

PLAINTIFF'S EXHIBIT

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Fundamentals of Industrial Hygiene

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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

mineral mixtures frequently have a composition as that of the original material, but are primarily concerned with dusts suspended with other dusts.

In many mineral mixtures, the balance of the mixture produces air-borne dust which is found in the original material. The grinding operation involves reversing the process.

In pulverized materials, the larger particle size than the handling of pulverized materials of the softer components, the handling methods.

These factors make it difficult to analyze air-borne dust, and to analyze the hazard of a dust.

The extremely small size of the particles makes the use of analytical methods of analysis. The various components of the dust are usually analyzed by using a polarizing microscope. The dusts are not commonly found in the normal range of crystalline SiO_2 in industrial compositions.

Measurement

The measurement of dust is a problem which admittedly does not have a simple solution.

In this country, evaluation of dust is made on the basis of the total dust when relating harmfulness to health. The technique must be used.

The safety profession is concerned with particles in units known as the millionth of an inch. The standard does not collect dust smaller than 100 microns, and it can be

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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)		
	A heat-resistant, chemically inert form of microcrystalline quartz	A Calculate from formula: 250

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TABLE 3-C. SELECTED INDUSTRIAL MINERAL DUSTS (Continued)

AMORPHOUS FREE SILICA (Noncrystalline)		
Diatomaceous earth	A soft, gritty amorphous silica composed of minute siliceous skeletons of small aquatic plants. Used in filtration and decolorization of liquids, insulation, filler in dynamite, wax, textiles, plastics, paint, and rubber. Calcined and flux-calcined diatomaceous earth contains appreciable amounts of cristobalite, and dust levels should be the same as for cristobalite.	Amorphous = 20 mppcf Calcined = use formula: $\frac{250}{\% \text{ SiO}_2 + 5}$
Silica gel	A regenerative absorbent consisting of the amorphous silica manufactured by the action of HCl on sodium silicate. Hard, glossy, quartz-like in appearance. Used in dehydrating and in drying and as a catalyst carrier.	20 mppcf
SILICATES		
(Compounds made up of silicon, oxygen, and one or more metals with or without hydrogen. These dusts cause nonspecific dust reactions, but generally do not interfere with pulmonary function or result in disability.)		
Asbestos	A hydrated magnesium silicate in fibrous form. The fibers are believed to be the more hazardous component of asbestos dust.	5 mppcf
Clays	A great variety of aluminum-silicate bearing rocks, plastic when wet, hard when dry. Used in pottery, stoneware, tile, bricks, cements, fillers, and abrasives. Kaolin is one type of clay. Some clay deposits may include appreciable quartz. Commercial grades of clays may contain up to 20 per cent quartz.	50 mppcf
Feldspar	Most abundant group of materials, composed of silicates of aluminum with sodium, potassium, calcium, and rarely barium. Most economically important mineral. Used for ceramics, glass, abrasive wheels, cements, insulation, and fertilizer.	50 mppcf
Fuller's earth	A hydrated silica-alumina compound, associated with ferric oxide. Used as a filter medium and as a catalyst and catalyst carrier and in cosmetics and insecticides.	50 mppcf

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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.

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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

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where arsenic may be two weeks after the exposure and where it is excreted to a considerable extent through the kidneys. BAL (2,3-dimercapto-1-propanol) was developed as an arsenical gas poisonantive in prevention of otherwise harmful arsenic compounds in the treatment of poisoning, although cases are reported in which BAL was

used (hydride). Severe industrial poisonings with arsine, often produced by the reaction of hydrogen with arsenic. The gas has been used in the acid cleaning of the handling of wet metals plant, in the cleaning of cars which have held hydrochloric acids, in the cleaning of metals with an acid containing arsenic, in the precipitation of metallic zinc from solutions.

Arsine causes a characteristic massive hemolysis leading to cyanosis, vomiting, diarrhea, and a dark color, disturbance of 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 occur. Inhalation of 250 ppm is usually lethal. Exposures of 25-50 ppm for half an hour are lethal and 10 ppm are lethal after longer exposure. The mean lethal dose (LD_{50}) is unknown in man, but in small mammals is about 0.5 mg/kg. Arsine 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.

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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

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nihilation 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 pre-
vents or inhibits the growth of micro-
organisms; a substance used to kill
microorganisms on animate surfaces,
such as skin.

Aplastic anemia. A condition in
which the bone marrow fails to pro-
duce 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 electri-
cal 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, sub-
stituted for natural abrasive such as
sandstone.

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

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

Asbestosis. A disease of the lungs
caused by the inhalation of fine air-
borne fibers of asbestos.

Asepsis. Clean and free of micro-
organisms.

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 ca-
pacity to transport oxygen. Simple
asphyxia is the result of exposure to
a substance, such as carbon dioxide,
that displaces oxygen.

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

Atmospheric pressure. The pres-
sure 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 indi-
visible. Now we know it can be split
and consists of an inner core (nu-
cleus) surrounded by electrons which
rotate around the nucleus like the
planets around the sun. As a chemi-
cal unit, it remains unchanged during
any chemical reaction, yet may un-

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