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Dust Problem in Industry

FRIDAY MORNING SESSION

October 6, 1933

Orig. Du 94

The special session devoted to a discussion of the dust problem in industry was called to order by J. R. Allan, assistant manager, Industrial Engineering and Construction Department, International Harvester Company, Chicago, who presided. He briefly outlined the purposes of the session and then presented the first speaker.

The Mechanical Control of Dust

Orig paper Du 94

By E. O. JONES

Consultant, National Founders Association, Chicago

The speaker said in part: During the last few years, much has been written about the pathological effects of dust. From this material there seems to be some lack of agreement among scientists as to the pathological effects of these types of dust, their dangerous dimensions, the length of time one must be exposed to their inhalation, the density of concentration which is dangerous, and the extent to which they are directly causative or contributory to disease.

It is unfortunate that in the twilight zone between ethics and non-ethics, there are certain members of the legal and medical profession who are willing to take advantage of these uncertainties and capitalize on them largely for their own benefit.

When the foundry industry was confronted with the accusation that it harbored a potential health hazard, its leaders immediately took steps to study the problem, with the object of eliciting all the facts and determining upon a course of procedure to eliminate the causation. This study has been under way in some localities for some time, but its procedure presents many difficult problems.

The mechanical control of dust is not our only problem, nor does the accomplishment of such control depend upon large expenditures of money. We know from experience that gradually human ingenuity will provide ways and means to this part of the problem.

But let us digress from the subject to consider the amount of dust we as individuals create. Take the molder, for instance, who goes to his bench at the start of his day's work. He reaches for his air hose, and starts the day by removing, with its force everything he can from his equipment. In close proximity to his bench, or on the window sill in front of him, you will usually find a varied collection of relics. He will usually wet down his sand pile, but seldom his floor or gangway. When he is through with his shift he usually grabs the air hose and proceeds to take a compressed air bath.

And we have the foundry laborer; he has many menial tasks to perform. When he sweeps or uses a shovel he seems to be of the opinion that his efforts are judged by the atmosphere he creates. If he does sprinkle the floor it is usually done very sparingly.

Shake-out men and crane men seemingly give little attention to the results of their thoughtlessness. Grab buckets are usually lifted to the limit of their lift and then dumped. Many companies have furnished equipment, such as positive pressure helmets and respirators, to employees who work in extremely dusty atmospheres. But it is surprising to note the apparent lack of interest on the part of the employee for whose protection this equipment is furnished.

From these remarks some may say "Why shift the responsibility?" Not a bit. We have merely cited these few facts as an indication that possibly we can improve the supervision. If we make every man responsible for the cleanliness in the vicinity in which he works, and every foreman responsible for his department, and then in turn make the superintendent answer for the cleanliness of his shop, we will not have to worry about the increase in labor cost. After dust gets into the atmosphere, it is, of course, very difficult and expensive to remove. Keeping the foundry floor off the ceiling is a man-size job.

Ventilation is a problem everywhere. A diligent survey of our existing equipment may develop the fact that by small expenditures we can improve conditions. Inspect your dust-arresting equipment. See that the rapping device is in order, that the screens are in good condition, we suggest that they are rapped and the hoppers emptied regularly. Repair any leaks in pipes. See that the valves close properly. Chutes should be kept in good repair and when emptying arrestors, respirators should be worn by the men whose duty it is to perform this work. If refuse from the arrestors is not removed at once, keep it in containers or wet down until it is removed. Above all, watch your air velocities and make sure you are removing at the source as much of the dust as the equipment was originally designed to do. You pay for the current the motor consumes to operate your suction equipment, therefore get the proper return for that expenditure.

Do not store or allow sand to accumulate around your blasting equipment. Make sure you are receiving the proper air changes in your sandblast rooms. Inspect your masks to the amount of air purging through. The wearer is prone many times to just crack or partially open the valve, and when this is done he is not getting the full protection for which the helmet was designed. We suggest that the helmet be removed from the sandblast room and stored at the end of the day in a dust-tight cabinet, instructing the wearer to clean before re-using.

In your cleaning rooms where tumbling barrels are used, we deal again with air velocities. Piping should be diligently inspected and kept in good repair. Make sure traps are performing the service they were designed for. It might be well to keep floors in this department wet down. Remove the day's accumulation of refuse at the end of the day's run. When cyclones are used, make sure you are not exhausting at the level of windows which may be opened in other parts of your plant.

We will have to look for further co-operation from the foundry equipment manufacturers who serve our industry. Equipment will have to be sold to us net to meet existing codes, but as dust-tight as human ingenuity can design them. After the equipment is installed, it will be the purchaser's responsibility to see that it is regularly inspected and maintained to perform the service for which it was originally designed.

And we refer again to the employee's responsibility. When he elects to work in a foundry, he should be willing to co-operate and wear the safety devices which are provided by his employer, and it will be the purchaser's responsibility to see that the equipment is well cared for and properly maintained.

Our industry is a basic one and we hope that it will long continue to be essential. For this reason we want to assure those who are sitting on the side lines that it is our determination and hope that, with the help of those in the medical profession who have given so generously of their time in scientific study, we can soon determine the actual extent of the hazard.

In the meantime, while many diverse opinions are being brought into agreement, it is imperative that we give more than passive assent to suggested measures of precaution or improvement. The accomplishment of worth while results depends upon the diligent and active co-operation of everyone concerned and the utilization of all known means of prevention and control. Only through united effort can we hope to accomplish an effective program which will give maximum of advantage to employers and employees alike, and to such an end we are confident the foundry industry will continue to dedicate its earnest and conscientious efforts.

How to Determine the Dust Content of the Atmosphere in Dusty Industries

Orig. paper Dec 94 ac

By DR. E. G. MEITER

Director, Industrial Hygiene Laboratory, Employers Mutual Liability Insurance Co., Milwaukee, Wis.

The importance of atmospheric dust as an agent in the causation of respiratory disease has long been known. However, it is only within the last few years that this subject has achieved medical and legal importance in dusty industries. Because of the extension of compensation laws to include occupational diseases, and through an ever-increasing number of legal suits against industrial concerns by employees claiming disability due to dust inhalation, there is need for a severe attack on the problem of eliminating or otherwise combating the dust hazard. In order to intelligently control the dustiness of the air, the amount of dust present must be determined. With a given dust, two factors are usually considered; (1) the number of dust particles in a given quantity of air, which is usually expressed in millions of particles per cubic foot of air; (2) particle-size, usually expressed in a size frequency distribution curve, that is the percentage less than stated size is plotted against the size of particles.

Instruments Used for Determining Atmospheric Dusts

Many instruments have been devised for determining the dust concentration in air and it may be well to give a brief historical review of this subject. The South African investigators began using the sugar tube method for the sampling of atmospheric dust in 1911; the same method was used by the U. S. Bureau of Mines as early as 1914. By this method a measured volume of the dust air is passed through a tube containing granulated sugar, which filters out the suspended dust. At the laboratory, the sugar is dissolved in water and the number of dust particles are determined by counting those in a small volume of the sugar solution under a microscope. This method of dust sampling had certain disadvantages, the chief of which was the fact that the purest commercial sugar contained a certain quantity of dust, which introduced considerable errors, especially in those samples containing a low dust concentration. To overcome the limitations of the sugar tube method various other devices were developed, one of which was the Palmer apparatus. This apparatus consisted essentially of a pear-shaped glass bulb, the lower end of which terminated in a U-tube or trap. Suction was applied to the glass bulb by means of an electric exhaust fan and the volume of air measured by means of a Petot tube. Dust-free distilled water was put into the U-tube. The air drawn through the water in the trap broke it up into a spray within the larger portion of the sampling bulb, which washed out and retained the dust. The dust so obtained was analyzed by the usual methods. The Palmer apparatus also had certain disadvantages, the chief of which was that its efficiency as a dust catcher was low. In the search for a more portable type of instrument, which at the same time would yield rapid results, the South African investigators introduced in 1916 a new instrument known as the Kotzé konimeter. The konimeter samples dust by impinging a small volume of air against the surface of a vaseline-coated glass plate, the vaseline serving to catch the dust particles. The dust retained on the glass plate was then counted under the microscope at a suitable magnification. The chief disadvantages of the konimeter are that in atmospheres containing a high concentration of dust, the spots are too dense to allow counting the individual particles and the method can, therefore, not be used in such cases, also many samples had to be taken to secure a correct average determination in places where the dust concentration was variable.

As a result of the different methods of dust determination being used by the different governmental bureaus and others, it was soon found that the various dust-sampling methods did not yield absolute results, consequently some confusion arose in interpreting the various dust studies. In order to arrive at some basis of comparison the U. S. Bureau of Mines conducted a laboratory study of dust-sampling instruments. The results of this study were published in Public Health Bulletin No. 144 entitled "Comparative Tests of Instruments for Determining Atmospheric Dusts." (1925) During the course of this study two of the investigators, Dr. L. Greenburg and G. W. Smith, devised a new apparatus called the impinger. In the comparative study the dust collecting efficiency of the impinger was found to be high, and in addition the method offered several advantages over previous methods. After several modifications to meet special requirements, this instrument was adopted by the Federal Public Health Service and Bureau of Mines as the standard technique for the sampling of dust in air. The instrument has been used in the study of a number of dust trades, and is the commonly accepted method in use today.

Size of Dust Particles Taken into the Lungs

It has been observed from a study of silicotic lungs that most of the dust particles that have penetrated into the air sacs are less than 10 microns in longest dimension (1 micron is 1/1000th of a millimeter, or 1/2500th of an inch). It is generally agreed, therefore, that we need not bother with particles larger than 10 microns in measuring the concentration of a dangerous dust.

So that you may visualize the size of these small particles consider a 280 mesh screen in which the screen openings are 50 microns. In the absence of a beam of light, an atmosphere containing these tiny particles will appear clear to the naked eye, and therefore is extremely deceptive. Only a powerful microscope can make such particles directly visible.

It is necessary, therefore, to make a microscopical examination of the atmosphere to learn how badly polluted it may be. Larger particles such as are visible to the naked eye are essentially harmless in the causation of silicosis, as these are caught by the membranes provided by nature in the nasal and other respiratory passages and are eventually coughed up or eliminated before any damage is done.

When small dust particles are dispersed in air, they are carried about like smoke and settle out very slowly. How long such particles will remain suspended in quiet air can be roughly determined from Stoke's law. Assuming a round particle to be one micron in diameter, it can be calculated by means of this law that such a particle will fall only 20.3 feet in 24 hours. It can be seen, therefore, that any fine dust dispersed into the air is not only a momentary hazard but remains in the air for an indefinite period. This fact is often overlooked by workmen, as it is usually assumed that as soon as the dust cloud is no longer visible all dust has settled out.

The term "dusty working place" is only a relative one. Most air, both inside and outside of factories, contains some dust. It is, therefore, necessary to adopt a standard content for the dividing line between slightly dusty and dusty working places. The Wisconsin dust code prescribes a "tentative figure of 15 million countable dust particles under 10 microns in longest dimension with free silica content of 35 per cent in a cubic foot of air as determined by Public Health Service technique. Variations in free silica content will make proportional inverse changes in this standard." In accordance with this standard the permissible count for practically pure silica would be 5,250,000 particles.

How Dust Samples are Collected

As mentioned previously, the instrument used in collecting the dust samples is that known as the "Impinger." With this instrument the air to be sampled is drawn through a glass tube and impinged at a high velocity on a glass plate which is immersed beneath a suitable liquid contained in the collecting flask.

The impinger, therefore, combines the principle of collecting dust by impingement with a water-washing or bubbling method and so possesses the advantages of both principles. The dust is thus trapped and remains in the collecting liquid. Suction is applied to the impinger by means of a steam ejector operated by compressed air. Where compressed air is not available, a small electrically-operated vacuum pump may be used. The rate of air flow is measured either by means of a small vacuum gage or an orifice-type flow meter.

The entire apparatus is calibrated before use against a standard gas meter, so that a known volume of air may be sampled. The rate of sampling is approximately one cubic foot of air per minute. The dust-collecting device is placed in close proximity to the breathing level of the workmen involved while performing their respective duties, so that air samples representing actual working conditions may be obtained. After a sufficient volume of dust-laden air has been sampled, the collecting liquid is placed in a suitable container and removed to the laboratory for the necessary analysis.

When the dust sample reaches the laboratory, the entire sample is filtered into a clean graduated flask through a 280-mesh screen so that only particles smaller than 50 microns are permitted to pass; particles larger than 50 microns are not considered injurious and are, therefore, removed from the sample. After proper dilution, the contents of the graduated flask are thoroughly shaken so that a uniform suspension is obtained, and two portions of about one cubic centimeter are removed with a pipette to just fill two Sedgwick-Rafter counting cells. The cells are allowed to stand at least 20 minutes and the dust particles are then counted by means of a microscope.

The microscope with an Abbe condenser is provided with an eyepiece micrometer, a 16-millimeter objective and a 7.X eyepiece. The eyepiece micrometer has a large square engraved on it, and this square is divided into 100 squares, one of which is further divided into 25 smaller squares. The proper tube length of the microscope is determined by calibration with a stage micrometer, so that a side of the large square of the eyepiece covers 1 millimeter (1,000 microns).

The large square of the eyepiece micrometer, therefore, encloses the dust in an area of one square millimeter, and since the counting cell is one millimeter deep, all the dust suspended in one cubic millimeter of the sample is under the ruled field. All particles visually less than 10 microns in longest diameter in one quarter of the field are counted at five points on the cell, namely, near the four corners and the center.

Two cells of each dust sample are counted and the average of 10 counts is obtained. Control counts are subtracted from the average sample counts, giving finally, average net counts of the number of particles which are then calculated in terms of particles per cubic foot of air sampled.

Having determined the concentration of dust particles less than 10 microns in diameter in a given atmosphere, it is also necessary to obtain information regarding the mineral composition of the dust before any evaluation of the health hazard can be made.

In general it may be said that the harmfulness of a quartz containing dust is usually in direct proportion to its free-silica (SiO_2) content. It is, therefore, necessary to distinguish between "free silica", that is the silica that occurs as quartz, and "combined silica", or the silica that is combined with other elements in the various silicate minerals. It should be borne in mind, therefore, that the total silica reported in the customary chemical analysis is no measure of the amount of free silica.

The quartz content of fine dusts is usually determined by a combination of petrographic and chemical methods. Each dust presents individual problems and no individual technique applies to all dusts regardless of their composition. Those interested in this problem should consult Reprint No. 1560 of the Public Health Reports, February 24, 1933, entitled "The Quantitative Determination of Quartz (free silica) in Dusts" by Adolph Knopf, Professor of Physical Geology, Yale University, and Consultant, United States Public Health Service.

Orig. paper
Du 94

Discussion of Dust Problems

By DR. LEONARD GREENBURG

Yale University, New Haven, Conn.

The speaker said in part: On the technical side of this problem you have been presented with two excellent papers by Mr. Jones and Dr. Meiter. There is little that I should add from this point of view. Perhaps the most valuable contribution that I can make is to present to you my own personal view of the broader administrative aspects of this problem gained as a result of many years of close contact. In order to do this, let us analyze the problem in its simplest terms.

We may begin by agreeing that pulmonary fibrosis results from the inhalation of certain dusts in known concentration over a sufficient period of time. This fact has been demonstrated repeatedly by means of industrial, laboratory and pathological studies. On this simple fact, I take it, there is complete agreement.

Such legitimate cases of disabling pulmonary fibrosis are held in many states to be the responsibility of the employer. Further, a perusal of the compensation laws makes it evident that there exists a decided trend in the direction of broadening the compensation acts throughout the Union for we find from time to time that additional states are being added to the list of those holding silicosis to be a compensable disease. We would certainly be blinding ourselves to the facts were we not to admit the existence of this trend in social legislation. It should be pointed out here that this is a very wholesome and desirable state of affairs. The insurance principle has justified its existence in spreading the burden of ill fortune over a long period of freedom from catastrophe and surely in the case of industrial accidents it has freed us from the deplorable state of affairs in existence prior to 1912. In the case of the occupational diseases we may hope for equally satisfactory results. Nevertheless, compensation insurance is not the complete solution of the problem at hand.

The only adequate means of avoiding the burden of silicosis is by the prevention of this disease. All other methods do not touch the crux of the problem and they carry in their wake a vast amount of litigation, illness, and a large financial burden on industry. If what we have agreed upon to this point is true it is obvious that industry must prevent the dissemination of dust in the workroom air by such adequate engineering techniques as are available; or in certain cases where this is not possible industry must provide, and force the worker to use, such means of personal protection as will adequately safeguard him against the inhalation of dust. It is only by these means that we can guarantee a future free of disabling pulmonary disease due to dust inhalation.

In spite of the very best efforts of industry to solve this problem there will undoubtedly be a certain number of cases brought to the courts and presented as legitimate cases of silicosis. While some of these are true cases of silicosis others, I have been informed, are not, but are designed merely as a means of obtaining funds from industry. A consideration of such cases brings us logically to the second part of the present discussion. What is the ideal method of handling compensation cases with reference to occupational disease and more particularly silicosis?

If we examine the development of the compensation acts we find that a technique designed primarily to adjudicate cases of industrial accidents has by degrees been given jurisdiction over occupational diseases. In fact, in some states diseases are regarded as injuries so that they may be brought within the scope of the original compensation acts. But on close examination it becomes apparent that diseases are far more difficult to adjudicate than are the ordinary injuries arising in industry. They present many technical facets and often require a detailed knowledge of this particular branch of medicine with which the average commissioner is very often unfamiliar. As a result we find in practice that the Court is presented with highly technical evidence by experts for the plaintiff and for the defendant which is very difficult if not impossible to satisfactorily evaluate. Often the commissioner is caught between the conflicting views of such witnesses and is not provided with his own experts to aid him in arriving at the real scientific background of the problem at hand.

What we really need is a strengthening of the technical side of the compensation acts to keep pace with the increased factual understanding regarding the occupational diseases. This does not merely refer to the Courts themselves but should begin with the promulgation of accurately worded compensation acts which clearly define the diseases for which compensation is to be paid. Compensation commissioners should be assisted by boards of technical experts composed of engineers appointed by the deans of the various engineering schools and of physicians appointed by the deans of the recognized medical schools. The engineers selected should have a very complete knowledge of factory conditions and the field of ventilation, and the physicians should be experts in the field of industrial hygiene and occupational disease. It is only with the aid of such highly specialized boards, or their equivalents, that the compensation commissioners may be able to do complete justice to both sides in these highly technical cases. It is the belief of the speaker that employers and employees alike would benefit greatly from the establishment and use of such boards. In order to hasten the establishment of this system employers are justified in appealing to their legislatures with this end in view; certainly such a legitimate demand should receive the hearty support of all concerned.

Frequently one is asked, what should be done with those claims which are based on little or no real evidence of injury to the worker but which are merely reared by some very enterprising attorney? Such claims are, I have been told, becoming very common of late and constitute a real problem to industry. It is obvious that the compensation advisory boards suggested earlier will, as soon as they are formed, serve the future as a healthy bulwark against this type of baseless claim and I venture to predict that few such cases would be favorably acted upon by a board of real experts in this field. At the present time factory officials should employ the very best legal talent available and should reinforce such legal talent with technical and medical experts thoroughly versed in the field of silicosis. Many cases have been lost by a failure to bring to bear the requisite technical aid required to prove the non-existence of a hazard. Here is an excellent example of a case in which money may be saved in the end by increased expenditures.

We now arrive at the final steps in the control of this problem, the physical and X-ray examination of the worker. Every factory should have pre-employment and routine post-examinations. It seems obvious that the burden of the health of the worker should not be placed on the plant without the privilege of the pre-employment examination. How can industry be legitimately expected to hire a worker "in the blind" as to his or her physical condition and then a day later be expected to shoulder the burden of the worker's health? By repeated physical examinations it is possible to discern the faint early deviations from normal health if any take place. In this manner the employer would be forewarned very early if any workmen showed lung changes suggestive of early silicosis. The routine industrial health examination on a broad scale throughout the major portion of American industry would constitute a public health procedure of major significance. By its means a very large proportion of the population would be aided in the prevention of the degenerative diseases of middle life which today constitutes such a real menace.

ADJOURNMENT

4. Eliminate protruding obstructions which workmen may strike against. Where this is impossible, post warning signs and paint the obstructions with bright colored paint. If you are going to speed up the tempo of the job and secure more results per hour for each man, the field must be cleared for quick operations back and forth. Some obstructions cannot be removed, and these should be marked so that quick detours are possible without slowing up the speed of the operation. Danger signs should be posted in passageways where there is insufficient overhead clearances. Runways and passageways should be kept free from loose materials and rubbish.

5. Adequate lighting, particularly where footings are uncertain or where there are dangerous projections, is important. As soon as a man is hurt on the job the news is instantly spread among all the workmen and they immediately slow up to prevent such an accident happening to them. The job cannot be kept in high gear if the men are thinking in terms of moving slowly and carefully.

6. Insist that all employees wear good heavy soled shoes. This is perhaps the easiest and simplest rule to support and the one that will be the most productive of results. In our own company we put on a "shoe examination" at payoff time with the warning that if they do not have heavy soles they do not need to come back Monday morning. If men are not afraid of stepping on something and injuring their feet, they will snap into the need that is required to reduce unit costs.

The cost of handling materials is one of the largest items on any piece of construction work and these costs can be lowered by safety rules such as the following:

1. Construct suitable toeboards around all floor openings and at the edges of the platforms, scaffolds and staging.
2. Caution workmen against placing tools, rivets, bolts or other materials at points from which they may be accidentally pushed or knicked off on somebody below.
3. Materials should never be dropped from overhead unless absolutely necessary. In such cases, make sure that any person below is warned.
4. Materials may be passed or carried from point to point and should never be thrown.
5. Never permit workmen to stand or walk beneath swinging loads.
6. Materials should be piled carefully so they cannot topple over.
7. Where it is necessary to stand bulky material, such as planks or forms on end, they should be placed so they cannot be blown over or upset.
8. Warn workmen against dislodging materials when taking supplies from piles or trucks.

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Silicosis

Occupational Disease Hazard of Silicosis in Construction Operation and Its Prevention

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The speaker said in part: This paper is based on approximately eight years of personal study of the effect of underground dusts on health and safety, supplemented by about twenty-five additional years of close attention to data and studies made by others. The subject will be handled from an engineering viewpoint rather than from that of the pathologist, the doctor, or the lawyer; and while this is unusual it should be logical, as the real solution of a serious and widespread industrial health problem, brought about by breathing dust, is that of prevention of dust disease.

There appears to be warrant for the conclusion that any dust, or combination of dusts—whether of a coal or metal mine or a tunnel—which is insoluble or soluble with difficulty in the fluids and tissues of the respiratory organs, is likely to be harmful ultimately to the health of underground workers, if it is present in the air in minute form and is breathed in large quantity over large portions of the working shift for any considerable number of months consecutively per year; some soluble dusts which occur in underground workings are also decidedly harmful. It appears that the quantity of dust in the air breathed more or less continuously, together with its lack of solubility or difficult solubility, governs the hygienic harmfulness of dust to workers much more than do the specific physical or chemical qualities of the dusts likely to be found in underground workings; this does not mean that air containing a large quantity of finely divided flint dust or similar hard, sharp, insoluble material is not likely to be more harmful than air containing a similar quantity of probably less inherently harmful dusts, such as very fine limestone, coal, or shale. Breathing comparatively small amounts of finely divided free silica or similar hard, sharp, insoluble, supposedly more dangerous type of dust is, however, likely to be much less harmful to health than breathing much larger amounts of less inherently harmful dust, such as that from coal, shale, hematite, ore, or limestone, or combinations of such dusts.

Physical examination of underground workers shows that men who work in very dusty places in coal mines have definite respiratory disease, whether the dust is from coal only or from a mixture of coal with rock or shale or clay. Men have worked in coal mines and have then gone to work in dusty metal mines or tunnels and have become affected by miners' consumption, or have worked in metal mines or tunnels and later have succumbed to respiratory disease after having worked in dusty places in coal mines. While dusts insoluble or difficultly soluble in the pores and tissues of the respiratory organs are chiefly responsible for respiratory disease in miners, there are certain soluble dusts of lead, arsenic, and other rocks or ores which are definitely poisonous or which result in material harm to the health of workers.

That the quantity of dust breathed is the important point in the harmfulness of dust is a certainty, yet to state what is that dangerous quantity or what is a safe limit is difficult, in fact, is impossible with our present facilities and knowledge. In South Africa an arbitrary limit of 5 mg., or 300,000,000 particles per cubic meter of air, was set. Their recent reports, however, give the average air dustiness of the working places as around or just over 1 mg. per cubic meter of air; there is probably not one dry mine or tunnel in the United States where the average air dustiness of working places is as low as 5 mg. per cubic meter of air (the South African standard) or 10 mg. per cubic meter of air (the standard set by Higgins and Lanza in their study of miners' consumption in the Joplin, Mo. district in 1915), and a recent state regulation restricts the number of dust particles to a maximum of 15,000,000 per cubic foot of air or about 530,000,000 per cubic meter. In general, the average air dustiness of working places of our dry metal mines runs above 20 mg. per cubic meter of air and many run above 50.

The outstanding remedy for the bad situation with respect to dust disease (in many localities a most distressing one) in underground workings is education—education of underground workers in the necessity of taking such precautions as are available; of employers in recognizing the seriousness of the situation and in providing devices and methods to reduce or prevent the incidence of disease and, if necessary, enforcing their adoption on the workers; of the doctors in correctly diagnosing the disease, giving publicity to its prevalence, seriousness, preventive remedies, etc., and in death certificates religiously assigning dust disease as the cause where such is the case; and of the merchants, newspapers, and other influences in the community in trying to prevent the disease rather than in hiding its existence.

As specific remedial measures for metal mines and tunnels, the writer suggests the following: mechanical ventilation, with a definite person or persons in charge, should be adopted to force moving currents of air in every place where men work in order to remove dust, heat, and gases. The use of water should be enforced in all drillings, in the sprinkling of ore and rock piles, in the wetting of timbers, man and haulage ways, and in every place where dust may be found. Where possible, the blasting should all be done after a shift; where this cannot be done there should be an enforcement of strict regulations as to the wetting of the region of blasting both before and after firing the shots, as to the removal of all explosive fumes by adequate air currents, and as to the prevention of entrance into a blasted place until all dust, fumes, etc. have been removed. There should by all means be strict physical examination of underground workers before employment and at periods of not more than six months during the employment, with prompt removal from dangerously dusty work should unfavorable physical symptoms be found.

In our coal mines education is also badly needed.

The dust health problem of the contractor is likely to be somewhat different than that of the mine operator—yet some of the factors are fundamentally similar. There is no question that far too much stress has been laid on silica dust and silicosis when the emphasis should be placed on the very definite dangers to workers in breathing a large quantity of any and all kinds of finely divided dust which the worker accumulates or is likely to accumulate day by day in his system; the resultant respiratory disease should be termed pneumonoconiosis or simply dust disease rather than silicosis or anthracosis, etc., since it is highly probable that no person has ever been incapacitated by the breathing of any single dust but rather by a combination of dusts.

While it appears that all dusts and combinations of dusts which are breathed into the respiratory passages in large quantities and over considerable time periods are likely to be harmful to health, unquestionably some dusts are relatively more harmful than others; some have effect in one manner, some in another; some dusts affect the lungs, some the bronchial apparatus, some the eyes, some the septum of the nose, some the stomach and some the skin; some individuals have considerable resistance to the harmful effect of breathing dust, others are readily susceptible to it; some nationalities are likely to succumb quickly to dust disease, and others are much better able to resist its inroads on health. Having breathed one kind of dust does not aid any human being to resist any other kind of dust; tuberculosis may accompany the other ills due to breathing of silica dust, but tuberculosis does not always accompany or result from breathing silica dust; tuberculosis may occur in connection with the breathing of coal dust or other dusts, though it is not so likely to be found in connection with coal and with some other types of dusts; silica as a rock, whether as free silica or as a silicate, is practically insoluble in water, but when in the form of very finely divided particles which float in air these very finely divided particles are readily soluble even in water; no human being knows what percentage of silica in a dust is likely to give silicosis, whether 5 per cent, 25 per cent, 50 per cent or more, and silicosis (so-called) is alleged to have been caused by breathing dust with as little as 3 per cent silica; no person knows what quantity of dust in air (silica or other dust) is likely to be dangerous though numerous arbitrary standards of air dustiness are given to the public, these standards ranging from as low as 250,000 particles per cubic foot of air to 15,000,000 particles; present methods of determining air dustiness, whether by weight or by count of particles, are anything but accurate or dependable; while the x-ray is unquestionably useful in determining the condition of the respiratory passages as to dust harm, it is improbable that any person can from the x-ray alone determine whether the person x-rayed has silicosis, anthracosis, or any other specific type of dust disease; practically every human being breathes silica dust, as 50 or more per cent of the earth's crust with which we come in contact is siliceous and probably 15 or more per cent is free silica and all of us breathe dust from fields, roads, etc.; dusty air, with high temperatures (say, over 80 degrees Fahrenheit) and high humidity, is more likely to be harmful because of dust than air with less trying temperatures; dust laden air contaminated with gases, such as high carbon dioxide or high carbon monoxide, is more likely to give ill health from dust than would air free of high content of extraneous gases; dust disease may incapacitate its victim or may kill him in less than a year from the time he first works in the dusty place, but in general it takes a much longer period; it is said that any person may work in a dusty atmosphere for several years without apparent ill health, yet several years after leaving the dusty work, may succumb to dust disease; generally when a worker has become afflicted with dust disease, it is impossible to cure him so as to completely remove the ill effects, and this is aptly expressed by a doctor in "The American Stone Trade", August, 1933, as follows: "No treatment for the cure of silicosis is known. We can't make stiff tissues soft again. Prevention is the only resource." It is said that sickness causes at least eight times as much loss of time to workers as to industrial accidents and unquestionably one of the most prolific causes of sickness of industrial workers is the breathing of dust; dust disease unquestionably is the scourge of the industrial worker of today.

What can and should be done about it?

First of all, industry should recognize that any and all dusts breathed in large quantities for a long period are likely to be dangerous to the persons who breathe them; then available measures should be taken to prevent air dustiness, the most essential being:

1. Use water in drilling, or sprinkling surfaces, or in connection with processes.
2. Use the best possible ventilation to sweep away any fine dust which may get into the air where people work.
3. Install the best available equipment to prevent dust formation.
4. Have every person in the organization undergo a real physical examination before entering the organization and at stated intervals (not less than annually), with removal from dusty air as soon as symptoms develop in the respiratory tract.
5. All those really interested in the preservation of the health of workers should familiarize themselves with available data as to dust dangers; a limited bibliography.
6. While there is now an enormous amount of litigation as to dust disease chiefly of the misnomer "silicosis", knowledge of a definite, dependable, accurate character about dust disease is woefully lacking and there is probably no more fruitful field for concerted, unbiased, disinterested investigation than that in connection with the health harmfulness from dust. Industrial organizations, co-operating with the state and the Federal government as well as other parties, should institute studies as to dust disease to have available authentic disinterested data for use not only in connection with the numerous court actions now pending, and likely to increase, but also as a solid background for state regulations and state laws which now are being framed without dependable data chiefly because no really dependable data are in existence.