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DUST

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This pamphlet is a compilation of experience. It must not be confused with Federal, State or insurance requirements.

General Statement

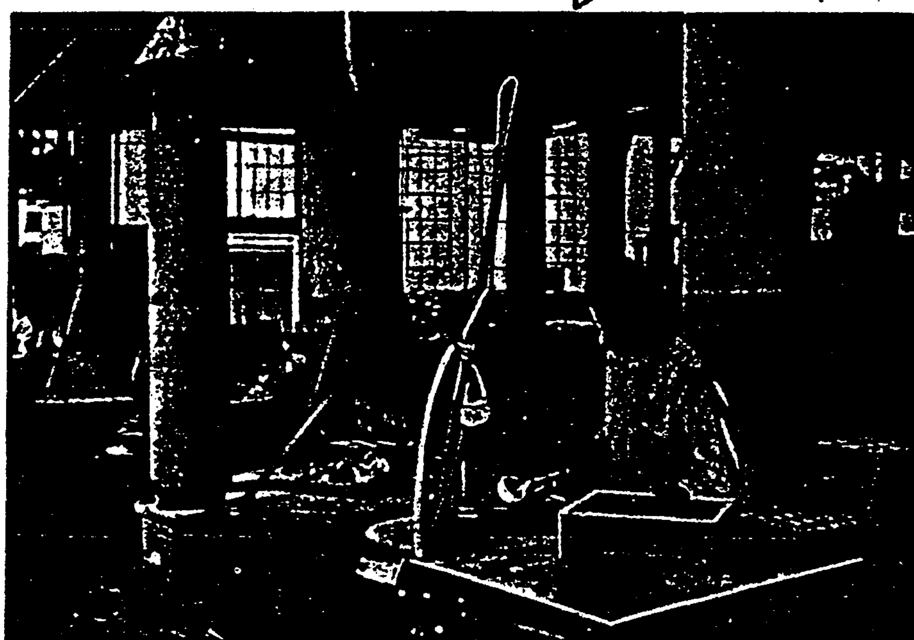
There is a definite relationship between dust and occupational disease. In industrial processes, dust may be responsible for the occurrence of various types of intoxications (lead poisoning) and infection (anthrax).

The chemical composition of dust may be of more importance than the weight and number of individual particles composing it. This seems particularly true of dust containing poisonous substances and infectious organisms (lead, anthrax, etc.). Apart from its relation to respiratory diseases, an important role is played by dust in the irritation of the eye, ear, nose and throat; this is manifested by the undue prevalence of chronic inflammatory conditions of these organs in various industries. It is also seen in the frequent occurrence of the ulcerations of the nasal septum in certain workers.

Flour and sugar dusts, usually considered harmless, may be converted into lactic acid in the mouth and thereby increase the virulence of germs; this is illustrated by the undue prevalence of dental decay and pneumonia in some flour and sugar workers.

Skin irritation is sometimes produced by a combination of dust, sweat and heat, particularly among persons exposed to mineral, metallic, sugar, flour, aniline or other dusts.

Numerous studies have been made of the effects of smoke and soot upon the health of workers by anti-smoke commissions. The results show an apparent relationship between the smoke nuisance and diseases of the respiratory organs, especially pneumonia.



Courtesy Metropolitan Life Ins. Co.

Figure 1. Smith-Greenburg impinger taking sample of air near lead casting operation.

Certain injurious effects of dusts cannot be questioned. This is further emphasized by the study of tuberculosis in relation to the dusty trades. It is fortunate, however, that only about 25 per cent of dust inhaled actually reaches the lungs. According to Lehmann and other investigators, the bulk of dust that may be inhaled is either sneezed or coughed up, or swallowed.

Haldane says that, in addition to the mechanical irritative and poisonous influence of dust, "it inevitably tends to lower the social status and self-respect of work people."

Effects of Dust Inhalation

Zenker has applied the name of *pneumonoconiosis* to the various forms of diseases of the lungs caused by the inhalation of dust. It represents two words from the Greek which mean "lung" and "dust." The kind of dust inhaled determines the type of pulmonary lesions. However, there is one pathological process which underlies all forms of lung disease and this consists of a fibrosis or a replacement of the elastic tissue of the lungs by that of an unyielding scar tissue.

Probably the most important kind of disease of the lungs caused by the inhalation of dust is that which has been named *"silicosis."* This disease is caused by breathing air which contains a relatively large amount of free silica.

The chief forms in which free silica is encountered in industrial processes are crystalline silicon dioxide, granite, quartz and sandstone.

There are two tentative standards existing in regard to the dangerous quantity of free silica in atmospheric dust:

1. The South African experience established the upper limit of safety between eight and nine million particles per cubic foot of air.

Courtesy Metropolitan Life Ins. Co.

Figure 2. Smith-Greenburg impinger with hand-driven pump for collection of samples where electricity or compressed air is not available.

2. The United States Public Health Service in its research at Barre, Vt. found that the upper limit was somewhere between ten and twenty millions of particles per cubic foot.

These upper limits of safety are obviously dependent upon the percentages of free silica found in the atmosphere under consideration.

Classifications of Dusts

The size of dust particles has much to do with whether or not they will cause trouble in the lungs. The larger particles may be neglected when considering this point. The words "large" and "small" are used here in a relative sense, for all of these particles are exceedingly small. For instance, the particles that are significant in considering the production of a fibrous reaction in the lungs range in size from 2 to 0.5 micromillimeters in diameter (a micro-millimeter is the equivalent of 1/25000th of an inch). Gibbs has classified dust particles according to size as follows:

Dusts—greater than 10m-mm. in diameter.

Clouds—from 10 to 0.1 m-mm. in diameter.

Smokes—from 0.1 to 0.001 m-mm. in diameter.

Although size of particles is important, the quality of the dust is equally of moment, *for there are both non-irritant and irritant dusts.* A physiologic classification of dusts by Dr. C. K. Drinker is apropos here:

I. Poisonous (from a chemical standpoint.
   (a) Lead, mercury, arsenic and others. This kind of dust is taken up by the liver after absorption through the lungs or gastro-intestinal tract.

II. Non-poisonous
   (a) Organic—mainly the vegetable fibres, such as cotton, jute, hemp, etc. (according to Landis these do not produce lung fibrosis).
   (b) Inorganic (mineral dusts)
      1. Non-silica-containing substances, such as coal and lime. (No fibrosis).
      2. Combined silica (silicates)—no fibrosis.
         Orothosilicates—clay.
         Metasilicates—talc.
         Trisilicates—feldspar.
      3. Harmful silica (crystalline silicon dioxide) granite, quartz, sandstone.

The Mechanism of Absorption of Dust Particles

The lungs of persons living in large towns are always more deeply pigmented than those of persons who live in the country. On examination the cause of the pigmentation is found to be particles of carbon or other kinds of dust. The finer particles in the atmosphere are responsible for these changes, the coarser particles usually having been entrapped in the nose or the upper portion of the respiratory tract and usually later expelled by coughing. It is likely that particles over 2 micro-millimeters in size do not reach the lungs.

Normally the structure of the windpipe and the bronchial tubes is a defensive barrier. Dust is caught in the mucous secreted by these tubes and is wafted outward by the waving action of the small hairs of the epithelial lining of these tubes. It is said that recurrent colds lead to a shedding of the surface lining and an important defense is thus lost to the lungs. This circumstance is not without effect since chronic catarrh of the upper respiratory passages has been found to be a frequent precursor of pneumonoconiosis.

In the ultimate structure or alveoli of the lungs the possible fate of particles inhaled may be:

1. Going out the same route as that by which entrance was gained.
2. Removal by the blood stream.
3. Removal by the lymph stream.

The stages by which a particle may be removed from an alveolus are as follows:

1. By phagocytosis. This process is accomplished by certain kinds of cells which are given off by the blood vessel walls, when an irritant comes into that neighborhood. These free cells move into the alveolus or tiny lung space, and surround or engulf the foreign particles. The phagocytic cell then moves through the walls of the alveolus and probably back into the lymphatic circulation.
2. The phagocytic cell may then be carried into the lymphatic circulation and to the glands at the roots of the lungs. This may happen within 24 hours at first, but later, collections of lymphoid material may offer obstruction to such migrations. These nodular collections may show as dense spots in an X-ray film. Later on they may become fibrous and show as dense strands in a film.
3. The phagocytic cell may migrate back into the blood stream going through the blood vessel wall.

Haldane and Mavrogordato have proposed a theory, which simply stated is as follows: the question of whether or not a given dust will cause a disease process in the lungs (aside from the particle size and the poisonous chemical character of the dust) is probably dependent upon the difficulty of absorption rather than upon the massive deposition of material. In illustrating this theory, experimental animals were caused to breathe carbon dust. The lungs showed a definite clearing after a

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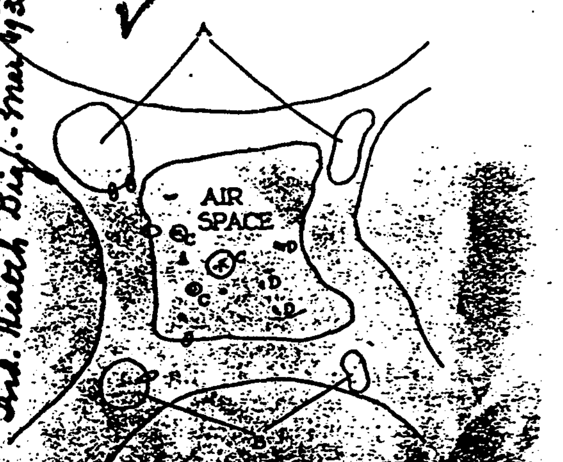


Figure 3. Lung cell (alveolus). Schematic drawing showing engulfed cells migrating to blood and lymph vessels. A, blood vessels; B, lymph vessels. C, C, C, cells with engulfed particles. D, D, D, dust particles [illegible] air space.

few months; this was not true when silica was breathed; probably it acted as an irritant. This caused a circulatory disturbance by which the particles became coated with serum. Because of the lack of absorptive power of silica particles, the consequent circulatory disturbance and production of serum, the particles of silica were not taken up by the white blood cells and removed from the lungs as had been the case with carbon particles. This behavior of different kinds of particles was responsible for the working out of the theory as stated.

Probably the best analysis of present day opinion with regard to the effects of dusts upon the human body has been made by Dr. E. L. Collis in the report of the Fourth International Medical Congress on Industrial Accidents and Diseases:

1. Dust particles which have reached the alveoli are there engulfed by cells originating from the epithelium lining the alveoli and are carried within them into the lymph channels of the lungs.
2. Particles of some kinds of dusts are more readily engulfed than those of others. Organic particles, such as coal, are most readily taken up, and particles of silica least readily; but when certain cells have been, as it were, educated in the function of absorbing dust particles through the presence of, say, coal dust, they more readily take up particles of such substances as emery, carborundum, and silica.
3. Particles of certain dusts, such as carborundum, when engulfed and carried into the lung tissue, remain inert, and produce no reaction.
4. But silica particles slowly dissolve within and react chemically upon the cells containing them, causing cell death and mummification.
5. The dead, mummified cells collect in and block up the lymph passages and glands; here they disintegrate and distribute the dissolved silica, which reacts with the surrounding tissues.
6. The final result of the reaction is the formation of scar tissue as a solid mass of material which in time replaces the normal alveolar structure of the lungs; the condition is one of silicosis.
7. All the various stages through which silicosis advances can be detected by X-ray photography.
8. The same results follow whether fine silica dust be artificially placed in the body or soluble silica be injected, but in the latter case the disintegrating changes take place more rapidly.
9. Dead tissue so caused forms a medium in which tuberculosis germs readily flourish.
10. When soluble silica is introduced into the blood stream it reacts with liver cells, causing scar tissue there, and also in kidney cells.
11. Statistical records indicate that Bright's disease as a cause of death is unusually prevalent among certain occupational groups exposed to silica dust.
12. Clinical observations have shown that (a) in many persons who have been exposed to silica dust for a period sufficiently long to enable the dust to gain access to the lungs, the silicotic process continues to advance after complete withdrawal from exposure; (b) the silicotic process may progress to fatal termination without the effect of any intercurrent disease; but (c) a silicotic patient is particularly liable to fall a victim to tuberculous infection; (d) tuberculous infection in a lung containing silica particles hurries the process of silicosis; (e) pulmonary tuberculosis in silicotic subjects, (depending upon the amount of scar tissue present,) runs an unusually rapid and fatal course; but (f) when silicotic persons are protected from exposure to tuberculosis infection, the occurrence of tuberculosis among them is minimized; hence tuberculosis in such persons appears to result from fresh infection during adult life; (g) tuberculosis infection from silicotic persons seems to be less potent than usual for infecting nonsilicotic persons.

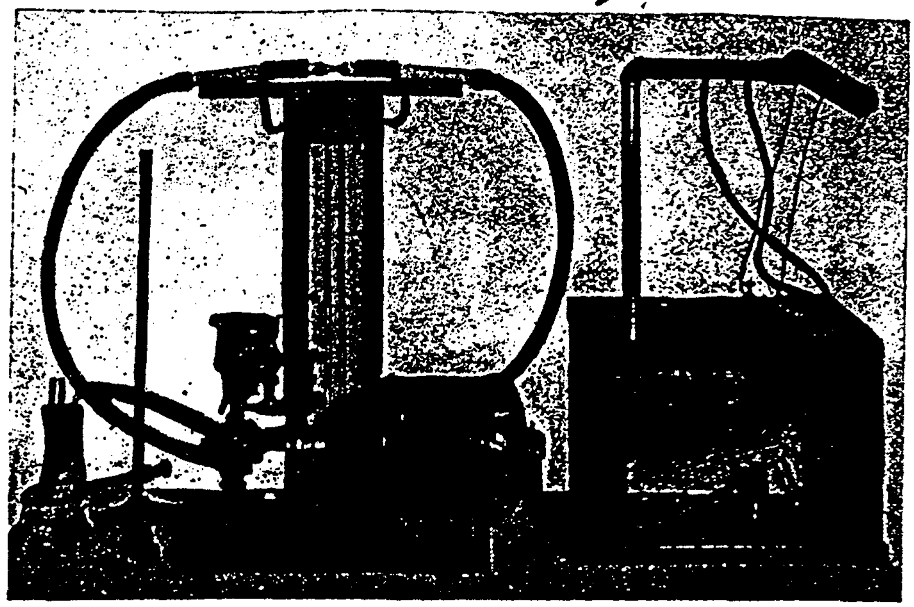


Figure 4. Left: Smith-Greenburg impinger. Right: Drinker electric precipitator at Industrial Laboratory, Metropolitan Life Insurance Co.

How Much of the Inhaled Dust Is Retained?

Drinker, Thomson and Finn have noted in an article published in the Journal of Industrial Hygiene for January, 1928, the following effects:

Suspensions of freshly generated zinc oxide fume (particles of about 0.4 micron) of Kadox (a zinc oxide powder with particles about 0.15 micron) and of marble dust (particles about 0.3 to 6 microns) were set up in a 1,600 cubic foot gas cabinet.

The subjects, seated outside the cabinet, inhaled the air from within and exhaled through an electric precipitator into a 125-liter spirometer.

The percentage retentions for all three suspensions averaged 55 with a standard deviation of 9.4. The concentrations inhaled varied from about 50 to 450 mg. per cubic meter, the exposures from five to forty minutes, and the rates of breathing from 6 to 18 respirations per minute.

Preventive Measures

Kober discusses this important phase of the dust problem under six headings:

1. Prevention of Dust Formation.

   A number of important processes in industry can be properly controlled by the application of oil, sprays of water or jets of steam. This method of protection is especially applicable to the metal, lead and pottery industries, rock drilling, mining, blasting, stone-crushing, cutting and grinding.

   Several investigators have emphasized this method of control, believing that proper usage and adaptations would result in the abolition of some of the more severe diseases arising from exposure to dust.

   Another important application of wetting processes is prevention of disastrous explosions of coal dust in mines.

2. Prevention of Dust and Fume Diffusion.

   Protection is accomplished under this head by the enclosure of machinery or operations in air-tight cases. This method, however, sometimes gives rise to great difficulty because many processes cannot be wholly enclosed and still be effective.

3. Removal of Dust and Fumes.

Much has been accomplished by devising systems of mechanical exhaust ventilation, which remove dust and fumes at the point of origin. Various codes have been invented which lay down specific rules and definite provisions for removal of dust and fumes by the proper construction of benches, tables, and other furniture with reference to hoods and other section apparatus.

A very important point in the arrangement of this type of protection is that provision should be made to carry the dust and fumes away from the face of the worker.

It is not within the province of this work to give details as to the working out of various exhaust systems. (See Safe Practices Pamphlet No. 32, "Exhaust Systems.")

4. Collection of Dust and Fumes.

Where poisonous fumes and gases exist, methods of collection consist of condensation, absorption by water or chemicals, destructive distillation by heat in a closed vessel, combustion of gases that can be burned, and finally, by the discharge of gases into the air above the working level. Valuable by-products are also recovered by condensation and absorption.

An example is the value of blast-furnace and coke-oven gases, which are used for fuel, for heat and power, and also sulphuric acid fumes which are collected and made into sulphuric acid.

Certain dusts which have no especial value can be passed through a tower and precipitated by means of fine water spray. Where the dust is of value, it may be collected in suitable tanks under water for ultimate recovery of constituents.

Large particles of dust are usually collected by a so-called cyclone separator in which the dust is collected by centrifugal force. Mechanical filtrations have been accomplished by the use of mechanical knocking devices, through textile fabric or wires of different meshes.

Electrical precipitation as developed by Cottrell has been found efficient in precipitating and collecting certain kinds of dust.

5. Masks and Respirators.

It should be borne in mind that masks and respirators are usually uncomfortable to those who wear them. There is an endless number of these devices upon the market. The best respirators so far designed are intended to filter out dusts and fumes by means of sponge, cotton, wool, gauze or other material. Most of these are efficient for a certain period, after which they become clogged and need to be replaced. Masks are more reliable and afford a greater amount of protection under ordinary conditions. (See Safe Practices Pamphlet No. 64). Kober states that working conditions should be so nearly perfect as to obviate the use of respirators. Until this is accomplished, he says their employment should be encouraged.

6. The Cleaning of Workshops.

It is impossible to set up exact standards which will apply to all

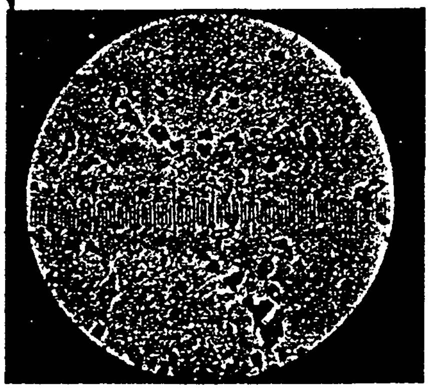


Figure 5. Microphotograph of talc dust; on scale 1 division equals 1 m-mm.

cases and all industries. It is also well to emphasize the fact that no amount of ventilation can do away with the necessity for frequent and systematic cleaning of plants. Shops should be swept daily after work has ceased, using damp sawdust or other material and having windows open widely. Some industries use a vacuum system for cleaning and dusting and this should always be encouraged.

Under certain conditions, cement floors made with a considerable incline for drainage have been useful in facilitating washing.

Feather dusters ordinarily do not remove dust, but merely redistribute it. Moist cloths have been found efficacious for removing dust from surfaces of furniture. "Dust oil" has not been found efficient, as usually it only allays the dust and does not remove it.

Dust Respirators

Through the Bureau of Mines, S. H. Katz, G. W. Smith and E. G. Meiter conducted a study on the construction and filtering efficiency of dust respirators. The conclusions reached were as follows:

1. The efficiencies of industrial dust respirators in restraining tobacco smoke range from 5 to 33 percent when the air is passed at a rate of 32 liters per minute. A gas-mask canister with two filters of absorbent cotton showed 63 percent efficiency. The Fogler flat felt filter was most efficient, showing 97 per cent.

2. The efficiencies against silica dust floated in air, range from about 9 to 70 percent for dust respirators, or about twice the efficiency against the tobacco smoke; most of the silica particles were 1 micron in diameter or four times the diameter of the tobacco-smoke particles.

3. As dust particles most injurious to miners, stone workers, and many others engaged in dusty trades are about 1 micron in diameter, respirators, if worn, can prevent a considerable amount of dust, but not all of it, from being inhaled.

4. Although the laboratory study has shown that most dust respirators are not highly efficient in removing tobacco smoke (very difficult to arrest) from air, a filter that removes 50 percent of the tobacco smoke from air flowing at rate of 85 liters per minute is very efficient in restraining the ordinary dusts encountered in industry and also the smokes, (such as those from burning wood and other carbonaceous material) that city firemen encounter. Hence, the Bureau of Mines adopted a 50 percent efficiency test against tobacco smoke as a standard requirement, (in addition to others) for the approval of respirators or gas masks designed to afford protection from smoke or dust.

5. Because the laboratory tests of the dust respirators were severe, the low efficiencies given do not indicate the general effectiveness of these respirators under all industrial conditions. Much of the dust encountered in industry is less difficult to arrest; the overall efficiency of the respirators in actual service may thus be correspondingly higher. The tests therefore show that as a rule the respirators are of much value in removing injurious dust from inspired air.

6. The discomfort caused by respirators covering the face—the heat generated, the irritation of the skin in contact with the respirators, and the resistance to the flow of the air breathed—are the most serious disadvantages of respirators. The resistances of industrial dust respirators to air flowing at 85 liters per minute were 0.25 to 1.5 inches of water. The Fogler flat felt filter had a resistance of 2.25 inches and the gas-mask canister 3.6 inches.

7. A man wearing a gas mask can work hard only about half an hour; then the extra effort caused by the resistance to breathing compels him to stop to rest or greatly reduce his exertion.

The resistance of the dust respirators, although causing some discomfort, does not seriously interfere with a man's exertions until the filter becomes clogged with deposited dust and the resistance correspondingly increased. The filter must then be cleaned or freed of dust, or be replaced by a fresh one.

8. Filters of various fabrics, including cheesecloth, canton flannel, unbleached muslin, closely woven bleached muslin, filter paper, and absorbent cotton, all made for test

purposes so as to expose exactly 100 square centimeters of filter area, were tested against tobacco smoke and against silica dust in air flowing at a rate of 10 liters per minute.

Each material was tested in a single layer and in multiple layers. Results showed that each layer of fabric (in effect) removes about the same proportion of smoke or dust that penetrates to it before the filters become clogged or altered by deposits of an arrested material, such as silica dust. Consequently, when the efficiency of a single ply of a filter is known, the efficiency of any multiple ply filter of that material may be calculated.

9. Silica dust clogged filters rapidly and increased the resistance to air flow, but some materials were more resistant to clogging than others. The dense filters of paper or closely woven muslin clogged most rapidly; filters of loose texture like cheesecloth or absorbent cotton clogged the least.

10. The efficiencies of the filters were increased by clogging with dust until eventually many filters gave an efficiency of 100 per cent.

11. Tobacco smoke did not clog filters, and there was no increase in efficiency as the smoke was deposited.

12. A few tests were made with woolen fabrics, but they proved to be no better as filters than cotton fabrics of similar texture.

13. The efficiency of the filters decreased somewhat with an increase in the rate of air flow. Sometimes a cotton fabric with a nap showed a decrease after humid smoke had wet it and the moisture had caused the fibers of the nap to adhere together.

14. The resistance of the filters to air flow increases in proportion to the number of plies of fabrics after the first ply. The first filter layer shows a somewhat higher resistance than the additional ones.

15. The resistance of fabric filters to air flow is very nearly proportional to the rate of air flow.

16. Air filters of high efficiency can be made with a sufficient number of plies of material that has a low efficiency per single ply—cheesecloth, for example. Such filters have less resistance to air flow than equally efficient filters made of fewer plies of the higher-efficiency materials, such as closely woven muslin.

17. The thicker filters of loose-textured material clog less rapidly than equally efficient filters composed of fewer plies of tightly woven material.

18. A new type of dust respirator was designed and constructed according to the principles brought out in the tests. This respirator consists of a large filter of canton flannel made into a cap or turban for the head. Air filters through the canton flannel to the interior, passes through a check valve, and is then conducted through a rubber tube running over the forehead and between the eyes to the nose, which is covered with a small rubber nose

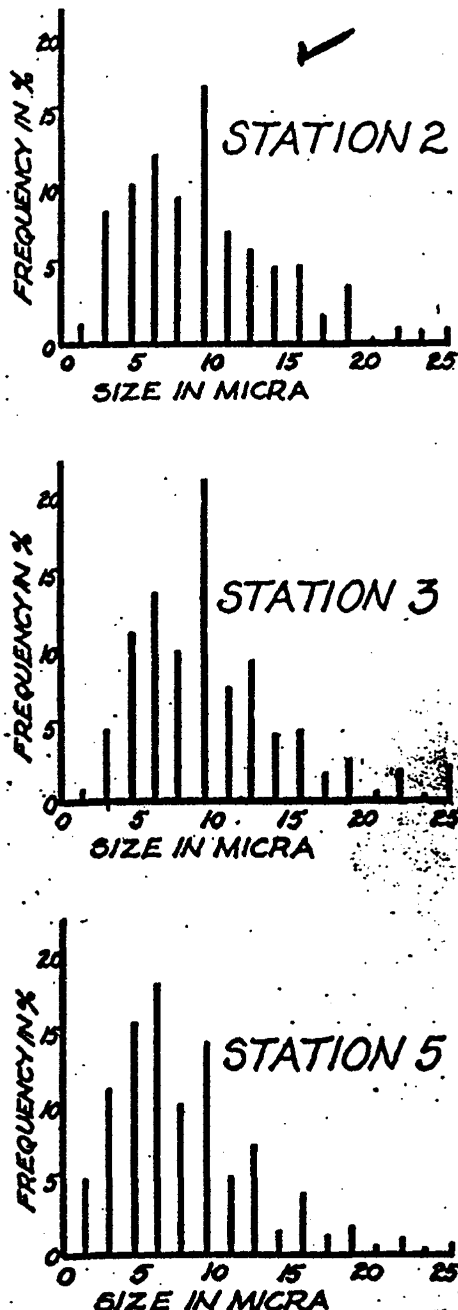


Figure 6. Graph of particle sizes in three samples of dust, after recording microscopic count.

cap. At an air flow of 85 liters per minute the efficiency of this respirator was 58 per cent against tobacco smoke and 93 per cent against silica dust.

19. The data presented and the principles outlined may aid manufacturers in improving dust respirators.

20. *Although the use of respirators should be encouraged among workers in dusty industries, a respirator cannot be considered a final safeguard.* In mining and in other industries efforts to prevent the formation of dust and its distribution by the air, by the use of hollow drill steel and water, and by sprays on the undercutting machines should be continued.

The National Safety Council has previously called attention in the reports given by A. L. Watson, Chairman of the Industrial Poisons Committee (at the Eleventh Annual Safety Congress in 1922), to desirable qualifications in respirators:

1. Lightness in weight.
2. Automatic adjustment to facial lines.
3. Comfortable contact edges which will not irritate.
4. No obstruction to vision.
5. No interference with wearing goggles.
6. No serious resistance to breathing.
7. Relief valve that will not clog.
8. No interference with chewing and spitting.
9. Relief valve placed so as not to blow dust in eyes.
10. Headbands durable and easy to fasten.
11. Inflation valves easy to operate if contact is pneumatic.
12. Durability of parts requiring adjustment.
13. Little attention required.

More recently Barreto, Drinker, Finn, and Thomson tested the efficiency of dust masks and respirators and emphasized the following points:

1. Masks for protection against dust and fume particles must be provided with effective filters, preferably of a fibrous nature and with large cross-sectional area. The materials used in gas masks for protection against poisonous gases are ineffective in removing particles of dust and fumes.

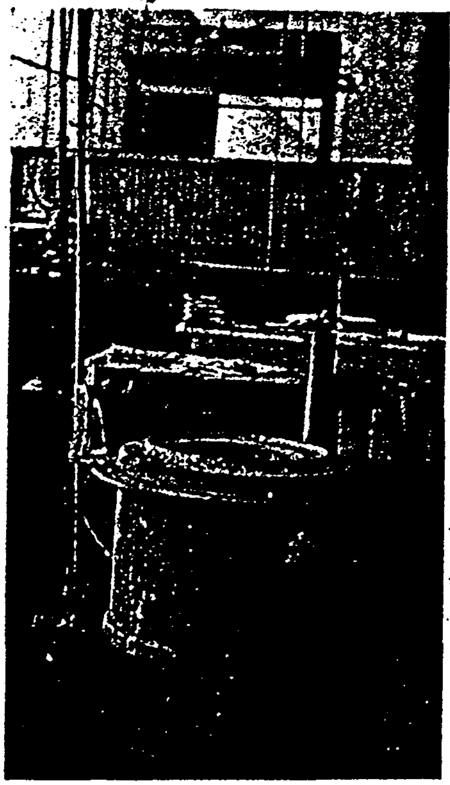
2. The efficiency of masks of large or small area can be very greatly increased by plugging the surface meshes with a freshly generated, finely divided fume like zinc, magnesium, or aluminum oxide. If the filtering area is small, plugging quickly increases the resistance to prohibitive figures; but masks with large area (800 to 1,200 sq. cm.) can be plugged to give perfect protection against finely divided lead fume and over 97 per cent against tobacco smoke. At the same time, the resistance to air flow can be kept below 30 mm. of water pressure measured at 85 liters a minute.

Other Methods of Protection

Dr. R. C. Williams calls attention to the following general measures for protection against dusts and fumes:

1. Industrial Law

   The foundation of industrial hygiene and sanitation rests on industrial law. The history of the control of industrial hazards is the history of the enactment of industrial laws. Industrial laws must be scientifically sound. Fundamentally, the law is for the protection of the worker, but, on the other hand, in forming such a law the effect on industry and the cost of production must be considered. The elimination of all dustiness in the work processes where there is a dust hazard, may be desirable, but there is no scientific reason for such a requirement if the dust itself is not a specific poison.



Courtesy Metropolitan Life Ins. Co.

Figure 7. Impinger in use for determination of fumes from a lead pot.

2. Law Enforcement

   Industrial laws are valueless unless enforced. The method of law enforcement in industry is usually through factory inspection and the actual checking up of the efficiency of protective devices. Competent factory inspection insures the control of industrial hazards and the maintenance of acceptable sanitary conditions.

3. Education

   The worker needs to realize the danger of certain health hazards as well as does the employer. Protective measures may be required by law and provided by the employer, but if the worker does not understand the necessity for their use much of their protective value is lost. Wholesome, common-sense education is the means by which the need for intelligent use of protective measures is impressed upon the workers.

4. Scientific Study of Industrial Hazards

   The correct basis of industrial law rests on comprehensive scientific understanding of the hazards that are to be controlled. The proper control and prevention of the health hazards of industry and their effect upon the health and physical condition of the worker can be obtained only through careful and thorough scientific investigations. The maintenance of adequate industrial sickness records by employers in order to determine the cause of sickness among workers, and to gauge the efficiency of measures used to reduce health hazards is an important part of the study of industrial hazards.

Dusts as Explosion Hazards

The National Safety Council has called attention to this matter in its Safe Practices Pamphlet No. 34 on the subject "Industrial Explosion Hazards." A partial list of flammable dusts is given here:

Sugar	Flax
Dextrin	Cotton
Starch	Celluloid
Cocoa	Gum
Flour	Paper
Grain	Tanning bark
Maize	Cork
Fine wood dust	Bronze
Fertilizer	Iron
Charcoal	Hemp
Coal	Oakum
Lampblack	Powdered drugs
Sulphur	Aluminum
Metallic dyes	Antimony
Oat husks	Hard rubber
Malt.	Powdered milk
Spices	Zinc
Coffee	Leather
Rice milling	Magnesium
Alfalfa	Soap powder
Wool	Shellac

Methods of Dust Collection for Study

Methods by which dust may be collected and studied as to chemical content, size of particles and amount per unit of air, have been the cause of much research and investigation. These methods may be briefly summarized as follows:

1. Settling.
2. Counting.
3. Filtering.
4. Scrubbing.
5. Electrical precipitation.

Settling usually produces a piling-up effect so that the counting of separate particles is impossible.

Counting. An efficient jet dust counter has been devised by Owens.

Filtering has long been used, especially by the Bureau of Mines; different substances have been used for the filter, such as cotton, nitrocellulose, glass wool, paper and alundum crucibles of the insoluble type, and sugar as the best example of the soluble type. The difficulty with filter collectors is that they clog and resist the air flow, thereby preventing the possibility of getting the true quantitative dust content of the sample being tested.

Scrubbing methods (so-called because of the admixture of the dust particles with water) are much used because of the cheapness of water. The Drinker collector is an efficient kind of scrubber collector.

The United States Public Health Service and the U. S. Bureau of Mines have recently made use of an apparatus in their field work, called an impinger. By means of this instrument the air is impinged at a high velocity on a wet surface and then bubbled through a layer of water. Large volumes of air can be sampled and the efficiency has been found to be between 93 and 96 percent, according to conditions.

Electric precipitation has been practiced for some time, the most notable example being the Cottrell precipitator, used extensively to collect smoke. A modification of the Cottrell device represents the best type of electric precipitation collector and one from which the particle size may be studied, as well as the chemical constitution of the dust.

Wherever there is a noticeable amount of dust produced in a given industrial process, the important steps in the investigation of the dust hazard would be:

1. The quantitative estimation of crystalline silicon dioxide in the sample of air breathed by workmen.
2. A chemical analysis of the dust sample.
3. A computation of a frequency distribution of the particle size.
4. Examination of workmen for physical effects.

Outline of a Typical Dust Study

The United States Public Health Service has recently published a monograph entitled "The Health of Workers in Dusty Trades." The method used in this study is here outlined:

1. Physical examinations for the purpose of determining general physical conditions.

   The data from this procedure gave important physical differences; the industrial rating of the individual; the group to which he belonged; and lastly, aided in the selection of cases for special study.

2. Special physical examinations to determine the problem of specific disease of the respiratory system.

   This entailed a special study of lung pathology resulting from dust exposure.

3. Sickness records of the nature and severity of disabling illnesses.

   These record cards showed all absences from work lasting two days or longer. Diagnoses were made in all cases.

4. Occupational environment.

   Chemical and petrographic analyses of all dust samples.

Summary

Dr. Edgar L. Collis calls attention to the following points with reference to exposure to dust:

1. Inhalation of all forms of dust is accompanied by diminished power of chest expansion.
2. Diminished power of chest expansion so produced is accompanied by high blood pressure.
3. Animal dusts (apart from the presence in them of disease germs) when inhaled, produce relatively fewer effects than do vegetable and mineral dusts.
4. Vegetable dusts, when inhaled, tend to produce a type of chest affection best described as asthmatic.
5. Of mineral dusts, those composed of calcium salts are least injurious.
6. Inhalation of mineral dusts which do not contain free silica tends to produce irritation of the upper air passages and respiratory diseases other than a fibrous reaction.
7. Inhalation of mineral dusts which contain free silica is associated with an excess of scar tissue formation, an excess which bears a direct relation to the amount of free silica present.
8. In general, dusts appear to be more injurious as their chemical composition differs from that of the human body or from the elements of which the body is normally composed.

Courtesy Metropolitan Life Ins. Co.

Figure 8. Drinker electric precipitator in use for determination of lead fumes from casting of bronze.

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