

To evaluate the exposures, it is first necessary to determine the composition of the dust that remains suspended in the air workmen breathe.

Operations that involve crushing, grinding, or polishing of minerals or

to crystallized silicon dioxide
d, but is also widely distrib-
percentage of crystalline SiO₂ in a
s for evaluating the hazards asso-
e. See Table 3-A.

3-A ARIOUS MATERIALS

	Normal Range Crystalline SiO ₂ —%
	50-90
	15-25
tions	10-35
s	0-60
	0-80
)	0-3
	12-25
	0-40
	0-10
	0-5
	5-15

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mineral mixtures frequently do not produce air-borne dusts of the same
composition as that of the material being fabricated. We are usually
primarily concerned with the percentage of crystalline SiO₂ that is
suspended with other dusts in the air.

In many mineral mixtures, the crystalline SiO₂ is harder than the
balance of the mixture, and most crushing and grinding operations
produce air-borne dust with a lower percentage of crystalline SiO₂ than
is found in the original mineral mixture. Occasionally, when the grind-
ing operation involves a great deal of impact force, the situation is
reversed.

In pulverized materials, the crystalline SiO₂ is frequently found in
larger particle size than the softer components; and when this is the case,
the handling of pulverized materials may also produce a higher percent-
age of the softer components in the air-borne dust which is produced by
handling methods.

These factors make it necessary to actually obtain a sample of air-
borne dust, and to analyze this sample if the composition is to be used in
evaluating the hazard associated with breathing the dust.

The extremely small size of the dust—zero to 5 microns—makes chemi-
cal methods of analysis, which depend upon the differential solubility of
the various components, too unreliable to be used alone. Petrographic
analysis (using a polarized microscope) and X-ray diffraction analyses
techniques are usually preferred. These require equipment and proce-
dures not commonly found in chemical laboratories. Table 3-A indicates
the normal range of crystalline SiO₂ found by analysis of many minerals
and industrial compositions.

Measurement

The measurement of air-borne dust concentrations involves a technique
which admittedly does not collect all of the dust in the air.

In this country, evaluation of the harmful effects of dust has been
made on the basis of those dust particles collected by impingement; and
when relating harmful dust concentration to values so obtained, this
technique must be used.

The safety professional commonly measures the size of air-borne dust
particles in units known as microns (Figure 3-1). (A micron is one
thousandth of a millimeter or approximately one twenty-five thousandth
of an inch.) The standard technique used to evaluate dust concentra-
tions does not collect or count dust particles much smaller than one
micron, and it can readily be shown from settling formulas that dust

3-PNEUMOCONIOSIS-PRODUCING DUSTS

exposure. So that an exposure can be properly evaluated, the percentage of uncombined silica must be determined by petrographic analysis using a polarizing microscope or, preferably, by X-ray diffraction analyses and special analytical chemical procedures.

With the exception of asbestos and some talcs, the silicate dusts do not ordinarily cause a serious disabling lung condition such as is produced by free silica. Much higher levels of silicate dusts can be tolerated.

In many industries, men have worked with silicate dusts that contained no free silica without development of disability or of nodulation in the lungs. The X ray may show shadows indicating dust deposits in the lungs, but the pneumoconiosis is essentially harmless.

Disabling pneumoconioses from exposure to abnormally high concentrations of mica, tremolite talc, and kaolin dusts have been described in the literature. The clinical signs are not the same for these silicate dusts as for free silica. The body does not have adequate defense against indiscriminate amounts of dust of any kind. Therefore, although specific symptoms have not been described for many mineral dusts, the general experience would indicate that dust levels should be kept below the threshold limit values shown in Table 3-C.

Asbestosis

Asbestos is a general term applied to several minerals having a fibrous character. These asbestos minerals are hydrated silicates of magnesium with variable amounts of iron, calcium, sodium, potassium, and aluminum present as impurities.

Asbestos when inhaled produces fibrous tissue in the lungs of both men and animals. It has been shown that fibers of asbestos must be present for the production of *asbestosis*. Other silicate minerals of the same chemical composition but nonfibrous in form produce no reaction or a relatively mild reaction, but not the severe reaction of fibrous asbestos dust.

These facts lead to the conclusion that asbestosis is mainly the result of physical irritation of the lung tissue and not of a chemical action, which is thought to be one of the causes of silicosis. It is suspected that lung cancer may be induced by asbestos.

Anthracosilicosis

Anthracosilicosis, a complex form of pneumoconiosis, is a chronic disease caused by breathing air containing dust that has free silica as one

(Text continues on page 116.)

TABLE 3-C
SELECTED INDUSTRIAL MINERAL DUSTS

Substance	Description and Uses See Preface to Threshold Limit Values, Appendix A.	Threshold Limit in Million Particles per Cubic Foot of Air*
CRYSTALLINE FREE SILICA (SiO ₂ , including microcrystalline forms)		
Chalcedony	A heat-resistant, chemically inert form of microcrystalline quartz. decorative material. Rare in industry.	Calculate from formula: 250
Chert	A microcrystalline form of silica. An impure form of flint used in abrasives.	$\frac{\% \text{ SiO}_2 + 5}{250}$

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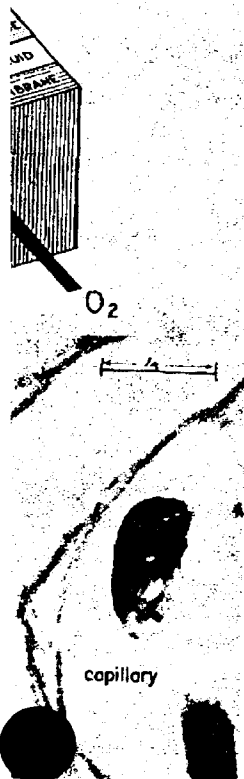
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early quiescent (because the aerosols will be deposited. These aerosols act almost like n, unlike the mucous lining of

the airways, but which serves the same cleansing function. This fluid flows upward in the sacs, toward the bronchioles, apparently by capillary action, and will carry with it deposited particles or dissolved particles and gases.

Aerosols that are not removed from the alveoli in this manner may fall prey to the mobile phagocyte cells, which are the type of white blood cells capable of ingesting particles. These cells, once laden with foreign matter, may: (a) migrate to the small bronchioles, where the mucous lining carries them out of the system; (b) pass through the alveolar membrane into the lymph vessels associated with the blood capillaries, or (c) be destroyed (if the contaminant is cytotoxic) and break up, releasing the particles into the alveolar sac.

If the aerosol is not removed by these means, it may form a deposit in the sac. Such deposits may or may not acutely effect lung health.

All of the defense mechanisms discussed are subject to some deterioration and slowing down with age or ill health. So an older worker's lungs will not cleanse themselves as quickly or efficiently as those of a younger person. Also, some contaminants may impede the defense mechanisms themselves, increasing the rate of retention of the contaminant in the lungs.

Hazards

Now, let's look at some of the unhealthy conditions to which the lung is subject, associated terminology, and some typical hazardous substances.

The membrane lining in the nasal passages can be affected by a number of causes. The resultant condition is called *rhinitis*. Inflammation in the larynx is called *laryngitis*, that of the bronchial tubes, *bronchitis*. Constriction of the tube muscles, in response to irritation, allergy, or other stimulus is called *asthma*.

In the lung sacs, a number of conditions can develop:

- *Pneumonitis*—produced by an outpouring of fluid in the lungs in response to irritation. This fluid production is analagous to the protective mechanism of a blister in response to a burn. *Pneumonia* is the same condition, but involving greater quantities of fluid.
- *Emphysema*—in which the walls of the individual grapes (alveoli) rupture or dilate. The wall of the resulting larger sac has lost its naturally elastic recoil, and so does not exhaust air as efficiently, and does not offer the large area for gas transfer afforded by the several smaller sacs. This condition is on a tremendous increase today.

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- *Pleurisy* is caused when the outer lung lining (the visceral pleura) and the chest cavity's inner lining (the parietal pleura) lose their lubricating properties. The resultant friction causes irritation and pain.
- *Lung cancer*. No doubt exists that certain aerosols predispose the lungs to cancer. This disease, like emphysema, is on the increase.
- *Pneumoconiosis* (dusty lung). This is a catchall word for various pulmonary manifestations of dust inhalation, whether the dust is harmful or not. Two common forms of pneumoconiosis are silicosis and asbestosis. The typical pathological condition in harmful pneumoconiosis is the existence of fibrotic (stringy) tissue in the alveolar sacs, at the "Y" branches in the small bronchi leading to the alveolar sacs, or at lymph nodes in the lungs. This fibrotic tissue, caused by some dust particles, reduces the efficiency of the lungs by making them less resilient, and by reducing the effective working surface for gaseous exchange. A simple benign pneumoconiosis with little disturbance of pulmonary function can also predispose to such diseases as pneumonia and tuberculosis.

Contaminant effects

Inhaled contaminants that adversely affect the lungs fall into three general categories:

- *Aerosols*, which, when deposited in the lungs, may produce either tissue damage, tissue reaction, disease, or physical plugging.
- *Toxic gases that produce adverse reaction* in the tissue of the lungs themselves.
- *Toxic aerosols or gases that do not affect the lung tissue*, but are passed from the lung into the blood stream, where they are carried to other body organs, or have adverse effects on the oxygen-carrying capacity of the bloodstream itself. (See Chapter 11, "Toxicology.")

An example of the first type is asbestos fiber, which causes fibrotic growth in the alveolar tissue, plugging the ducts or limiting the effective area of the alveolar lining. Other harmful aerosols are certain fungi found in sugar cane residues, producing bagassosis.

Hydrogen fluoride is a gas that directly affects lung tissue. It is a primary irritant of mucous membranes, causing chemical burns. Inhalation of this gas will cause pulmonary edema, and direct interference with the gas transfer function of the alveoli lining.

MONITORING, AND PROTECTION

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irectly affects lung tissue. It is a rbranes, causing chemical burns. monary edema, and direct interfer- the alveoli lining.

Typical of the lung's role in passing toxic gases into the blood stream, without itself being harmed, is the case of carbon monoxide. The CO passes through the alveolar walls into the blood, where it ties up red corpuscles so they can't accept oxygen, thus causing oxygen starvation. Cyanide gas has another effect—it prevents the utilization of molecular oxygen by cells.

Sometimes several types of lung hazards occur simultaneously. In mining operations, for instance, explosives release oxides of nitrogen. These impair the bronchial clearance mechanism, so that coal dust associated with the explosions is not efficiently cleansed from the lungs.

Aerosol deposition

In the case of gases, the concentration that reaches the alveolar sacs will be nearly the same as the concentration in the air breathed.

With aerosols, this is not the case. Large particles, more than 10 microns, will be deposited long before they reach the sacs, through gravity and impaction. Only the smaller particles will reach the alveoli. In the sacs, Brownian movement of the particles results in deposition by diffusion.

Since the very small aerosol particles are the only ones that are likely to reach the alveoli in great quantities, and since the alveoli are the most important area in the lungs, it is clear that the minute aerosols are potentially more harmful than larger aerosols. (This fact points up the fallacy of using a coarse filter mask for dangerous aerosols: it will pass the very particles that are most hazardous.)

Monitoring respiratory hazards

There are a number of reasons for carrying out sampling procedures:

- In emergency situations, for instance where someone has already fainted. The handicap here is that the event is passed, and sampling will only give an estimate of what contamination levels prevailed.
- Areas where emergencies are ready to happen. An example is tank entry. It is assumed a hazard exists, and monitoring is carried out to verify the assumption and to define the hazard accurately.
- Sampling for chronic exposures.
- Sampling to investigate complaints.
- Monitoring for compliance with regulations.



FIG. 17-4.~Examples of emergency and nonemergency respirators. The air line respirator (top) has auxiliary air supply to allow escape in case the line should break. The cartridge respirator (below) is not for use in atmospheres immediately hazardous to life, but rather as a defense against prolonged exposures to low gas and vapor concentrations and harmful aerosols.

negative pressure in the facepiece of fitted masks, inward contaminant flow is, pressure-demand breathing has the facepiece exhalation valve and a slight, positive pressure in the

able with ratings up to two hours on to be available. The closed-circuitive training than the open-circuit (1) personnel spend 30 hours train-

ing with such apparatus before they are qualified.

Usually, the only limitation of self-contained breathing apparatus is the possibility of poisoning by skin absorption.

The gas mask operates with a negative pressure upon inhalation, and therefore the mask should be carefully fitted and the wearer should be alert for symptoms of leakage. Both multipurpose (formerly designated "universal") and special-purpose canisters are available.

The USBM recommends that where possible canisters designed to remove specific gases or vapors be used. Because gas masks cannot be used in oxygen-deficient atmospheres or in high concentrations of gases and vapors, they are being replaced in many cases by self-contained breathing apparatus and the third type described next.

The hose mask with blower. The latter type incorporates a hand-operated or motor-driven blower, and the wearer may use up to 300 feet of large-diameter, wire-wrapped, oilproof hose. If the blower fails, the wearer can breathe through the large hose alone with no more resistance than is encountered in a gas mask. It is important that a safety professional be standing by the blower to make sure that only *respirable* air is supplied at the intake.

Air line respirator with auxiliary self-contained cylinder. Air line respirators alone are not regarded as safe for use in immediately dangerous atmospheres. Should the air supply fail for any reason, the wearer cannot get air through the valves and small-diameter hose. But with the auxiliary air cylinder, the wearer can breathe supplemental air while making his exit from the hazardous atmosphere.

Nonemergency respirators

Respiratory protective devices intended only for use in nonemergency situations should ideally be used only as temporary measures while engineering controls for contaminants are being installed. They are, however, widely used in industry as a primary line of defense against inhalation hazards (Figure 17-4).

A **supplied-air respirator**, the air line respirator with continuous flow, is particularly suitable, when equipped with helmets or hoods, for lead grinding or abrasive blasting.

Dispersoid respirators can be divided into three classes: those for use

as protection against (a) pneumoconiosis-producing dusts and mists (such as silica and asbestos); (b) toxic dusts, metallic fumes, and mists not significantly more toxic than lead (zinc dust, lead fume, and chromic acid mist are examples); and (c) radionuclides and highly toxic dusts, fumes, and mists—significantly more toxic than lead (such as all radionuclides and beryllium).

This third classification is subdivided into three groups, with a different type of dispersoid respirator for each: half-mask respirators are suggested for use in contaminant concentrations up to 10 times the threshold limit value, full facepieces up to 100 times the TLV, and positive-pressure dispersoid respirators up to 1000 times the TLV.

Nuisance dusts and mists are included with silica and asbestos in the first class (a), above. U.S. Bureau of Mines approved respirators should be used even for nuisance materials such as coal, sawdust, and flour, since no one can foretell the possible effects of breathing such materials, and the legal complications that may arise from unapproved nuisance-dust respirators may be more costly and troublesome than the use of the approved respirator.

Chemical-cartridge respirators are designed for use in low concentrations of gases or vapors and are also frequently equipped with filters for protection against dusts and mists, during paint spraying.

Employee training

As is true with all protective equipment, respiratory protective devices will be effective only when acceptable to the worker. The best way to achieve acceptance is to explain exactly why the respirator needs to be worn, and what might happen if the respirator were not worn.

Where nonemergency respirators are used, the wearer should be allowed to try on several styles from various manufacturers to choose the one best suited to him.

In addition to convincing a worker of the need for wearing a respirator, and providing him with a comfortable model, he must be trained to wear it correctly. Such training may vary from showing the user how to check the facepiece fit of a small dust respirator, to training sessions of several hours for the more complicated self-contained apparatus.

During initial training, special emphasis should be placed upon facepiece fit. Several simple tests will disclose improper fit. The exhalation valve can be closed and the wearer exhales (a slight positive pressure should build up in the facepiece without leakage of air at the seal). Or

MONITORING, AND PROTECTION

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the filter or cartridge inlets or the breathing tubes are closed off and the
wearer inhales (the facepiece should collapse and remain collapsed for a
few seconds). These initial procedures can be carried a step further by
allowing the wearer to check the fit he has obtained in an odorous but
harmless atmosphere, such as that created by isoamyl acetate.

Maintenance

The U.S. Bureau of Mines recommended procedures for cleaning and
disinfecting respirators include new disinfectants replacing such materi-
als as formalin and alcohol. After disassembling the respirator, clean
and disinfect facepiece and breathing tube in warm (120 F) cleaner-dis-
infectant solution. This may be prepared from quaternary-ammonium,
detergent, and alkaline-salt compounds that are available from respirator
manufacturers and other sources. Rinse thoroughly in warm water since
the wearer may be allergic to quaternary-ammonium compounds. Or
clean facepiece and breathing tube in a warm (120 F) liquid detergent
solution, rinse in warm water, then immerse for 2 minutes in one of the
following: (a) hypochlorite solution (50 ppm chlorine) prepared by
diluting concentrated hypochlorite solution (5 per cent chlorine) with
water; (b) aqueous iodine solution (50 ppm iodine) prepared by dis-
solving soluble iodine compound in water. *Note: 50 ppm is equivalent
to 0.005 per cent. Chlorine and iodine solutions stronger than 50 ppm
may damage rubber parts.*

Air dry in a clean place. Clean and inspect other respirator parts
according to manufacturer's instructions. Reassemble respirator and
store in a clean, dry place.

hair and nails where arsenic may be detected about two weeks after the beginning of exposure and where it persists for months and sometimes for years after the exposure is terminated. Inhaled arsenic is excreted to a considerable extent through the kidney and can be detected in the urine within a few hours of the start of the exposure and for a long time after.

The compound BAL (2,3-dimercapto-1-propanol) was developed as an antidote for arsenical gas poisoning. It is effective in prevention of poisoning from otherwise harmful doses of the arsenic compounds in general, and in the treatment of existing cases of poisoning, although cases have been reported in which BAL was not effective.

Arsine (arsenic hydride). Several acute industrial poisonings with arsenic are likely to be the result of inhalation of arsine, often produced accidentally when hydrogen is generated in the presence of a material which contains arsenic. The gas has been reported in the acid cleaning of filter plates, in the handling of waste from a light metals plant, in the cleaning of tank cars which have held sulfuric and hydrochloric acids, in the cleaning of pipes with an acid contaminated with arsenic, in the precipitation of cadmium with metallic zinc, and in other operations.

Arsine gas causes a characteristic syndrome of massive hemolysis leading to renal failure. It is associated with nausea, vomiting, diarrhea, change in skin color, disturbance of vascular tone, electrocardiographic

abnormality, and liver disfunction. If the patient survives long enough, manifestations of chronic arsenic poisoning may appear. After exposure, a latent period of 1 to 36 hours may ensue. Inhalation of 250 ppm is instantly lethal. Exposures of 25-50 ppm for half an hour are lethal and 10 ppm are lethal after longer exposure. The mean lethal dose (LD₅₀) is unknown in man, but in small mammals is about 0.5 mg/kg. Arsine gas can be fixed by tissues other than blood. It binds to the kidneys and liver and inhibits respiration of slices of these tissues *in vitro*. In low concentration exposures, clearance of arsine from plasma, where it dissolves into the erythrocyte, is rapid and efficient. When high concentrations of arsine gas are suddenly dissolved in plasma, in large acute exposures, the amount of circulating arsine may exceed the binding capacity of the erythrocytes, and the gas may damage vital organs directly. This would explain death due to arsine poisoning before hemolysis occurs.

The possibility of arsine formation should always be considered when there is freshly formed hydrogen around ores of the heavy metals, since arsenic is widely distributed in small amounts and only a trace of it is required to produce enough arsine to be troublesome.

Asbestos is a hydrated magnesium silicate found in the minerals chrysotile, amosite, crocidolite, and tremolite. Practically all the commercial asbestos used in this country is chrysotile. It is used almost exclusively for

heat insulation or for textiles which must resist high temperature, such as heat-resistant clothing and brake linings.

Inhalation of excessive quantities of asbestos fiber can produce a fibrosis in the lungs similar to that found in silicosis but somewhat milder and usually not so rapidly progressive. Like silicosis, the condition develops and advances slowly and is equally resistant to treatment. There is also good evidence that inhaled asbestos causes lung cancer.

Asphalt. Although asphalt itself is considered to be substantially non-toxic, it may cause inflammation or dermatitis on contact in some individuals. Careful supervision of worker's personal cleanliness is essential in the prevention of dermatitis or other ill effects. Skin contact with the asphalt should be avoided—individuals working with asphalt should wear suitable protective equipment, including goggles to protect the eyes. The effect of exposure to vapors from liquid or cutback asphalt depends on the particular solvent added to the asphalt. Steps should be taken to hold the solvent vapor concentration in the breathing zone below its threshold limit value. Where operations require heating or grinding asphalt inside a building, suitable ventilation should be provided.

B

Barium, in the form of its soluble salts, is toxic on both ingestion and inhalation and highly caustic when applied to the skin. The carbonate

the various processes in mining and preparing anthracite (hard) coal and, to a lesser degree, bituminous coal.

Anthraxosis. A disease of the lungs caused by prolonged inhalation of dust that contains particles of carbon and coal.

Anthrax. A highly virulent bacterial infection picked up from infected animals and animal products.

Antibiotic. A substance produced by a microorganism usually a mold or fungus, which in dilute solutions kills other organisms, or retards or completely represses their growth, normally without harm to higher orders of life.

Antibody. Any of the body globulins that combine specifically with antigens and neutralize toxins, agglutinate bacteria or cells, and precipitate soluble antigens. It is found naturally in the body or produced by the body in response to the introduction into its tissues of a foreign substance.

Antigen. A substance that, when introduced into the body, stimulates the production of an antibody.

Antimony. Gray metal often associated with lead and arsenic. Hazardous from inhalation and ingestion. Soluble salts may cause dermatitis.

Antioxidant. A compound which prevents deterioration by oxidation. Antioxidants for human food and animal feeds, sometimes referred to as freshness preservers, retard rancidity of fats and lessen loss of fat-soluble vitamins (A, D, E, K). Antioxidants also are added to rubber, motor lubricants and other materials to inhibit deterioration.

Anti-particle. A particle which interacts with its counterpart of the

same mass but opposite electric charge and magnetic properties (e.g., proton and anti-proton or neutron and anti-neutron), with complete annihilation of both and production of an equivalent amount of radiation energy. The positron and its anti-particle, the electron, annihilate each other upon interaction and produce gamma rays.

Antiseptic. A substance that prevents or inhibits the growth of microorganisms; a substance used to kill microorganisms on animate surfaces, such as skin.

Aplastic anemia. A condition in which the bone marrow fails to produce an adequate number of red blood corpuscles.

Approved. Tested and listed as satisfactory by an authority having jurisdiction, such as U.S. Department of the Interior, Bureau of Mines, or U.S. Department of Agriculture.

Arc welding. One form of electrical welding using either uncoated or coated rods.

Aromatic. Applied to a group of hydrocarbons and their derivatives characterized by presence of the benzene nucleus (molecular ring structure). See also *aliphatic*.

Arsenic. Silvery brittle crystalline metal. Hazardous from inhalation and ingestion. Usually encountered as arsenic trioxide.

Artificial abrasive. Materials, such as *carborundum* or *emery*, substituted for natural abrasive such as sandstone.

Artificial radioactivity. That produced by bombardment of a target element with nuclear particles. Iodine-131 is an artificially produced radioactive substance.

Asbestos. A hydrated magnesium silicate in fibrous form. The fibers are believed to be the more hazardous component of asbestos dust.

Asbestosis. A disease of the lungs caused by the inhalation of fine airborne fibers of asbestos.

Asepsis. Clean and free of microorganisms.

Aspect ratio. In air distribution outlets, the ratio of the width of the core of a grille, face, or register to its length.

Asphyxia. Suffocation from lack of oxygen. Chemical asphyxia is produced by a substance, such as carbon monoxide, that combines with hemoglobin to reduce the blood's capacity to transport oxygen. Simple asphyxia is the result of exposure to a substance, such as carbon dioxide, that displaces oxygen.

Asthma. Constriction of the bronchial tube muscles, in response to irritation, allergy, or other stimulus.

Atmospheric pressure. The pressure exerted by the weight of the atmosphere—about 14.7 pounds per square inch, which is equivalent to the pressure exerted by a column of mercury (Hg) 760 mm high. See *absolute pressure* and *gage pressure*.

Atom. All materials are made of atoms. The elements, such as iron, lead and sulfur, differ from each other because they contain different atoms. The word "atom" comes from the Greek word meaning indivisible. Now we know it can be split and consists of an inner core (*nucleus*) surrounded by *electrons* which rotate around the nucleus like the planets around the sun. As a chemical unit, it remains unchanged during any chemical reaction, yet may un-

