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Glasses are now made light enough for the use of men working in the same department with the welder, but not in direct contact with the welding flame or arc, so as to protect them from sudden flash.

Welding helmets are so constructed that there will be no reflection from operators working in staggered positions. It is always well to see that the glass fits properly in the welding helmet. A cheap helmet in which the glass will not fit properly may result in an eye burn that will, in the end, cost a great deal more than the slight extra cost of good protection. This is forcibly shown by the example of a large plant where men, paid the topnotch wage, were permitted to work about 18 hours. This unit of the plant was keyed to the utmost. Unfortunately, the purchasing agent — not realizing the danger of the arc — bought helmets without the proper inside shields. The result was that practically all of the welders suffered, more or less, from eye burns which threw them out of work from two to four days. This, of course, meant far more of a loss to the firm in time than the outlay of fifty cents or a dollar extra for the proper type of helmet.

It is also well to remember that the glass should be of constant shade and density so that the operator will be able to judge the flow of the welding rod. It costs a lot of money to deposit some of these welding rods on seams, or other jobs, and it is too costly to have to grind it off again. Such a waste of time and material will amount to quite an item in a year. One of the big railroad companies has found that if they stick to a special density of welding glass, some operators can put a door frame into a steel car with little or no grinding of the seams.

With all the modern equipment available for eye protection there is no reason why men should suffer eye injuries and perhaps be physically handicapped for life; nor should the employer lose the productive time when this can be so easily prevented.

Dust Hazards in Industry

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The control of dust in industry is receiving increased attention. While the health hazards produced by the inhalation of certain dusts have been known for a considerable period of time, it remained for the past decade to bring the real importance of these hazards to the attention of industry. This is best attested to by the instituting of industrial hygiene departments in a majority of the states, several cities, and many industrial companies. Where heretofore a silicosis or lead case with many of these companies was the usual and expected thing, it is now a rarity. This progress has been due very largely to our increasing knowledge of the hazards, and of proper methods to use for the protection of the worker.

In the ceramic industry, due to its diversified fields and due to the volume of industrial workers employed in them, it is of especial importance that we recognize and combat effectively these health hazards. In the pottery, the refractory, and the porcelain industries — to mention only a few — the worker is frequently exposed to either high concentrations of silica or certain toxic dusts.

We might classify, for our purpose at least, dusts encountered in various industrial operations as nuisance, such as flour, wood, etc.; fibrosis-producing, of which silica and asbestos are recognized; toxic, such as lead, zinc, etc.; and explosive, of which coal and grain dust are the best examples. We shall confine ourselves primarily to a discussion of the second and third types — the fibrosis-producing and toxic dusts, because it is from these two that the majority of industrial dust hazards arise.

In determining the dust hazard of any operation, it is imperative to know both the amount and kind of dust found in the atmosphere in the worker's breathing zone. The kind of dust can frequently be determined from a knowledge of the material or materials being processed. However, where a combination of materials or constituents is used, it is desirable to know as accurately as possible the amount of each. This frequently necessitates a chemical and petrographic examination of the collected dust.

Of the several instruments used in this country for dust sampling, the Greenburg-Smith impinger (modified form, by Hatch, Warren, and Drinker) has enjoyed the greatest popularity. This has been partially, if not largely, due to the fact that the dust surveys made by the U. S. Public Health Service record the results in counts taken from impinger-collected samples. The instrument also has the further advantages of large sampling volume (one cubic foot per minute), and high collecting efficiency against many of the commoner types of dust, including silica, asbestos, and lead. It should be remembered, however, that its collecting efficiency against the various metal fumes is considerably lower than that against dusts.[1]

In operation, a dust sample is collected by drawing the dust-laden air at the rate of 1 C. F. M. through a small orifice in a collecting fluid — usually water, alcohol, or some suitable acid. The dust impinges on the bottom of the flask with an approximate velocity of 100 m. per second, and is thereby sufficiently wetted to be held in the collecting fluid. The sample can then be counted, determined gravimetrically, or chemically.

There has recently been placed on the market a smaller sized impinger, called the micro impinger, in which the sampling rate is one-tenth that of the regular type, and the volume of sampling fluid used is about 10 ml. This instrument, I believe, is hand operated. Its chief advantage lies in its increased portability. Recent tests made by the U. S. Bureau of Mines indicate its collecting efficiencies to be similar to those of regular type.[2]

Another instrument which is finding increased popularity, especially for field use, for dust sampling is the Bausch & Lomb dust counter. This instrument, which is a combination of the Owens jet dust counter and the Kotze Konimeter, provides facilities for taking a large number of grab samples and, if desired, reading the dust count immediately in the field. Due to the several variables which occur between different dusts, no satisfactory conversion of the readings made with the Bausch & Lomb counter and those made with the impinger has been devised.[3] However, for any one given industrial process the ratio of these two values is fairly constant.

The electric precipitator has for quite some time been used as a laboratory device for dust studies. This device operates in principal by drawing the dust-laden air stream either between two oppositely charged electrodes or through a high A. C. potential field. The precipitated dust is caught on either a glass or metal tube and the amount determined either gravimetrically, chemically, or counted. The device possesses very high collecting efficiency against all dusts and fumes. Recently an instrument intended for field usage has been developed.

Among the various other dust sampling devices, which are used to some extent both here and abroad, are the thermal precipitator, the Owens jet dust counter, and the Kotze Konimeter. Both the Owens jet dust counter and the Konimeter have enjoyed their greatest popularity in European countries — chiefly Great Britain.

If industrial dust hazards are to be properly diagnosed, the results obtained from the dust samples which are collected by any of the above-mentioned methods must be properly interpreted. In brief, we must be able to say whether or not, even though we have found dust in the atmosphere, we have an industrial hazard. Silica and asbestos dust samples are usually counted according to the procedure developed by the U. S. Public Health Service,[4] and the number of particles found expressed as the number of either *free silica* or asbestosis particles per cubic foot of air volume. This presupposes, of course, that we know the percent of the harmful constituent in the atmosphere or that we determine this value from petrographic or chemical analysis. We can then set up a working formula such as percent free silica $\times$ total count $=$ free silica count. We now believe this free silica value should be kept below 5,000,000; in fact, some authorities would put the value even lower — possibly 4,000,000. The finally accepted value, from the standpoint of silicosis prevention, whatever it becomes, must be such that it will be safe for any individual to spend his entire lifetime on a given occupation without contracting silicosis.[5]

The size of the dust particles present is very important. It has been found, of course, that the most active particles in the production of silicosis are the smallest. Particles above 10 microns in diameter are believed to be relatively unimportant so far as the production of silicosis goes. It should be pointed out here that the most hazardous sizes of dust are those sizes which remain longest in the atmosphere and are most difficult to remove from the zone of the worker by mechanical filtration. The small sizes are also those which are most numerously produced during mechanical operations. For example, Hatch and Pool [6] found that 10^{12} particles less than 0.8 micron are produced each minute by an ordinary pneumatic rock drill. From a consideration of Stoke's Law, particles of this size will settle at the rate of about 4 inches per hour, so that the hazard encountered in this particular case can easily be appreciated.

Recent studies by Gardner, however, indicate that the activity of silica dust for producing silicosis increases to a maximum as the size of the particles decreases. This lower limit of particle size has not satisfactorily been determined but may lie about .002 micron.[7] This phenomenon may be explained on the basis of the lung's refusal to retain the very finely divided particles.

Lead and other toxic dusts are usually determined by chemical analysis of the dust sample. If the amount of lead found does not exceed .15 mg. of lead per cubic meter of air sampled, the atmosphere is considered safe for workers.

The final phase of our discussion will consist primarily of a consideration of the protective measures which can be used to satisfactorily prevent the occurrence of occupational disease from industrial dust.

First of all, good housekeeping in the industrial plant will go a long way toward the prevention of excessive dustiness. Procedures such as constantly stirring up the settled dust by means of the too frequently used air hose, dry sweeping, and inadequate removal of settled dust, all tend to increase the dust concentration of the worker's atmosphere. Provision should be made for adequate removal of settled dust at times when the least number of employees are exposed. Vacuum cleaning, or damp sweeping, should be used and the operators of the cleaning equipment protected with satisfactory respirators.

Frequently, a non-dust-producing or non-hazardous-dust-producing operation can be substituted for those in which hazardous dusts are found. An example of this is the substitution of shot blasting for sand blasting. This type of dust control is sometimes objectionable because of expense, dissimilar end results obtained, or for some other reason. However, there are frequently occasions where the substitution can be conveniently made.

Also, wet grinding or drilling can very often be used in place of dry drilling. This type of dust control is used quite extensively in the granite and rock quarrying industries, and is quite effective. It has, of course, the disadvantages of necessitating an adequate water supply and having the worker exposed to wet and often sloppy working conditions.

Some industries use what might be termed an indirect method of dust control by limiting the periods of exposure of a given worker to the hazardous dusts so that his total daily exposure is below that necessary to produce occupational disease. This procedure is not to be strongly recommended.

Possibly one of the most effective methods of controlling industrial dust hazards is by means of ventilation. This can be done by adequately ventilating the working space in general, or by means of local exhaust ventilation. The latter method has the advantage of removing the hazardous constituent close to its source of formation, and thus effecting economies in power consumption for moving the required air. It is necessary, of course, in order for local exhaust ventilation to be optimally effective, that the exhaust system be properly designed to adequately take care of the various industrial operations for which it is intended.

A final method of dust control, and the one in which the author is primarily interested, is by means of personal protective equipment, such as a dust respirator. This type of control is not recommended as a cure-all for every dust problem, but can be advantageously used in a large number of cases.

The dust respirator, the supplied-air respirator, and the sand blast helmet all have been developed to a high degree of efficiency and perfection. For hazardous dusty operations, those devices which are approved by the U. S. Bureau of Mines are recommended. For operations involving no particularly hazardous dust, but where protection is still required, the cheaper unapproved devices can frequently be used satisfactorily.

Oftentimes it can be found more advantageous to apply personal respiratory protection to workers than to use ventilation. On the other hand, frequently the reverse may be true, or a combination of the two methods may be used. Quite frequently it becomes practically impossible as well as quite uneconomical to remove harmful atmospheric constituents to a safe level, and respiratory protection is used as an adjunct.

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Protection from Industrial Toxic Gases and Vapors

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The problem of protecting industrial workers from toxic gases and vapors has long been partially realized, but until recently little in the form of specific protection was proposed. In many of our present day industries, the exposure to toxic vapors and gases becomes exceedingly hazardous unless proper protective measures are applied.

This paper does not have for its purpose the cataloging of all gases and vapors with their toxicity limits, but rather a brief outlining of the most commonly found vapors and gases of industry and adequate protective measures which can be used.

In this discussion it would be well to distinguish between the terms fumes, vapors, and gases. Much confusion at the present time appears to be in evidence regarding the use of these terms. The word "fume" is applied to a class of dispersoids formed by the burning or heating of metals, such as lead, magnesium, or zinc fume. Fumes consist of very finely divided solid particles and are different in this respect from gases.

True gases, on the other hand, contain of themselves no solid particles, but are composed of molecules of the gaseous element or elements. The term gas is applied to those substances which exist in the gaseous phase at normal temperatures and pressures. A vapor, however, is the gaseous phase of a material which exists in a liquid or solid form at normal temperatures and pressures. Examples of the former are oxygen, helium, ammonia, etc.; of the latter, gasoline, carbon disulfide, carbon tetrachloride, etc.

According to Henderson and Haggard,[1] all gases can be classified into the following four main groups:

(1) *Asphyxiants* — those gases which are injurious because of their causing oxygen deficiency in the tissues. This group includes the so-called simple asphyxiants, such as nitrogen and carbon dioxide, and also the chemical asphyxiants, of which carbon monoxide and hydrogen cyanide are examples.