Courtesy M. S. A. Co.

FIG. 1. THE MIDGET IMPINGER USED FOR COLLECTING ATMOSPHERIC DUST SAMPLES.

Industrial Hygiene Importance of Dust

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Nearly all types of modern industry are concerned with dust and its control.

THE annual cost to industry from uncontrolled dust amounts to a staggering figure. In many cases the problem of dust is dismissed by management as only a nuisance. In other plants, the recovery of certain dusts is economically sound, especially where the particulate matter may contain precious metals or may carry valuable processing stock. Aside from any nuisance or economic loss resulting from the escape of dust there are certain dust exposures which may result in acute health hazards. This is especially true of dusts containing a high percentage of free silica, asbestos, or other toxic materials. Where health considerations are involved in such exposures, legal aspects present themselves. In most states where occupational diseases are compensable, specific coverage is given to those disabilities resulting from the inhalation of silica dust.

Definitions

Many times true dusts are confused with fumes, smokes, mists, and fogs. In order to differentiate between the origin of these materials, a definition of them is in order.

DUSTS are formed by the reduction of earthy materials and are usually produced by such operations as crushing, grinding, buffing, etc. The particle size of dusts may vary considerably, ranging from sub-microscopic to visible.

FUMES are formed by condensation and sublimation. Chemically, they are metallic and are usually the oxides of such metals as zinc, and lead. The particle size is usually below one micron.

Smoke comes from the burning of organic material and its particle size is usually less than one-half micron.

Mists and **Fogs** result from the condensation of water vapor on suitable nuclei, and the particle size will vary with given conditions.

General Properties

As a substance is reduced in particle size, there are certain general properties of the material which are changed. On breaking up a solid into finely divided particles, the surface area is greatly enlarged and therefore the space occupied is greatly increased. As an example, a piece of quartz one centimeter on each side when crushed to where the particles of one micron in size will present a system containing 10^{12} number of particles. The total surface area will be 6 square meters. If these dust particles are dispersed onto the atmosphere in such manner that the concentration will be 100 million particles per cubic foot, the space occupied by this dispersed system will be 10 thousand cubic feet.

The chemical activity of a solid is considerably increased by a reduction in particle size. Thus the rate of oxidation is increased as is evidenced by occasional disastrous dust explosions. The phenomena of adsorption becomes more important as gases are more easily adsorbed on the surface of the smaller particle.

From the standpoint of health hazards resulting from dust exposures, the physiological properties of dust vary somewhat with the particle size. It is an accepted fact that with exposures to silica dust, the smaller the particle size, the greater the hazard.

Physiological Response

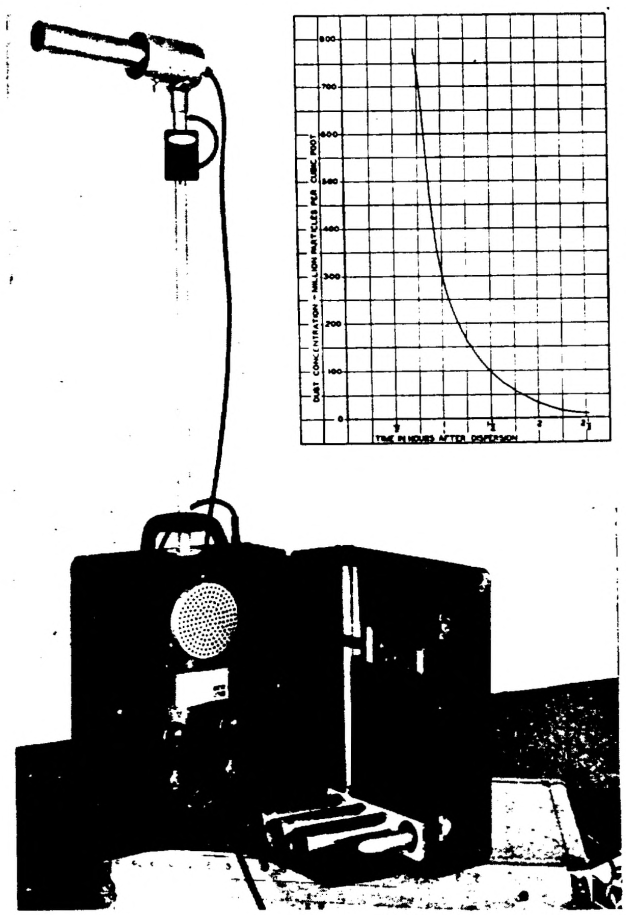
Drinker has summarized the reactions resulting from the inhalation of dust by classifying the response into four groups. These are:

(a) **Pneumoconiosis**—The dusts producing this type reaction are harmful only when inhaled. The principal materials producing this type reaction are free silica and asbestos dust. On inhalation, these two materials produce specific lung pathology and from the standpoint of disability, present the most important of the dust exposures.

(b) **Toxic Reaction**—(As poisoning by lead, cadmium or radium) These materials produce harmful effects when taken into the body both by inhalation and ingestion. With reference to lead and its compounds which may be present in the atmosphere as particulate matter, it has been fairly well established that entrance into the body by inhalation is more important mode of entry than the same material taken by mouth. This is primarily due to the fact that when such materials are taken into the body by inhalation, the major portion is taken into the blood stream, whereas, a considerable part of that taken by mouth is removed by certain organs of the body.

(c) **Metal Fume Fevers**—These conditions result from the inhalation of finely divided fume particles. The importance of metal fume fever has been brought to the attention of industry by the great amount of welding which has been an important industrial tool for the past few years. Where burning or welding is done on surfaces which have been galvanized, the problem of metal fumes becomes immediately important.

FIG. 2. THE ELECTROSTATIC PRECIPITATOR AS USED FOR COLLECTING ATMOSPHERIC SAMPLES OF DUST AND FUMES. INSERT SHOWS RATE OF SETTLING OF DUST.



This is also a problem in foundries where the pouring of brass is done.

(d) **Allergy**—This type reaction is in general produced by pollen and certain organic dusts.

Common Industrial Dusts

Carbonates are usually combined with either calcium or magnesium. They normally occur in nature as calcite and magnasite or as dolomite, which contains both magnesium and calcium as the carbonate. Limestone and marble contain considerable amounts of these carbonates, as do the materials from which cement is made.

Due to the solubility in body fluids, these materials are removed when taken into the body by inhalation. The presence of carbon dioxide in such fluids is an important factor influencing their solubility. The same thing applies to the presence of carbon dioxide in water which comes into contact with these materials. In the presence of carbon dioxide the carbonate is converted to the more soluble bicarbonate, thus adding to the ease with which it is removed by solution.

Experimental and practical observations on carbonate dust indicate that these materials are not harmful when taken into the body by inhalation. This is probably due to the fact that they are easily removed due to their solubility.

Sulfates are common industrial materials and this general class may be illustrated by gypsum, which is calcium sulfate. This is a common material and is widely used in many industrial operations. It is generally considered that this type material is non-toxic and does not present any particular problem from a health standpoint.

Oxides vary considerably in their physiological reaction. In general the nature of the reaction will be dependent on the type metal from which the oxide is derived. Where such metals are specifically toxic, as would be the case with arsenic or lead, a specific toxic reaction could be expected from the inhalation of the oxide. However, other oxides appear to be relatively harmless, particularly where the metal is of a non-specific type. This is true of iron oxide. The mining of iron results in the exposure of a great number of men to the oxides of

FIG. 3. GEORGIA KAOLIN DUST MAGNIFICATION 130X.

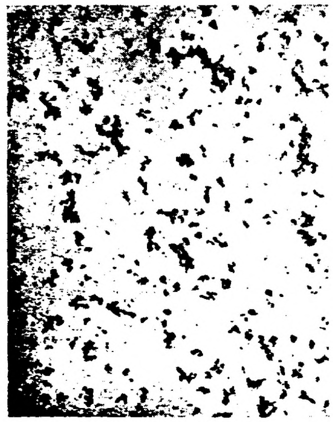


FIG. 4. QUARTZ DUST (SiO_2) MAGNIFICATION 130X.

FIG. 5. CALCIUM CARBONATE DUST MAGNIFICATION 130X.

this metal. However, it appears that exposure to the dust of iron does not produce pathology unless such exposure is accompanied by the pressure of free silica.

The mining of coal results in exposure to coal dust which contains a high percentage of carbon. Detailed studies of exposure to coal dust have been made by the U. S. Public Health Service and other agencies. It has been found that in general, coal dust is retained in the lungs only when such dust contains a high percentage of free silica. Although coal dust may be deposited in the lungs of exposed individuals, the condition resulting is usually not considered disabling unless silica is present.

Silicates make up an important class of industrial materials and are used principally in the production of ceramics and similar materials. Talc, kaolin, mica, clays, etc., are chemically silicates and their widespread industrial application results in a great number of employees being exposed to this type dust. With the exception of asbestos, which is a silicate, this general class of materials does not appear to produce a disabling condition, except in isolated cases, when taken into the body by inhalation.

Asbestos is the only silicate known at the present time which produces a lung pathology comparable with that resulting from exposure to silica dust.

Of all the dust found in industry probably the most important is the silica or silicon dioxide. It occurs in the form of quartz, flint, sandstone, and chert; and is associated with many other minerals and ores. The disabling condition resulting from the inhalation of free silica is known as silicosis and has long been a problem with industries such as stone cutting, granite, foundry, abrasive, and the like, where silica is used in processing. There are relatively few industrial operations which might result in direct exposure to pure silica dust. The importance of silica lies in its association with other materials. As an example, in foundry operations the dust generally will contain clay and materials of a nonsilicious character, so that the actual percentage of free silica may be relatively low. This is also true in exposures to coal, iron oxide, and the mining of ores. When hard rock or silica is present, these dusts become important mainly due to the presence of silica rather than to the inherent properties of the parent material.

Factors Influencing Hazards

In evaluating the exposure to a dust there are several factors which should be taken into consideration. The duration of exposure is important, as it will indicate in a general way the total amount of dust which might be expected to have entered the body. Obviously other factors enter into such an evaluation of total dustiness, and these will be discussed later. History of past exposure is important. This is particularly true where an individual is exposed to silica dust. This point is of extreme importance to industry due to the fact that a worker may have contracted silicosis under a previous employment. Where such a condition exists, the desirability of preemployment examination is obvious.

The concentration of dust breathed is important as this, within certain limits, will determine the possibility of development of dust diseases. Considerable research and practical observations have been made in the field of dust exposures to correlate clinical findings with atmospheric concentrations. For free silica, asbestos, and some of the other materials, fairly definite standards have been established. The nature of dust is important primarily from the standpoint of free silica content. This is particularly true of mixed dusts which constitute the majority of industrial exposures. The volume of air breathed enters into the picture as it directly influences the amount of dust which will be taken into the body. The rate of respiration or amount of air breathed in general will be determined by the physical effort required on the particular job. Where heavy work is being done, naturally an individual will require more ventilation than where less physical effort is involved.

Dust Measurements

In addition to the factors influencing dust hazards, it is necessary to make direct dust measurements in order to obtain a true evaluation of any dust exposure. Such measurements are made by the actual collection of dust samples, the counting of the dust particles, and by the identification of the materials making up the dispersed system. For the collection of dust samples, several instruments may be employed.

Much of the early work done on the control of silicosis in the mining areas of South Africa was carried out with the Konimeter. This instrument has been used some in this country, however, it has not met with the popularity which is enjoyed by certain other methods. From the standpoint of collecting efficiency, the electrostatic precipitator is probably the choice instrument, however, most of the work done on correlating atmospheric dust concentrations with medical findings has been based on samples collected and counted by the Greenburg-Smith technique. The collecting device employed is an impinger unit which samples at the rate of one cubic foot per minute.

Counting by this technique is done under light field. The percentage of free silica in a dust sample is usually determined by either chemical or petrographic methods.

Permissible concentrations of dust have been established for free silica, asbestos, and other materials. For both silica and asbestos, 5 million particles per cubic foot is considered as maximum working concentration. The U. S. Public Health Service has suggested a procedure by which the total dust concentration in millions of particles per cubic foot is multiplied by a percentage of free silica. If the resulting figure is more than 5 million particles per cubic foot, the condition is considered unsafe. If less than 5 million, the condition is considered safe. There should be considered certain limits of dustiness for any type of dust, whether it be merely a nuisance value or health consideration. To most industrial hygienists, 50 million particles per cubic foot is the maximum atmospheric concentration of dust under which an employee should work. It should be pointed out that the only way of determining both the nature of the dust and the actual concentration is by direct sampling and similar procedures for the counting of dust.

Case History

MANY industries having problems of dust control recognize the existence of such problems to varied degrees. Some take passive attitudes, while others apply sound engineering procedures which result in a real job of dust control. Such modern engineering methods are used by the LeTourneau Company of Toccoa, Georgia.

This particular plant manufactures heavy road grading equipment and its major dust problem lies in operation of a foundry for the protection of basic steel parts. It is interesting to note that this Company considers the control of dust as a part of the general overall production schedule and as a result has its control methods integrated into general plant operations.

Although there are several methods which can be used for control of dust, ventilation, both in the form of general and local exhaust, probably offers the most satisfactory method and it is this approach which has been used by the LeTourneau Company. For general ventilation in the foundry, two 15-foot fans are installed which handle 500 thousand cubic feet per minute each. Actually, the material removed by these fans is made up principally of smoke rather than true dust.

Two electric arc furnaces are operated and these are equipped with roof fans located immediately above the units. These fans handle 60 thousand cubic feet per minute each. Again, the major portion of the material coming from the arc furnaces is smoke rather than true dust, and comes from the alloy and flux material charged into the furnaces.

A problem of dust control in any foundry is the shakeout operation. This is particularly true where shakeout is mechanical and handled on a vibrating screen or grate. Here, a line conveyor system is used to bring the castings directly to the shakeout grate. A canopy type hood is installed immediately over the grate itself. In addition to canopy, side enclosures are provided which prevent air leakage. The fan serving this hood delivers 35 thousand cubic feet per minute, which results in a high capturing velocity at the entrance and discharge ports. An excellent job of dust control results on this particular operation.

Sand conditioning in many foundries is a dusty job. With the LeTourneau Company this is handled by means of local exhaust ventilation and three bag type filters handling 6 thousand cubic feet per minute each. Tumbling operations for cast cleaning are also provided with local exhaust ventila-

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FIG. 6. LOCAL EXHAUST ON TUMBLERS FOR CAST CLEANING.

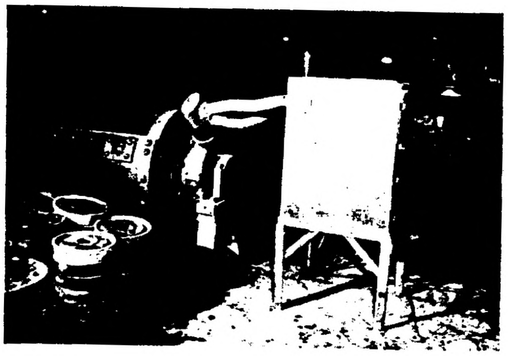
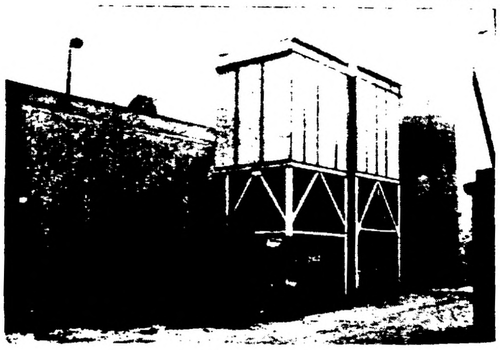


FIG. 7. BAG HOUSE AND SAND BLAST UNIT FOR CAST CLEANING.

Courtesy LeTourneau Co



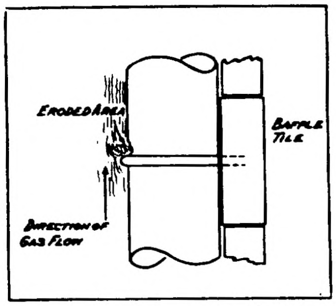


FIG. 3

at least 75%. Figure 2 shows the condition of the tube that failed.

Other tubes were found eroded adjacent to U bolts holding baffle tiles. The U bolts provided sufficient interruption in gas flow to cause eddy currents and localized impingement. (Fig. 3.)

Erosion by particles of fly ash and unburned fuel has also been found in stoker-fired boilers.

At the time of each shutdown for cleaning and preventitive maintenance (at least once every four months), all areas vulnerable to erosive attack should be examined. Areas most susceptible are:

1. Where flow of gases makes a turn, throwing out particles of solids.
2. Behind any cracks, breaks, or gaps in a gas baffle.
3. Adjacent to any projection that might divert normal flow of gases.

Should the boiler be provided with an induced draft fan, observe the condition of the blading. Abnormal wear may be indicative of erosive attack in the boiler.

Careful attention by all engineers to the problem of erosion may well prevent a serious accident.

in the plant.

The modernization program of the Brock Candy Company is taking place at a time when almost any product, regardless of quality or cost, can be sold. The real bottlenecks today are shortages of raw materials and skilled personnel. However, progressive businessmen know that these conditions are only temporary and that within a few years, companies which cannot guarantee quality will not be able to sell their products. The Brock Candy Company will continue to be a leader in its field because it has refused to sacrifice quality of its products in these days when consumer demands are greater than the supply of raw materials and because it has already inaugurated a program of control and research which will result in constant improvements.

Candy Making

(*Continued from page* 60)

not be taken for granted, a chemical laboratory is essential.

The Brock Candy Company is now in the process of constructing a modern chemical laboratory and training a technician to perform control analyses. The laboratory, which is located in a large air conditioned room near the candy cooking operations, is equipped with modern stone-topped laboratory benches, the latest chemical glassware, and such special analytical instruments as balances, vacuum oven, refractometer, and pH meter. Provision has been made for such analyses as moisture, invert sugar, viscosity, pH, melting point, and refractive index. Many of the control tests have been developed specifically for the Brock Candy Company, and new procedures will be added from time to time as the need arises.

The Industrial Research Institute of the University of Chattanooga has cooperated with the Brock Candy Company in selecting the equipment, outlining and developing analytical procedures, and training a technician to operate the control laboratory. A research project on improvement of the quality of candy has been sponsored by the Brock Candy Company at the Industrial Research Institute of the University of Chattanooga.

Since all raw materials will be analyzed and tested in the company laboratory, variation in properties will be detected before the material is used. This procedure will assure products of uniform quality, since inferior raw materials will be discarded and formulations will be based on the actual analysis of high grade raw materials rather than on standard procedure which do not make allowance for variation in the ingredients. Analysis and testing will assure high quality of finished products and permit any difference in quality to be detected. In this way, any unavoidable errors in manufacture can be corrected and adequate controls instituted to prevent their reoccurrence.

The facilities of the control laboratory will also be available for the evaluation of research and development work being carried out in the factory. In addition to maintaining the production of uniform high quality products, the personnel and equipment of the control laboratory will be available for many other technical assignments

Dust

(*Continued from page* 64)

tion and dust arrestors as is shown in the photograph. Note that exhaust is applied through the trunnion of the tumbler.

In foundry operations or any other industrial type processing, housekeeping is an important factor influencing the generation of dust. This foundry employs two five horsepower vacuum cleaners for floor maintenance. By this procedure loose dust, sand, and the like, is removed from the floor and is not projected into the atmosphere by the movement of machinery, scuffing of feet, and the like. This is one impressive point in the operation of this particular foundry. Excellent housekeeping is combined with a good procedure for materials handled.

In all of the attempts at dust control at the LeTourneau Company, employee cooperation is obtained. Employee cooperation comes through planned program of employee education and employee participation in affairs involving the health of the worker.

Periodic dust samples collected in the LeTourneau foundry indicate atmospheric concentrations on various operations well below what is considered as maximum safe working limits.