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Character and Composition of Industrial Dusts

Committee on Engineering Control Tells of Types of Instruments Now Available

INSTRUMENTS now available for determining the nature and composition of industrial dusts are discussed in a report to the National Silicosis Conference prepared by a subcommittee of the Committee on Engineering Control, headed by Warren A. Cook, of the Connecticut State Department of Health, Hartford, Connecticut. The subcommittee was headed by J. J. Bloomfield.

Size of Particles

So far as the size of dust particles is concerned, the committee points out, 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 lungs, the site where the harmful effects of the dust take place. It has already been shown that not all of the particles of inhaled dust gain access to or are retained by the human lungs. For these reasons it is of some value to determine the size of the dust present in the industrial atmosphere.

It has also been demonstrated that particles of a size greater than 10 microns in longest dimension are very seldom found in the lungs, due partly to the fact that the number of such particles in industrial air is comparatively small when particles in the lower size range are considered. Due to gravity, which causes rapid settling of suspensions, and due to the protective action of the upper respiratory tract, these larger particles do not penetrate to the terminal portions of the lungs. Hence, it is obvious that attention should be directed to those particles which are less than 10 microns in longest dimension.

The likely procedure for the sampling of atmospheric dusts for particle-size studies would be to employ the same instrument utilized in sampling dust for quantification.

Owens Dust Counter

In the past, the Owens jet dust counter has been employed extensively for such investigations, although of late impinger samples have been utilized for this purpose; comparative studies of the two instruments yield practically identical results. The Owens jet dust counter obtains a sample of dust from the air in more or less unaltered condition, since with this device the atmospheric dust is directly projected on a naked cover slip. Moreover, the instrument is small, compact, requires only hand power, and samples are obtained quickly and easily without needing much skill of operation.

Once these samples have been obtained and properly mounted, the dust particles may be measured by the use of a filar ocular micrometer at a magnification of 1,000 diameters (oil immersion objective). The horizontal diameters of at least 200 dust particles in several representative fields are measured for each sample. With this magnification it is possible to measure particles as small as 0.5 micron in size, while particles smaller than this size are easily distinguished at this magnification and their presence recorded.

Photographic Methods

Photographic methods have been suggested and used for measuring dust particles, but in order to obtain good photomicrographs it is essential that the dust particles be in one plane, free from Brownian movement and well dispersed. Since industrial dusts are seldom of a uinform size, it is difficult to fulfill the first requirement. Comparisons have been made between the results obtained with the direct filar measurements and the photographic method on typical industrial dust samples. This comparison demonstrates that the simpler and less expensive filar method yields practically the same results. Since the filar method fulfills the requirements of this problem, it is suggested for use in such studies unless permanent records are desired, where photographs might well meet the requirement. Another method for particle-size studies employed recently is the microprojection technique described by Brown. Still another technique for determining the size frequency of dust in air is that given by Green, using Patterson's graticule method.

This committee recognizes the fact that the major portion of the dust suspended in industrial atmospheres is of a size capable of gaining entrance to the lungs. Hence, the plant engineer will not be greatly concerned with the determination of the size of industrial dusts. The discussion of the size of dusts in air is presented in this report primarily for those who may be interested in this subject, especially when dealing with a dusty process heretofore not studied.

Composition of Industrial Dusts

The work of the past 20 years on the so-called fibrosis-producing dusts has demonstrated that, in general, the degree of health hazard associated with the inhalation of any dust, all other factors remaining constant, is dependent upon the mineralogical composition.

The determination of the composition of mineral dusts found in industry often presents appreciable difficulties and requires a somewhat different technique from that which is customarily employed in chemical analyses. For certain dusts a combination of chemical and petrographic methods may be necessary. In other instances the ordinary chemical methods will suffice. The difficulty with petrographic studies of dust is due to the fact that the size of dust in the air is much smaller than that which lends itself to usual petrographic technique. For this reason it has been found necessary to utilize samples of dust which have settled on rafters, ledges, and on other objects in the workroom. In many instances such samples of settled dust will not be of the same composition as the dust that is actually suspended at the breathing level of the worker. Hence the recent practice has been to analyze, in addition to the settled dust, the dust actually suspended in the air, which may be collected by the ordinary type of vacuum cleaner, using a paper bag as a filter.

Concerning the chemical composition of various mineral dusts found in industry, the reader is referred to such treatises on this subject as *The Analysis of Silicate and Carbonate Rock*, by W. F. Hillebrand, and *The Commercial Granites of New England*, by T. Nelson Dale, both of the United States Geological Survey. A chemical method which has been found useful for the determination of free silica in certain minerals is that described by Selvig. A petrographic method recently

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the same method as developed by Messrs. Bogue and Lerch, except for the end point. End points (1) and (3) have been in general use, but end points (2) and (4), the idea of which was conceived by the Working Committee, found greater favor among those who tried them. The latter end points are specified in the recommended methods, end point (2) for the preferred method, and end point (4) for the alternate method. Method IIa-IIIa is a combination of method IIa and method IIIa and gives the operator his choice of barium chloride and sodium chloride as accelerator. These methods, rewritten in A.S.T.M. style, are recommended for publication as tentative, to be included in the present *Tentative Methods of Chemical Analysis of Portland Cement* (A.S.T.M. Designation: C 114) of the American Society for Testing Materials.

The Working Committee gave serious thought to the possibility of recommending method IV as a second alternate method, but it was decided that it was not advisable to recommend too many alternate methods when one alternate method in the form of method IIa-IIIa would satisfy the requirements in most cases for a quick method of test. On the basis of averages and probable errors, as compared with method Ia, method IV seems to have a tendency to give high results with clinker low in free lime; but, as a whole, it compares favorably with methods IIa and IIIa. The A.S.T.M. methods are primarily for the purpose of acceptance tests. Any laboratory would be justified in using method IV for obtaining information which is not intended for the acceptance or rejection of cement.

Discussion of Methods

Method V did not find very much favor among those co-operating laboratories that were able to obtain the necessary apparatus. The expensive equipment required is probably the chief objection to the method. Some of the operators also had considerable trouble in getting rapid and clear filtration, which was possibly due to lack of experience with the method. It is possible for an experienced operator to obtain results that check fairly well with results by method Ia.

On the average, method Ia requires about 7 hr. for a determination, while method IIa-IIIa requires about 3 hr. When only one or two determinations are to be run, method IV or method V may be used to good advantage, as each requires only 1 hr. or less per determination, but these procedures require constant attention. When a larger number of determinations are to be made in one day, most operators will find it more satisfactory to use method IIa-IIIa, because it does not require constant attention and they can attend to other work at the same time.

Anhydrous or nearly anhydrous glycerol was required for methods Ib, IIb, and IIIb and directions were given for its preparation from ordinary glycerol. Two of the co-operating laboratories in this country reported the purchase of anhydrous glycerol, but the Working Committee was unable to locate a source of anhydrous glycerol in this country.

One of these two laboratories obtained some glycerol which was labelled "c.p. anhydrous special glycerol." Several months after its use, its specific gravity was determined and the water content was calculated to be 1.6 per cent. Complete information about this glycerol could not be obtained from the dealer.

The other laboratory used glycerol which a well-known manufacturer markets as "special-absolute-pure glycerine, c.p." at a high price. Tests of the material indicated that it contains 5 per cent of water. This has been taken up with the manufacturer, but as yet a reply has not been received.

Meaning of "Chemically Pure"

It seems that some dealers of laboratory supplies have the impression that "chemically pure" glycerol is 100 per cent glycerol. It is natural, but erroneous. It is obvious that water is not considered to be an impurity by manufacturers. In the method a note has accordingly been included calling attention to the possible presence of water. Five per cent of water is allowed, but it is necessary to test the glycerol in order to be sure that this limit is not exceeded.

The work of the investigation shows that when a salt is not used to accelerate the solution of free calcium oxide in the glycerol-ethanol method, the result is not affected by water whose content in the solvent may be as great as 0.8 per cent. On the other hand, when a salt is used as accelerator, there may be an appreciable decomposition of sample, which is increased by the presence of water. However, the method, in which such an accelerator may be used, can be employed only as an alternate method and is subject to a check by the standard method in case of dispute. The removal of water from glycerol would mean additional expense. For these reasons anhydrous glycerol is not specified, either in the preferred method or in the alternate method. A note has been inserted calling attention to the tendency of the alternate method (method B) to give higher results than the preferred method (method A), and to the value of occasionally checking results of the alternate method by the preferred method.

CHARACTER OF DUSTS

(Continued from page 211)

described by Ross and Sehl has been found to be of value in determining free silica in dust. A paper discussing general petrographic methods and their specific application to industrial dust analysis with particular emphasis on those properties that are used in the identification of particles less than 10 microns in diameter has been recently published by Williams, together with the technique which he employs. However, a combination of both chemical and petrographic methods is, in most instances, advisable, and the procedures employed for such determinations have been fully discussed by Knopf. An excellent treatment of the entire subjejct of the determination of the composition of industrial dusts is also discussed by Drinker and Hatch.

It is apparent from the present discussion of the determination of the composition of industrial dusts that there is a great need for a standardized procedure on this subject. The entire matter should be a subject of research in order that there may be developed some simple and easy technique capable of being employed by a chemist or engineer. A method which shows some promise has recently been described by Clark, which employs X-ray diffraction technique.

This committee desires to call attention to the fact that the accurate determination of the composition of an industrial dust is not a task which can be readily performed except by a specialist well versed in the field of chemistry and mineralogy.

Accident Statistics for 1938

NATIONAL Safety Council, 20 North Wacker Drive, Chicago, has published a series of annual statistical reports on various industries, including one headed *Accident Rates in the Cement, Mining and Quarry Industries*. The report carries 9 pages (8½ by 11 in.) of accident statistics, covering figures on all phases of the accident-prevention record for the calendar year 1938.

Devices for Quick Sampling of Industrial Dusts

A QUANTITATIVE basis upon which plant engineers may approach the dust problem, not only from the viewpoint of exact studies of the concentration and character of industrial dusts, but also from the standpoint of determining dust concentration quickly and in routine fashion, is presented in the report to the National Silicosis Conference by the Committe on Engineering Control, of which Warren A Cook[1] is chairman. The report was prepared by the subcommittee on the determination of concentration and character of industrial dusts, headed by J. J. Bloomfield.

Sampling of Dusts

The range in dust concentrations encountered in industries is very great, depending on the industrial processes, the devices installed for mitigating the dust created, and the efficiency with which such devices function. For these reasons an ideal instrument should be one capable of sampling with equal efficiency in both high and low dust concentrations. This requires a dust-collecting medium which will not add dust, to any great degree, to the dust in the sampled air. Furthermore, the collecting medium must be uniform in dust content, so that one or two control tests on this medium will be sufficient for a series of samples.

Since the dust content of industrial air is ever varying, it is essential that the dust-sampling instrument be capable of collecting air for any desired length of time, in order to obtain a representative picture of existing conditions. And finally, the ideal instrument will be one that requires only a simple and fairly rapid method of analysis.

At present there are no instruments which may be said to be ideal. However, several devices which have been used for many years approach the above requirements.

The Impinger

The impinger apparatus and the methods of sampling and enumeration of dust as adopted by the Public Health Service, the American Public Health Association, and others, have been employed for more than 13 years as a standard instrument and procedure for detailed dust studies. This instrument and the technique of sampling and enumeration have been shown to be of practical value as a method for the study of the industrial dust problem, and for this reason the committee recommends the impinger procedure for use in basic studies of the dust problem, especially in those studies which embrace medical, engineering, and statistical phases of the problem. Other devices also are available for the sampling of dust over a continuous period. These are the electrical precipitator, the paper thimble, the electrostatic precipitator and the hot-wire thermal precipitator.

One of the problems confronting the engineer is a rapid method of evaluating the effectiveness of any measures or devices which may have been installed for the control of dust in industry. It is quite obvious that for control purposes dust determinations are unnecessary when visible clouds of dust are present. However, when dealing with lower concentrations, it is valuable to have data both before and after the installation of suppressive measures. Furthermore, the intelligent engineer will desire to have daily or weekly records of dust concentration in various parts of a plant. For such purposes, some simple device requiring but little skill in sampling and evaluation is highly desirable. At the present time there are several instruments which may be used for this purpose, but none is ideal. Development of more satisfactory and convenient routine dust determinators is needed.

The Konimeter

The konimeter, which samples dust by impinging air at a high velocity against a sticky glass plate, has been employed for many years in South Africa, where it was first developed, as well as in this country. The type of konimeter most frequently used in this country is the one employing a circular glass plate which is revolved to produce a ring of dust spots near the periphery. The konimeter has been found to be highly efficient, and may be employed for concentrations not exceeding 35 million particles per cubic foot of air. It calls for very little skill in sampling, is light, simple and quick to handle, needs no power for operation, and requires only a microscope for enumeration. The disadvantages of this instrument are that the dust can not be weighed or analyzed chemically, the device obtains only a grab sample, and is limited to dust concentrations of 35 million particles per cubic foot or less. This limit, however, is usually sufficient in determining whether or not a hazard exists.

This device has undergone several modifications. One type is equipped with a microscope that permits counting of samples without recourse to laboratory procedure.

The Owens jet dust counter is another device that collects a grab sample. This instrument works on the principle that when air containing dust passes through a narrow orifice facing a glass surface a short distance away from the jet, the dust will adhere to the glass. In this instrument this result is achieved by causing a very fine, ribbon-shaped jet of air to strike a microscope cover glass situated about 1 millimeter from a slot-shaped opening forming the jet. The air, before entering the slot, is passed through a damping chamber, and the velocity in the jet is such that a fall of pressure results, in this way bringing about a condensation of moisture. The air is then deflected and the dust, being unable to turn the corner, strikes the cover glass: the velocity of the air drops, the pressure and temperature rise, causing the water to be evaporated and to leave the dust behind. This device has undergone two modifications, each of which tends to make it more useful in control dust studies. A second form of this device is now being manufactured in this country. The latter type has as yet not been tested in actual practice. Another instrument which may be employed for routine control work is the photographic dust counter, developed by Ficklen and Ott.

Improved Equipment Needed

There is a definite need for improvement in dust-determination apparatus that will allow the engineer at the plant to obtain an indication of the dust concentration in the air without the necessity of extensive training in the utilization of elaborate instruments or tedious laboratory procedures. Some of the methods cited herein for use in routine

[1] Connecticut State Department of Health, Hartford, Connecticut.

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[1] Connecticut State Department of Health, Hartford, Connecticut.

control studies, or modification of them, can be used for rapid and facile determination of industrial dust, but each has serious limitations. It is hoped, however, that new devices or methods may be developed which will come nearer to approaching this need than those now available.

It is the desire of this committee to point out that the purpose of dust sampling and enumeration with these simpler devices, as well as with the one recommended for detailed studies, is not to measure the absolute dust concentration but to obtain an index of the dustiness of the air associated with a process.

In connection with the use of simple instruments and methods for the evaluation of industrial dust in routine control studies, it is desirable, when possible, that some relationship be established between the method used and the standard and more exact procedures followed in detailed studies. This is especially desirable with reference to determinations of dust concentrations for the purpose of knowing whether or not dust conditions in a plant are within certain requirements of State codes. The tendency at present is to write definite limits of dustiness into some State codes. Hence, in determining dust concentration values that are to be related to code concentrations a method must be used that has a definite relation to the method employed in establishing the code value.

Big Re-Dedication Service at Buffington by Universal Atlas

MORE than 2,000 people, including employees, friends, and customers of Universal Atlas Cement Company, and local civic leaders, gathered at the company's Chicago plant at Buffington, Indiana, on Friday afternoon, June 30, to celebrate an outstanding safety achievement of 1938. The occasion was the rededication of the Portland Cement Association safety trophy which the plant first won in 1934, and again in 1938, for completing a calendar year without a lost-time accident.

Speakers who praised the employees for the teamwork and co-operation necessary to establish the record were Professor Frank C. Hockema, assistant to the president, Purdue University; Frank T. Sheets, president, Portland Cement Association; Blaine S. Smith, president of the company, and J. H. Kempster, general superintendent of the plant. Professor Hockema appeared as a substitute for Dr. E. C. Elliott, president of Purdue University, who was unable to arrive in time to deliver his address. Dr. Elliott arrived at Buffington later in the day to view the trophy and to meet officials and guests of the company who appeared on the program. Other speakers on the program were J. P. Lewis, assistant general superintendent of the plant, who, on behalf of the employees, responded to the presentation of the trophy, and E. E. Moore, general superintendent, Gary works, Carnegie-Illinois Steel Corporation, who introduced Professor Hockema.

In his address, Mr. Smith praised employees for the teamwork and co-operation which had made possible the perfect safety record in 1938, and announced that the trophy re-dedication was the twenty-seventh of its kind to be held at the company's plants. In discussing the type of teamwork that exists at the Buffington plant, he said, "Here at Buffington we have a happy family group. It is portrayed by the service record of employees. There are in the audience today a number of persons who have worked with the corporation for a quarter of a century or more, and who have now retired on pensions. A great many of you who are active employees have had 15 to 20 years of service. The average for all employees at Buffington plant is more than 10 years, and those with the rank of foreman and above have an average service record of more than 22 years."



Two Universal Atlas employees have service record of 34 years without a lost-time accident

Mr. Smith paid special tribute to the outstanding safety records of two Buffington plant employees. "We have two men here at Buffington," he said, "who have spent more than 34 years in this plant—John Kluga and John Skuta—and during this long service they have never lost any time because of accidents. Theirs is an enviable record."

Coal Analysis Directories Now Available

FOR the first time in the history of the coal industry, it is now possible to obtain complete, authentic information on the analyses of any size of coal, from every shipping mine.

National Coal Publications, Pittsburgh, Pa., has obtained and compiled complete copies of all analysis data, filed with the National Bituminous Coal Commission by the District Producers Boards. These figures cover practically every size produced by every shipping mine within each district. They are, without doubt, the most exhaustive and the most truly representative of the quality of coal as shipped, that have ever been compiled or made available to users of coal.

These figures are being published in separate books for each district. Clear, easily read type is being used, and all books are well bound for permanent use. The books are of a small handy size, measuring approximately 5½ by 7½ in.

Lehigh Bids Low on Cement for Grand Coulee

LEHIGH Portland Cement Company's bid $1.54 f.o.b. mill at Metaline Falls was low for approximately 550,000 bbl. of cement for Grand Coulee dam, says the Spokane (Wash.) *Review*. This call for bids covers a portion of the remaining quantity of 3,662,000 bbl. required to finish the dam.

Spokane Portland bid $1.70 for furnishing 534,000 barrels at its Irvin plant. Five Washington, four California, two Oregon and one Montana company participated in the bidding, delivery requirements of the procurement division at Washington, D. C., being 1,897,000 barrels for the remainder of 1939, and 1,765,000 for 1940.

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Director of Research, Portland Cement Association

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