DATA SHEET 531

PLAINTIFF'S EXHIBIT

NSC-26

DUSTS, FUMES, AND MISTS IN INDUSTRY

DEPOSITION EXHIBIT

#17

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Introduction

1. Industrial dusts, mists, and fumes, their hazards and their control, are discussed in this data sheet.* The general principles presented can be applied to evaluate most industrial situations involving these air contaminants and to determine the need for controls. This data sheet is intended to guide employers, plant safety engineers, personnel managers, and supervisors.

2. A plant manager who believes that he has a toxic or irritating dust problem should consult a competent industrial hygienist. Such help may be obtained from his own company, insurance carrier, private consultants, or state health or labor agency.

3. To protect the health of employees who work where a dust, fume, or mist created by a manufacturing process is released into the atmosphere, a control program may be required. In such a case, three steps must be taken:

a. The properties of the specific dust, fume, or mist and its possible physiological effects on employees must be ascertained.

b. The particular exposure must be evaluated by dust counts or by chemical analyses of air samples, and a step-by-step analysis of the operations must be made to find the areas where employees are exposed to hazardous amounts of the material. The operational analysis also should determine how the dust, fume, or mist is dispersed.

c. Appropriate methods of control must be provided where indicated. The type and extent of controls will depend upon the physical, chemical, and toxic properties of the dust, fume, or mist, the evaluation made of the exposure, and the operation that disperses the contaminant. The extensive controls needed for lead oxide dust, for example, would not be needed for limestone dust, since much greater quantities of limestone dust can be tolerated.

This data sheet is one of a series published by the National Safety Council, reflecting experience from many sources. Not every acceptable safety procedure in this field is necessarily included. This data sheet should not be confused with American Safety Standards, federal laws, insurance requirements, state laws, rules, regulations or municipal ordinances.

4. Except for the skin diseases, most occupational diseases are acquired by inhalation of material. Lung tissue is by far the most efficient medium the body possesses for absorbing materials. In addition, the surface area of this lung tissue averages 55 square meters or about 590 square feet.

5. Certain dusts that reach the lungs can pass directly into the blood stream and be absorbed over a long period of time. Others may stay in the lungs and set up local irritant or damaging action.

6. Toxic and irritant dusts can also be ingested in amounts that may cause trouble. If toxic dust swallowed with food or saliva is not soluble in body fluids, it is eliminated directly through the intestinal tract. Toxic materials that are readily soluble in body fluids can be absorbed in the digestive system and picked up by the blood.

7. A third way in which toxic and irritant substances may enter the system is skin absorption. Many organic compounds, such as TNT, cyanides, and most aromatic amines, amides, and phenols, can produce systemic poisoning by direct contact with the skin. Contact of toxic and irritant dusts with the skin also may result in skin irritation.

8. As compared to inhalation,

*This data sheet covers toxic and irritating air contaminants encountered in industry. It does *not* include a discussion of the explosive properties of such airborne particulate matter.

23. Dust particles are, of course, attracted by gravity. Their settling rate through still air will vary with their size, density, and shape. Microscopically small 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 microns will settle out relatively fast. The estimated settling rates for silica dusts in still air are given in Table I.

TABLE I. SETTLING RATES FOR SILICA DUSTS

Size in Microns	Time to Fall 1 Foot (minutes)
0.25	590.0
0.50	187.0
1.00	54.0
2.00	14.5
5.00	2.5

24. Most of the particles in air-borne 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.

Inhalation of Dusts, Fumes, and Mists

25. With the exception of such fibrous materials as asbestos, dust particles must usually be smaller than 5 microns in order to enter the alveoli or inner recesses of the lungs. Although a few particles up to 10 microns 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.

26. 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

nated. 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.

27. Ragweed pollen, which varies from 18 to 25 microns 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 air-borne sizes.

28. When dust-laden air is inhaled, some of the larger particles are trapped by the hairs in the nose. Other dust particles are removed from the air as it passes over the moist mucous membranes of the nose, throat, and other portions of the upper respiratory system.

29. The bronchi and other respiratory passages are covered with a large number of tiny, hairlike *cilia* or microscopic whiplashes, which aid in the removal of dust trapped on these moist surfaces. The cilia, all bending in one direction, make a fast stroke toward the mouth and a slower return stroke. This action tends to push mucous and deposited dust upward to the mouth so that the particles can be expectorated or swallowed.

Retention of dust

30. Many studies have been made in an effort to determine the amount of dust that is retained in the lungs, but there is no simple answer to this question. It has been shown that the size of the dust particles, the rate of respiration, the density of the dust in the air, the efficiency of the dust-catching mechanism, and probably many other factors are involved.

Sizes of particles inhaled

31. Although an occasional dust particle of larger size will enter the lungs, particles less than 3 microns in diameter are the most likely to do so and thus have the greatest opportunity to cause a physiological reaction. In silicotic lungs, for example, dust particles under 3 microns greatly outnumber larger ones, and many particles are less than 1 micron.

32. In the case of very fine fibrous asbestos dust, an exception occurs in the size of particles inhaled. Many fibers up to 100 microns long have been found in the lungs

Figure 2. Metal volatilized by the heat of welding later condenses to form a fume. On this bench-welding installation, fumes are removed at their point of origin by a properly located local exhaust installation. (Courtesy American Foundrymen's Society)

of asbestos workers at autopsy. A typical fibrosis caused by asbestos is produced by fibers ranging from 20 to 50 microns in length, but only a few microns wide.

Physiological effects

33. The physiological reactions caused by the inhalation of air-borne particulate matter will vary with different types of dusts, fumes, and mists. The reactions include:

a. The cardiopulmonary reaction which consists of the pneumoconioses, such as *silicosis* and *asbestosis*. In certain cases, specific types of lung pathology result, and the heart may be affected (cor pulmonale) when the fibrosis is advanced. In other cases, there is mainly just an accumulation of a relatively inert dust in the lungs.

b. The systemic reactions which are caused by toxic dusts of such elements as lead, manganese, cadmium, and mercury, by their compounds, and by certain organic compounds.

c. Metal fume fever which results from the inhalation of finely divided and freshly generated fume of zinc or possibly of magnesium or of their oxides. This is a transient condition.

d. Allergic and sensitization reactions which may be caused by inhalation of, or skin contact with, such materials as organic dusts from flour, grains, and some woods and dusts of a few organic and inorganic chemicals.

e. Bacterial and fungus infections which occur from inhalation of dusts containing active organisms, such as wool or fur dust contain-

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.)

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†
Kaolin	A type of clay composed of mixed silicates and used for refractories, ceramics, tile, and stoneware.	50 mppcf†
Mica	A large group of silicates of varying composition, but similar in physical properties. All have excellent cleavage and can be split into very thin sheets. Used in electrical insulation.	20 mppcf†
Portland cement	Fine powder containing compounds of lime, alumina, silica, and iron oxide. Used as construction material.	50 mppcf†
Silicon carbide (Carborundum)	Bluish-black, very hard crystals. Used as abrasive and refractory material.	50 mppcf†
Talc	A hydrous magnesium silicate used in ceramics, cosmetics, paint, and pharmaceuticals, and as a filler in soap, putty, and plaster.	20 mppcf†
Vermiculite	An expanded mica (hydrated magnesium-aluminum-iron silicate). Used in lightweight aggregates, insulation, fertilizer, and soil conditioners, as a filler in rubber and paints, and as a catalyst carrier.	50 mppcf†

†Threshold limits given for substances in "Silicates" group are for compounds containing *less* than 1 per cent crystalline silica. For compounds containing more than 1 per cent silica, calculate threshold limit from formula: $\frac{250}{\%\ SiO_2 + 5}$

ing anthrax spores or wood bark or grain dust containing parasitic fungi.

f. Irritation of the nose and throat, which is caused by acid, alkali, or other irritating dusts or mists. Some dusts such as soluble chromate dusts may cause ulceration of the nasal passages or even lung cancer.

g. Damage to internal tissues, which may result from inhaled radioactive materials such as radium and its daughter products and from other radioisotopes that emit highly ionizing radiation.

Pneumoconioses

34. *Pneumoconiosis* comes from three Greek words that mean "lung," "dust," and "abnormal condition." The present generally accepted meaning of the word is merely "dusty lung." The kind of dust inhaled determines the type of condition or injury. A number of organic dusts are capable of producting lung diseases, but not all these diseases are classified as pneumoconioses because they are not all a "dusty condition" of the lung.

35. In very rare cases, enough dust had 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

36. The most important lung disease caused by the inhalation of mineral dust is *silicosis*—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 (see Table II).

37. Although considerable progress has been made in dust control in industry, men still develop silicosis in plants and on jobs where dust control is not adequate. Engineering control is still the basic means of preventing this disease, and dust control equipment and procedures must be carefully maintained.

38. *Definition*. Silicosis has been defined as "a disease due to breathing air containing silica (SiO_2) characterized *anatomically* by generalized fibrotic 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."*

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

a. The amount and kind of dust inhaled.
b. The percentage of free silica contained in the dust.
c. The form of the silica.
d. The size of the particles inhaled.
e. The duration of the exposure.

*"Report (Joint) of the Committee on Pneumoconiosis and the Committee on Standard Practices in Compensation of Occupational Diseases." *Year Book*, 1933. American Public Health Association, 1790 Broadway, New York 19, p 100.

physiological effects of these products have not been well defined. Until more experience with human beings is available, it is believed these products should be handled with care.

57. *Free silica and silicates.* Free silica is uncombined silicon dioxide (SiO_2). Silicates contain silicon and oxygen combined with other elements in a more complex molecule. Analyses of minerals, particularly in geological reports, are sometimes reported as percentages of oxides, which may include SiO_2, Al_2O_3, K_2O, Fe_2O_3. The SiO_2 reported in such chemical analyses 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.

58. It is 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.

59. 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 also is 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.

60. 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.

61. 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 he 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.

62. 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.

63. 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 within threshold limit values or below (Table II).

Asbestosis

64. 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.

65. 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.

66. These facts lead to the conclusion that asbestosis is mainly the result of physical irritation of the lung tisssue 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. However, there is no impressive amount of evidence to support this assumption.

67. The fine air-borne fibers of asbestos can pass through the upper respiratory tract to the lower parts of the lungs to cause irritation and to form "asbestos bodies" where the fibers are encapsulated. This diffuse fibrosis probably begins as a "collar" about the terminal bronchioles. There is evidence that other minerals having a fibrous character can produce a reaction similar to that of asbestos. Fiber glass, however, does not produce such a reaction.

68. Following a study by the U. S. Public Health Service of the asbestos textile industry,* it was recommended that the dust concentration be kept at less than 5 mppcf to prevent asbestosis. Evaluation of an exposure to abestos dust is based on the *total* amount of dust because it has proved out in practice that if the fine dust is kept below the suggested threshold limit, the concentration of injurious fibers will also be kept within safe limits.

Talcosis

69. As used in industry, "talc" is a very general term. To the geologist, talc is a hydrous magnesium silicate, which may be a relatively pure mineral or may be mixed with tremolite or with dolomite depending upon where it is mined. The term "talc" is applied commercially to carbonate mixtures that have the same general feel and physical properties; it also is applied to pyrophyllite, a hydrous aluminum silicate, which frequently is mixed with a high percentage of quartz. The free silica generally found with pyrophyllite can cause silicosis. It is therefore essential to know which talc is being used in order to evaluate a specific dust exposure.

70. *Talcosis* is usually associated with tremolite talc. This disease produces changes in the lungs and symptoms similar to those of asbestosis.

Anthracosilicosis

71. *Anthracosilicosis*, a complex form of pneumoconiosis, is a chronic disease caused by breathing air containing dust that has free silica as one of its components and that is generated in the various processes involved in mining and preparing anthracite (hard coal)** and, to a lesser degree, bituminous coal.

72. The disease is characterized anatomically by generalized fibrotic changes throughout both lungs and by the presence of excessive amounts

*Dreesen, W. C., Dalla Valle, J. M., Edwards, T. I., Miller, J. W., and Sayers, R. R., *A Study of Asbestosis in the Asbestos Textile Industry*, U. S. Public Health Bulletin No. 241, U. S. Public Health Service, Washington 25, D. C. 1938.

***Anthracosilicosis among Hard-Coal Miners*, U. S. Public Health Bulletin No. 221, U. S. Public Health Service, Washington 25, D. C., 1935.

TABLE III. SELECTED TOXIC DUSTS AND FUMES (Continued)

Substance	Description and Effects	Threshold Limit in Milligrams per Cubic Meter of Air*
Manganese	Silvery gray metal. Hazardous from inhalation of fumes or dust.	5.0
Pentachlorophenol	Dark-colored flakes. Harmful dust. Emits toxic fumes when heated.	0.5 (skin**)
Phosphorus (yellow)	Poisonous mainly by inhalation. Severe burn hazard from skin contact.	0.1
Picric acid	Yellow crystals or liquid. Explosive—particularly metallic salts. Emits toxic fumes on decomposition.	0.1 (skin**)
Selenium compounds	Toxicity varies somewhat according to the solubility of the specific compound. Often causes contact dermatitis.	0.1
Sodium hydroxide	White, deliquescent pieces or lumps. Has severe action upon all body tissue.	2.0
Tellurium	Similar to selenium chemically and in physiological effects.	0.1
Titanium dioxide	White to black powder. Considered in the nuisance category.	15.0
Trinitrotoluene	Colorless to yellow monoclinic crystals. Emits toxic fumes of oxides of nitrogen when heated to decomposition. Highly poisonous explosive.	1.5 (skin**)
Uranium	Highly toxic and a radiation hazard that requires special consideration.	0.05 (soluble compounds) 0.25 (insoluble compounds)
Vanadium pentoxide	Yellow to red crystals. Acts chiefly as an irritant to the conjunctiva and respiratory tract.	0.5 (dust) 0.1 (fume)
Zinc oxide fume	Amorphous white or yellow powder. The powder is essentially nontoxic, but freshly generated fume may cause metal fume fever.	5.0
Zirconium compounds	Most compounds are insoluble and have low toxicity.	5.0

*These threshold limit values were adopted by the American Conference of Governmental Industrial Hygienists in 1962.

**The word "skin" in this table indicates that the substance can penetrate the skin to contribute to the exposure.

of the individual, may be alarming in a general X-ray screening program. On clinical examination of individuals showing the X-ray markings, however, often no disability or symptom can be found.

81. These shadows are frequently encountered when the dusts contain atoms of relatively high molecular weight because the heavier atoms are fairly opaque to X-rays. Insoluble barium dusts and tin oxide dusts, for example, can show very marked shadows on X-ray films without producing signs of significant pathology (barium dust that is soluble in the body fluids can give a toxic reaction).

82. Iron oxide, particularly excessive fume from welding operations, may produce *siderosis* with a pigmentation of the lungs (black in welders and red in iron ore miners) without disability. The X-ray shadows produced by the iron oxide in the lungs are somewhat similar to the shadows from silicosis. Because of this similarity, differential diagnosis is often difficult, and heavy exposures to iron oxide dust and fume may lead to medicolegal problems. It is therefore important to control iron oxide exposures even though siderosis is not disabling.

83. Limestone, marble, lime, gypsum, and portland cement dusts apparently have no serious effect even after long exposures. Also, many silicates and other minerals have not caused impairment in individuals inhaling the dusts, and the resulting pneumoconioses are generally classed as benign.

Toxic Dusts and Fumes

84. Systemic reactions are caused by toxic dusts and fumes of various elements and their compounds and by certain organic compounds. All metallic fumes are irritating, especially when freshly generated. Industrially important metals and their compounds that can have a toxic effect when the dust or fume is inhaled include arsenic, antimony, cadmium, chromium, lead, manganese, mercury, selenium, tellurium, thallium, uranium, and a few others.*

85. The effect of some metals, such as magnesium and zinc, appears to be transient. Only limited data are available on the exotic and rare earth metals.

86. Although the dusts and fumes from metals with low toxicity do not need as much attention as the dusts and fumes from highly toxic metals, they should not be neglected or disregarded. The metals with low toxicity are controlled more readily because greater amounts can be tolerated, but their dusts and fumes should be kept at reasonable levels since excessive amounts of any of them can be harmful (Table III).

Lead poisoning

87. Although extremely severe cases of lead poisoning are rare in industry today, lead exposures must be controlled to prevent even the moderate symptoms, which can be

*See the following National Safety Council Data Sheets: *Antimony and Its Compounds*, 408; *Arsenic and Its Inorganic Compounds*, 499; *Cadmium*, 312; *Lead*, 443; *Magnesium*, 426; *Manganese*, 306; *Mercury*, 203; *Titanium*, 485; *Zinc and Zinc Oxide*, 267; *Zirconium Powder*, 382.

fections from the inhalation of bacteria and fungi exists in several industries. Pulmonary anthrax from the inhalation of dust containing anthrax spores has occurred among employees engaged in the handling of wool and the crushing of bones from infected animals.

105. Fungi (molds) growing on grain have been found in sputum of workmen shoveling the grain and are believed to be the cause of outbreaks of respiratory disorders. Fungi found in sugar cane residues (bagasse) are believed to be part of the cause of *bagassosis*. Fungal spores formed under the bark of some trees have been blamed for respiratory difficulties among employees who debark dry logs.

106. Although the incidence of occupationally related bacterial and fungal infections is found to be relatively low, the respiratory effects can be troublesome and, in the case of pulmonary anthrax, even fatal. The basic methods of control are the same as those for the pneumoconiosis producing dusts, but sterilization and disinfection must be added.

Radioactive Dusts*

107. A radioactive contaminant may offer a chemical toxicity hazard in addition to an ionizing radiation exposure, and it may be present as a gas, dust, fume, or mist.

108. Radioactive contaminants taken into the body may be deposited in various organs where they constitute sources of internal radiation. The chemical characteristics of the radioactive contaminant or isotope determine the organ in which it will be deposited. The excretion rate is also dependent upon the chemical nature of the isotope, because the radioactive isotopes of an element follow the same metabolic process as do the stable isotopes of that element.

109. If a radioisotope has been deposited in the body, the internal exposure is regarded as continuous until the isotope is lost by radiological or biological decay. In some cases, exposures may last a lifetime.

110. Since radioisotopes are selectively taken up in individual organs, they may cause only localized irradiation. The radiosensitivity of the organ dictates the extent of the hazard of a particular radioactive substance. Solubility and particle size determine how much of the active material will gain access to and remain in the blood stream and various organs.

111. If radioactive air-borne contamination is known to be present, control measures are mandatory. If the presence of contamination is unknown but suspected, sampling must be done to determine whether or not air-borne concentrations of the radioisotope are below the threshold limit value.

112. Good personal hygiene and good operating techniques are much more important in the handling of radioactive materials than in the handling of most other materials used in industry.

113. Engineering controls for radioactive dusts are similar to those for other dusts and depend primarily upon capture at the point of generation. The difference lies in the fact that controls for radioactive dusts must be extremely efficient. Threshold limit values for radioactive particulate matter are very low, and in some cases 100 per cent efficiency in capture and retention is required.

Permissible Dustiness

114. Threshold limit values of mineral dusts and toxic dusts—that is, time-weighted average concentrations considered permissible for exposures of eight hours per day, five days per week—have been published by the American Conference of Governmental Industrial Hygienists. These values have been obtained from the experience of many groups in industry and from laboratory studies on animals. They are reviewed annually and changed as necessary on the basis of experience.

115. These values are set only as guides for the best practice and are not to be considered absolute values. There is reasonable assurance that occupational disease will not occur if exposures are kept below these levels. On the other hand, occupational disease is likely to develop in some people if the recommended levels are exceeded consistently.

116. The currently recommended threshold limits of particular dusts can be found in the most recently published ACGIH list, or the ACGIH can be consulted directly. Information on threshold limits also can be obtained from the National Safety Council, state occupational health agencies, the American Industrial Hygiene Association, and compensation insurance carriers.

117. No one knows the exact concentration at which men will start to develop silicosis, asbestosis, or lead poisoning. With some toxic dusts, however, experience has been wide enough to establish the present threshold limits as fairly reliable.

118. For example, if the level of lead in a workroom is kept below 0.2 mg/cu m, experience has shown that cases of lead intoxication will not occur. Experience also has shown that many men can tolerate lead levels well above 0.2 mg/cu m without signs of trouble.

Mineral dusts

119. In the United States, the threshold limits for mineral dusts are expressed in millions of particles per cubic foot of air (mppcf). The concentration of a mineral dust is determined by counting dust particles that are less than 10 microns in size in an aliquot sample after sampling a known volume of air in a known volume of liquid. In some European countries, mineral dusts are weighed, and permissible levels are expressed as milligrams of dust per cubic meter of air (mg/cu m). In England and some other areas, the number of particles per cubic centimeter is the current basis of measurement.

120. In comparing United States and foreign dust counts, it is helpful to keep in mind that 100 particles per cubic centimeter is equivalent to approximately 3 million particles per cubic foot.

121. It is difficult to compare dust counts with results obtained on the basis of weight. However, with either type of measurement, a threshold limit can be set as an objective. Experience has shown that maintaining dust levels below the recommended threshold limits has resulted in a great decrease in the incidence of occupational diseases.

122. Threshold limits are based on the percentage of free silica where this substance is the impor-

*For a detailed discussion of radioactivity and an extensive bibliography, see the chapter entitled "Ionizing Radiation" in the *Accident Prevention Manual for Industrial Operations*, published by the National Safety Council.

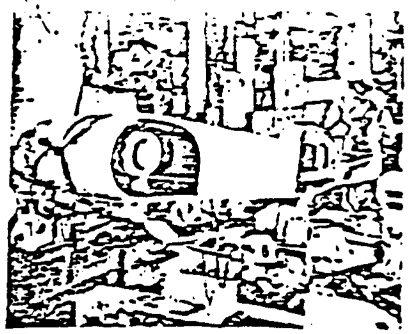

Figure 4. Since this swing-frame grinder is used in a variety of positions, the local exhaust system must be adjustable. The flexible duct (A) permits movement of the exhaust hood (B) as needed. (Courtesy American Foundrymen's Society)

nevertheless, should not be considered as a universal substitute for adequate local exhaust removal, elimination of the contaminant, or containment.

129. 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.

130. Each type of exposure must be considered separately. For example, a local exhaust system suitable for welding or cutting of steel might not be satisfactory for welding or cutting steel coated with red lead.

Local exhaust systems

131. 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. The system should be designed to enclose the process as completely as possible. This method usually is preferred to general ventilation, but should be used only when the contaminant cannot be controlled by isolation, process revision, or substitution of less harmful materials. Even though a process has been isolated, it may still require a local exhaust system.

132. A local exhaust system consists of four principal parts:

a. Hoods or other inlets, into which the air-borne 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.

133. While each of these parts should be designed and installed to perform its required function with respect to the system as a whole, 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 the shape of the hood or degree of enclosure, the location of the hood and its distance from the dust source, and the rate of flow of air into the hood. A poorly designed hood can make an exhaust system ineffective.

134. There is no standard hood. In every case, the hood must be designed to fit the specific operation and to make the exhaust effective without interfering with the operation (Figure 4). Among the factors to be considered are the natural air currents in the room and other exhausts or windows in the area.

135. 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 (Figure 5) because the velocity of the air in the zone of the hood influence is inversely proportional to the square of the distance from the face of the hood.

136. The hood opening, or part of it, should be located so as to receive directly dust that is thrown off along a well-designated path (Figure 6). The directional energy of the material can thus be used for its own capture. Air movement must always be past the employee, then over the dust source, and directly into the face of the hood.

137. 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.

138. Enough air must be supplied to the room from the outside to replace the air that is removed by the exhaust system. Otherwise, there will be interference with other exhaust systems in the area or with gas or oil flames in nearby furnaces. Great difficulty has occurred where an exhaust system caused a slightly negative pressure in a room containing a gas furnace. As a result air came down the furnace flue, and the area became contaminated with carbon monoxide from the furnace.

139. With small exhaust systems, air that is removed usually can be replaced by infiltration flow, but larger exhausts may need a positive air supply (Figure 7). An adequate supply of make-up air, tempered when necessary, is one of the most frequently overlooked fundamentals of ventilation. Air always should be supplied in quantities equal to or slightly in excess of the amounts exhausted.

140. The size of the ducts, the type and size of the dust collectors, and the type and size of the fan and motor (explosion-proof where necessary) are among the other factors which must be considered in the design of an exhaust system. Preventing ignition of a combustible

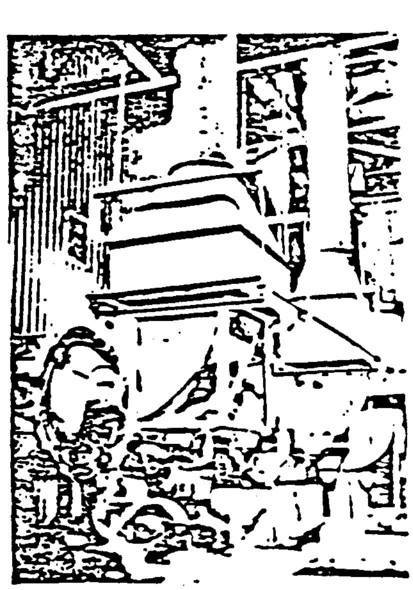

Figure 5. To achieve the proper exhaust air velocity, the hoods for these barrel furnaces can be positioned as close to the furnace spouts as practical. Such positioning is made possible by mounting the hoods on a trolley suspended from an overhead track. (Courtesy American Brake Shoe Co.)

hygiene should not be overlooked. The periodic medical examinations provide a good opportunity for instruction of employees in various personal hygiene measures.

157. Good washing facilities, clean lunchrooms, and clean work clothes can help prevent additional, even though minor, exposure to toxic materials. Also, contaminated work clothes should not be taken home where a toxic dust could contaminate the home or expose other members of the family. These recommendations become mandatory where such materials as beryllium and radioisotopes are handled.

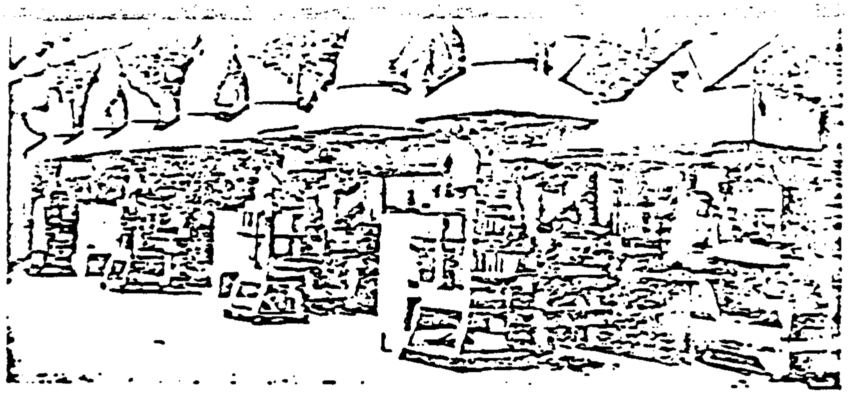

Figure 7. In this foundry, local exhaust hoods are installed over each station having a shell-molding machine and glue press. Adequate make-up air is supplied from ventilating duct situated between molding machines and presses. (Courtesy American Foundrymen's Society)

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- No. 426, *Magnesium*
- No. 306, *Manganese*
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