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What Does the Worker Breathe?

By J. J. BLOOMFIELD*

A study of the dust content of the workroom atmospheres in various dusty industries

THE properties of a given dust which determine its capacity to produce pulmonary pathology are, the nature of the dust, that is, its chemical and mineralogical composition, its particle size, and finally the quantity of the dust dispersed in the atmosphere.

One of the outstanding results of the last 20 years of research in the field of dust inhalation is the demonstration of the fact that, in general, the degree of health hazards associated with the inhalation of any dust, all other factors remaining constant, is dependent upon the mineralogical composition of the dust. For example, it is now well established that the inhalation of certain types of dust, such as granite dust, will in time produce fibrosis of the lungs, at times associated with tuberculosis.

In other cases exposure to dust may result in the production of much less fibrosis without notable tendency toward subsequent tuberculosis; this is true of cement dust. And finally, there are certain types of dust, as typified by marble dust, which in the quantities and lengths of exposure so far observed produce little lung fibrosis. In general it has been found that those dusts which are high in quartz content are the ones which produce a disabling fibrosis of the lungs most readily.

So far as the size of the dust particle is concerned, it is apparent that in order for any given dust to produce injury to the lungs, it must gain access to the parenchyma of the lung, the site where the harmful effects of the dust take place. It is known that not all of the particles of inhaled dust gain access or are retained by the human lung. In this connection it is of importance to have regard to the size of the dust particles present in the industrial atmosphere.

With reference to the quantity of dust present in the air of a workroom it is apparent that when the dust concentration is high the exposed person will inhale a greater quantity in a given

period of time than he will when the dust concentration of the atmosphere is relatively low, and since the rate of production of the fibrosis is partially dependent upon the rate in which the dust is inhaled, this latter item plays an important role in predicting the relative danger of different environments. Hence the need for evaluation of the quantity of dust in the industrial atmosphere is obvious.

Nature of Dust

Research on industrial dust inhalation has indicated that so far as their fibrosis producing qualities are concerned, dusts may be divided into three groups:

1. Those composed completely of combined silica (silicates) such as pure asbestos.
2. Those containing free silica in the crystalline form known as quartz. (Granite contains approximately 35 per cent of quartz.)
3. Dust containing free silica in a non-crystalline form, such as diatomaceous earth.

In general, it has been found that the harmfulness of a quartz-containing dust is in direct proportion to its quartz content. For this reason it is of the utmost importance to ascertain the exact mineralogical composition of a dust in

attempting to evaluate its harmfulness.

It has been our experience that to determine the exact mineralogical composition of a dust one should resort to a combined chemical and petrographic analysis. By no other method have we found it possible to determine the amount of quartz present in a given sample. In certain instances, such as a mixture of quartz and pure potash feldspar, it is possible to determine the amount of quartz present merely by chemical analysis.

However, most dusts which come into question are mixtures of quartz and silicates. The average granite is made up chiefly of three minerals in about the following percentage proportions: feldspar 60, quartz 30, and mica 15. Chemical analysis shows that this average granite contains 70 per cent of silica. Of this 70 per cent, 30 per cent is present as quartz (free silica), and the other 40 per cent is present as combined silica, in chemical combination with other minerals that make up granite. It is possible to determine these proportions only with the aid of a petrographic microscope.

In practice, samples of dust settled out of the atmosphere at the breathing level of the worker serve admirably for both chemical and mineralogical determination. Table 1 presents the quartz content of dusts obtained in various industries which we have studied.

TABLE I
Percentage of Quartz Present in Various Industrial Dusts

Kind of Dust	Percentage of Quartz
Rock drilling dust (bituminous coal mine)	54.0
Granite cutting dust	35.2
Rock drilling dust (anthracite coal mine)	31.0
Brass foundry dust	19.0
Dust from raw mills in cement plant	6.5
Slate mill dust (Vermont red slate)	3.0
Silverware polishing dust	1.7
Anthracite coal dust	1.5
Bituminous coal dust	1.2
Cement dust	1.0
Slate mill dust (Vermont green slate)	trace
Talc mill dust	none
Marble cutting dust	none

*Sanitary Engineer, United States Public Health Service, Washington, D. C.

TABLE II
Average Dust Counts in Certain Dusty Trades

Industry and Occupation	Dust exposure in millions of particles per cubic foot	Average per cent of quartz in dust
Tule Mining and Milling:		None
Jack-hammer drillers	2,160	None
Packers	50	None
Muckers	45	None
Crusher men and cylinder men	14	None
Slate Finishing Mills:		3
Floormen	1,598	3
Loaders	1,276	3
Disc crusher operators	312	3
Quartz Grinding Plant:		99
Mill operators	173	99
Laborers	83	99
Packers	55	99
Granite Quarrying and Finishing:		35
Leyner drillers	144	35
Jack-hammer drillers	112	35
Hand pneumatic tool finishers	59	35
Machine pneumatic tool finishers	36	35
Plug drillers	37	35
Attendant labor (indoors)	17	35
Anthracite Coal Mining:		1.5
Miners and helpers	232	1.5
Attendant labor	31	1.5
Bituminous Coal Mining:		1.2
Coal cutters and loaders	112	1.2
Attendant labor	4	1.2
Marble Cutters	33	None
Cotton Cloth Manufacturing		None
Carders	9	None
Weavers and spinners	5	None
Silverware Manufacturing:		1.7
Dusty trades	5	1.7
Non-dusty trades	2	1.7

It is evident from this table that rock drilling occupations in the coal mining industry and certain occupations in the granite cutting industry and in brass foundries would be in the hazardous class as judged by the proportions of quartz in the atmospheric dust.

It has been demonstrated that particles of dust of a size greater than 10 to 12 microns in longest dimension are very seldom found in the lungs. This absence of larger particles is partly due to the fact that the numbers of such particles greater than ten microns in size present in industrial air is, as compared with the lower sizes, comparatively small; furthermore, these larger particles do not penetrate to the terminal portions of the respiratory tract. Hence we need only concern ourselves with those dust particles that are less than ten microns in longest dimension.

In order to ascertain whether or not an industrial dust is capable of gaining access to the lungs, it is necessary to know something of the size of the par-

ticles in the dust under consideration. In practice the samples for particle size studies may be obtained by the use of the Owens jet dust counter. The advantage of this instrument over other devices is that the Owens apparatus projects the atmospheric dust in unaltered condition directly on a microscope cover-slip. This cover-slip may then be properly mounted and examined by any one of several methods.

Quantity of Dust

In another method a microphotograph of the dust is made at a high magnification; the particles revealed on an enlarged print or screen may be measured by means of a millimeter scale. No matter which method one uses for particle-size measurements the results may be treated in the customary manner. The particles may be grouped in classes according to size, from which a percentage distribution curve is easily obtained.

As pointed out earlier, a knowledge of the quantity of dust dispersed in the

atmosphere is very important, since with any given dust the rate of production of the injury will be dependent upon the total quantity inhaled.

From the practical hygienic viewpoint, the particle count is at present the best quantitative index of the degree of atmospheric pollution. The decision as to the size range of the particles which should be included in the dust count is a question requiring careful consideration. Obviously the size of the smallest visible particle will depend on the magnification and type of illumination used in the microscope, the refractive properties of the dust and to some extent on the visual acuity of the observer.

We must bear in mind that our chief interest in this problem is in the industrial hygienic aspect. Primarily we are interested in differentiating between the dust content in the ordinary normal atmospheres, not yet known to be harmful, and certain industrial dusts which are known to be associated with lung damage. This difference is sharply marked so far as the dust particles between approximately one-half and ten microns in diameter are concerned; but the difference between such normal and abnormal air is masked and lost when we include in our determination the particles of ultra-microscopic size which are present in vast numbers in all air.

So far as the upper limit of particle size is concerned it has been demonstrated by the South African studies that particles greater than ten microns in longest dimension are, as a rule, of negligible importance. The data concerning the lower size limit of potentially hazardous dust is not so conclusive. Moir of South Africa, who examined microscopically 120 dust particles obtained from two specimens of silicotic lung, found that only 13 per cent of the particles were less than 0.5 microns and about 36 per cent of the particles were less than one micron in diameter. The majority of the particles, 60 per cent, were between one and three microns in size. The median size of the dust was found to be 1.2 microns in diameter. Drinker, in comparing the size frequency of the particles measured by Moir with the particles measured by him of the dust found in the sputum of men employed in ore mills, found a close correspondence. These findings have also been corroborated by Mavrogordato.

In connection with the lower limit of particle size of dust of pathological significance the following pertinent question arises: Aside from the evidence

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direct or indirect of the non-retention of minute particles of dust by the lungs, what evidence is there that appreciable percentages of ordinary industrial dusts ever fragment into those minute sizes less than 0.5 microns in diameter?

The best answer to this question would be data of actual measurement of such dust. Unfortunately we have but scant published data on the particle size frequency of dusts in the air of industrial establishments. In 1929 Fehnel made some particle size measurements in connection with the dust study of hard rock drilling in New York City. He reported the findings on three samples, which showed the dust which was less than 1 micron in size to vary from 1 to 15 per cent. Most of the dust in these hard rock drilling operations was between 2 and 5 microns in size. Badham, in studying the dust hazard among sandstone workers in Sydney, Australia, measured some 16,000 particles of dust in the air of work places and found that 67 per cent of these particles were about 1 micron in size.

In a particle size study of 25 samples of eleven different kinds of aerial industrial dusts made by the filar micrometer method at a magnification of 1,000 diameters, the speaker found that practically all of the dust was less than 5 microns in size. Only 2 per cent of the particles were less than 0.5 microns, 21 per cent were less than 1 micron, and the majority of the dust, 71 per cent, was found to be between 1 and 3 microns in diameter.

From all of the evidence therefore, and in the absence of conclusive proof to the contrary, it is apparent that we need only be concerned with those dust particles between one-half and 5 microns in size, and from a practical standpoint the lower limit of particle size to be counted may well be taken at about one micron. Many methods have been devised and used for the purpose of determining the quantity of dust in air. Suffice it to say that for the purpose of dust sampling in either high or low dust concentrations, the Greenburg-Smith impinger apparatus now finds universal favor. This instrument has been used by the United States Public Health Service in all of its dust studies during the past nine years and is also being used by other workers in this field in this country and abroad.

During the past nine years the writer has made numerous investigations of dust hazard in many industrial establishments throughout the country. In Table II, a summary is presented of the average dust content of the air in a few of these dusty industries. This table clearly shows that the highest dust exposure was in the talc mines, slate finishing mills, quartz grinding plant, coal mining and granite cutting industries. Owing to the high percentage of quartz present in the dust of the quartz grinding and granite cutting plants, as compared with the dust in the other industries listed in Table II, quartz grinding and granite cutting are revealed to be the most hazardous of the occupations we have studied.

The Driver and His Truck

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ding or slipping is practically a danger of the past.

The question naturally arose, "Why would a six-wheel truck pull easier or coast farther than a four-wheel truck?" Consideration of the following facts, gives a simple explanation.

On a four-wheel truck at least 90 per cent of the payload and body is carried over the rear axle. A paved road seemingly level will, upon examination, prove to be a series of little waves of varying heights. As you follow a passenger car or truck along one of your best paved city roads notice the rear end of the vehicle bobbing up and down. This means that the load must be lifted vertically every time it passes over a little bump in the road. Remember that if it takes but 30 pounds to pull a ton along a road, it takes 2,000 pounds to lift it in a vertical direction. This constant lifting of the load is accomplished by power developed by the engine.

In a properly designed six-wheel vehicle the two axles are pivoted at a central point. If one of the axles passes over a four-inch bump in the road, the pivot point and the load are moved upward not more than one-half this distance. Due to flexible spring mounting, the lift of the load will probably be considerably less than one-half. In other words, the load rides along practically on a level while the axles bob up and down over slight variations in the road surface.

Government statistics show that the

blow on the road struck by an axle the six-wheel type is only one-half that of the rear axle of the four-wheel type carrying the same load. Decreased shocks will, of course, increase the life of the chassis and body, at the same time greatly reducing the fatigue of the drivers. The drivers tell us that they can drive longer distances with less fatigue than on any four-wheel vehicle.

As it has been indicated that the truck rides easier and pulls easier, it would be natural to expect a corresponding gasoline economy. In pulling a four-ton or greater load on six-wheel trucks, operators average from 10 to 15 miles per gallon under actual operating conditions.

The possibility of safe and economical operation of motor vehicles is decided largely at the time of purchase. We assume that every fleet operator will take proper care of his equipment if satisfactory results are to be obtained. It is impossible, however, to obtain satisfactory operation from a truck which does not fit the operator's requirements.

Railroad Safety Men Meet in St. Louis

THE Safety Section, American Railway Association, held a very successful Regional Safety Conference in St. Louis, at the Statler Hotel, on March 22. A program of outstanding value was presented in two sessions.

During the day Charles E. Hill, Chief Safety Agent, New York Central Lines, Chairman of the Safety Section, American Railway Association, called attention to some striking facts in railroad safety. Accidental deaths on railroads, he said, amount to only five per cent of the annual accidental death toll, and only one per cent of the serious injuries of all kinds happen on the steam railroads. There has been only one year since safety work was organized on the railroads when accidents did not decrease. In 1913 there were 3,715 deaths to railroad employees, in 1932 there were only 557. In 1913 there were 171,000 injuries to employees, but in 1932 only 17,400. Thus casualties to employees have been reduced 85 per cent in 19 years; and passenger fatalities in the same time have been reduced 92 per cent.

"However," said Mr. Hill, "there are still thousands of deaths and injuries happening to employees and others on the railroads each year and the railroads still have a very serious problem confronting them. The safety movement still needs more aggressive leadership."