ACCIDENT PREVENTION MANUAL

for Industrial Operations

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PLAINTIFF'S
EXHIBIT
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velocity. This type of dispersion is known as dynamic projection and is a result of the kinetic energy of the particle's motion. As the mass of the particle decreases, however, a point will be reached when its kinetic energy (which is one-half the mass times the square of the velocity) is too small to overcome air resistance. The particle's forward velocity is thus minimized and it remains suspended in the containing air mass.

As a rough approximation, macroscopic particles (those visible to the naked eye) are considered to be dispersed by dynamic projection. Microscopic particles (those visible only through a microscope) are considered to have a mass so small that their movement is dependent on the containing air mass. Contaminants such as the larger dust particles, mists, and sprays, which are dispersed by dynamic projection, can cause external injury such as acid burns, eye damage, and dermatitis. The microscopic particles are dangerous to health if inhaled.

Separation in airborne dusts

Dust in the air may or may not have the same composition as its parent material. The determining factors are the particle size and density of each component in the original mixture, and the hardness of the materials (hard materials will resist the pulverizing action of a mechanical device).

For example, foundry molding sand contains a large percentage of free silica with a lower percentage of clays. Most of the clays consist of fine particles that can be airborne, but most of the free silica particles are too large to be airborne. The airborne dust, therefore, as compared with the original mixture, may contain a much higher percentage of clays and a much lower percentage of free silica.

Dust particles are, of course, attracted by gravity. Their settling rate through still air will vary with their size, density, and shape. Microscopic particles settle out more slowly than larger particles because of their relatively minor density and because of their being influenced by Brownian movement. Mineral particles larger than 10 μ will settle out relatively fast. The estimated settling rates for silica dusts in still air are given in Table 39-A.

TABLE 39-A.

SETTLING RATES FOR SILICA DUSTS IN STILL AIR

Size (μ)	Time to Fall 1 ft (minutes)
0.25	590.0
0.50	187.0
1.00	54.0
2.00	14.5
5.00	2.5

Most of the particles in airborne industrial dusts are small. Because of air currents, the fine particles in dust clouds at an operation will remain suspended in the workroom air for relatively long periods of time. The smaller dust particles, moreover, will travel farther away from their point of origin than will the larger particles so that the farther dust is from its source, the greater the percentage of small particles it contains.

Mechanism of inhalation

With the exception of such fibrous materials as asbestos, dust particles must usually be smaller than 5 μ in order to enter the alveoli or inner recesses of the lungs (see illustration of the bronchial tree in Chapter 42, "Ionizing Radiation"). Although a few particles up to 10 μ in size may enter the lungs occasionally, nearly all the larger particles are trapped in the nasal passages, throat, larynx, trachea, and bronchi, from which they are expectorated or swallowed into the digestive tract. When larger particles of certain toxic dusts are trapped in the upper respiratory passages, they can be absorbed by the body fluids in the nasal passages and in the digestive tract before they are eliminated. Hence the final toxic effects of larger dust particles may be delayed. The larger particles of irritant dusts can cause immediate effects in the upper respiratory system.

Ragweed pollen, which varies from 18 to 25 μ in diameter can cause hay fever from its action in the upper respiratory system. This type of dust and other allergenic types, as well as bacterial and irritant dusts, can cause difficulty even in the larger airborne sizes.

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In very rare cases, enough dust has been inhaled to cause mechanical blockage of the air spaces. (Flour dust has been known to cause this condition.) Some dusts may be essentially inert and remain in the lungs indefinitely with no recognizable irritation, and a few (like limestone dust) may be gradually dissolved and eliminated without harm.

Silicosis is the most important lung disease caused by the inhalation of mineral dust. It is well-known in industries where crystalline free silica dust is present, such as foundries, glass manufacturing, granite cutting, mining, and tunneling in quartz rock. It is found throughout the world, and in the past it has had many names, such as miner's asthma, grinder's consumption, miner's phthisis, potter's rot, and stonemason's disease. The same occupational disease, however, is meant by all these names, and it is caused by dust from crystalline free silica, usually quartz.

Silicosis has been defined as "a disease due to breathing air containing silica characterized *anatomically* by generalized fibrous changes and the development of miliary nodulation in both lungs, and *clinically* by shortness of breath, decreased chest expansion, lessened capacity for work, absence of fever, increased susceptibility to tuberculosis (some or all of which symptoms may be present), and by characteristic X-ray findings."*

Silicosis has been known to manifest itself after widely differing periods of exposure to silica dust. Apparently, development of the disease depends upon:

1. The amount and kind of dust inhaled.
2. The percentage of free silica contained in the dust.
3. The form of the silica.
4. The size of the particles inhaled.
5. The duration of the exposure.
6. The powers of resistance of the individual concerned.
7. The presence or absence of a complicating process such as infection.

Many theories have been advanced over the years to explain why crystalline free silica acts as it does in the lungs. It is now believed that the fibrosis produced is caused not by the hardness or sharpness of the particles, but by a combination of slight solubility with a physiochemical effect and an immunological effect—but no one is certain of the exact mechanism of the disease. Experimental work on the reasons for the development of silicosis is still going on in various parts of the world. If the precise mechanism of silicosis could be determined, better medical preventive measures might be developed and possibly a cure could be found.

Amorphous free silica differs from crystalline free silica in physical structure and in physiological effects. In the amorphous state, molecules of silica are randomly oriented and may be naturally converted to opal and diatomaceous earth (kieselguhr) or artificially converted into such forms as silica gel, silica fume, and fused silica or quartz.

If amorphous silica is heated to a high temperature, as in calcining, forms of crystalline free silica called cristobalite and tridymite result, intermediate forms of amorphous silica are known as crypto-crystalline (ultra-microcrystalline). Inhalation of these crystalline forms can readily cause diatomite pneumoconiosis.

When diatomaceous earth is calcined, particularly in the presence of a trace of alkaline flux, appreciable quantities are converted to cristobalite. As a result of studies made by the U.S. Public Health Service, it has been recommended that the threshold limit value for crude or amorphous diatomite be placed at 20 mppcf (million particles per cubic foot), but that the atmospheric concentration for dust containing cristobalite be kept under 5 mppcf.

Various commercial products containing particles of silica under 1 μ in size are available. The physiological effects of these products have not been well defined. Until more experience with human beings is available, these products should be handled with care.

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*American Public Health Association, 1790 Broadway, New York City. "Report (Joint) of the Committee on Pneumoconiosis and the Committee on Standard Practices in Compensation of Occupational Diseases." *Year Book*, 1933.

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Free silica is uncombined silicon dioxide (SiO_2). Silicates contain silicon and oxygen combined with other elements in more complex molecules. The SiO_2 reported in chemical analyses for mineral and geological reports is the *total* of the silicon dioxide present, both the free silica (if present), and the silica combined in the mineral. Such analyses are not reliable indications of the silicosis potential of the material, because it is the uncombined or free silica that is most important in industrial dust 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.

There has been some experimental evidence that some dusts may tend to inhibit the action of silica on the body, but this inhibiting action is so slight and uncertain that it must be discounted in practice. In fact, there is also evidence that the nonsiliceous components of a dust mixture containing free silica may provoke a disabling condition more severe than that caused by the silica acting alone.

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 than of free silica dust 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. However, partially disabling pneumoconioses have been reported where men have worked for long periods of time in very high concentrations of certain silicate dusts. 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, but the symptoms can be marked.

Asbestosis. Several minerals having a fibrous character are classed as "asbestos"—hydrated silicates of magnesium with variable amounts of iron, calcium, sodium, potassium, and aluminum present as impurities. The fine airborne fibers of asbestos pass through the upper respiratory tra[illegible] the lower parts of the lungs to cause [illegible]tion and to form "asbestos bodies" [illegible] the fibers are encapsulated. This [illegible] fibrosis probably begins as a "collar" [illegible] the terminal bronchioles. There is ev[illegible] that other minerals having a fibrous cha[illegible]ter (except glass fiber) can produce a [illegible]tion similar to that of asbestos.

Following a study by the U.S. P[illegible] Health Service of the asbestos textile in[illegible]try,* it was recommended that the dust [illegible]centration be kept at less than 5 mppcf [illegible] prevent asbestosis. Evaluation of an ex[illegible]sure to asbestos dust is based on the [illegible] amount of dust, since the concentration [illegible] injurious fibers will be kept within [illegible] limits if the fine dust is kept below [illegible] suggested threshold limit.

Miscellaneous pneumoconioses. E[illegible] though a dust is classified as harm[illegible] amounts above the TLV can lead to tro[illegible] by causing a pneumoconiosis, mechanic[illegible] irritating the walls of the respiratory sy[illegible] or interfering with ordinary lung proces[illegible] Mica dust and kaolin dust are two good [illegible]amples of dusts that ordinarily are con[illegible]ered benign but amounts above the TLV [illegible] cause a troublesome pneumoconiosis. [illegible] pneumoconiosis has been observed in gr[illegible]ing operations where mica dust, but no [illegible] silica was present. There were ma[illegible] changes in the X-ray pictures of the l[illegible] and some disability. The cases occu[illegible] where the dust exposures were massive [illegible] many years.

Toxic dusts and fumes

Systemic reactions are caused by [illegible] dusts and fumes of various elements [illegible] their compounds and by certain organic [illegible]pounds. All metallic fumes are irritating [illegible]pecially when freshly generated. Indus[illegible] important metals and their compounds [illegible] can have a toxic effect when the du[illegible] fumes are inhaled include arsenic, anti[illegible] cadmium, chromium, lead, manganese, [illegible]cury, selenium, tellurium, thallium, ura[illegible] and a few others.

*U.S. Public health Service, Washi[illegible] D.C. "A Study of Asbestosis in the As[illegible] Textile Industry." Bulletin No. 241. 19[illegible]