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The Cement Mill Edition of Co[illegible] is edited exclusively for those interested in the manufacture of portland cement and related products.

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INHALATION OF DUST
and Control of Dust Hazards

By W. C. JAMES
Safety Engineer
Portland Cement Association
Chicago, Illinois

THE first part of this article, published in the July issue, discusses the concentration of industrial dusts and points out the harmless character of cement dust; but the need for more knowledge about dust is emphasized. The present concluding part takes up matters such as the effect of duration of exposure, and the adoption of preventive measures.—*Editor.*

THE United States Public Health Service has developed a formula for calculating the actual exposure in terms of particle hours. They recommend in Bulletin 217, "The Determination and Control of Industrial Dust," that the particle concentration in any area be multiplied by the number of hours an employee works in that area; that this product be calculated for each hour of the working day and that the total of these products be divided by the number of working hours to give the equivalent of continuous exposure during the day.

Equivalent Exposure

For example, a man may spend two hours a day in a concentration of 200 million particles per cubic foot; three hours in a concentration of 10 million particles; one and three-quarter hours in a concentration of 40 million particles and 15 minutes in concentration of 1200 million particles. The man's exposure would be calculated:

Hours per day a	Dust Concentration b	Particle-hours (millions) a and b
2	200	400
3	10	30
2¾	40	110
¼	1040	260
8 Total Hours		800

800 particle hours in millions per cubic foot =
8 hours
100 million particles per cu. ft. daily exposure.

Paper read before the Quarry Section of the All-Ohio Safety Congress, May 11, 1938.

The application of this formula in a practical problem is apparent. If you find, from a study of concentration and silica content, that in two or three areas in your plant atmospheric dust exceeds safe limits, you will make an analysis of the exposure by the P.H.S. method and attack that point where employee exposure is the greatest.

How Long in Developing

How long does it take silicosis to develop? The answer to such a question must be equivocal. Much depends on the physical condition of the worker. A man whose respiratory passages have been damaged so that dust is not readily excluded by the usual protective mechanism, may contract silicosis more readily than a man with normal nasal and bronchial passages. Also a man whose lungs have been damaged by pneumonia or tuberculosis may develop silicosis more quickly. We are probably all familiar with the reverse of this; i.e., that a man with silicosis has much less resistance against tuberculosis than a man with un affected lungs. This fact, incidentally, suggests one of the outstanding differences between the action of silica and other dusts. Medical authorities state that not only does the silicotic lesion in the lung resemble the lesion in tuberculosis, the silica actually stimulates the activity of tuberculosis and, at the same time, conceals its symptoms until it is far advanced. The seriousness of such a condition may readily be imagined. A tubercular with significant quantities of silica in his lungs may be rapidly getting worse, yet diagnostic symptoms are often lacking. Frequently only a careful X-ray examination can reveal the presence of tuberculosis in a silicotic. Mr. P. N. Bushnell, speaking before the Metals Sections of this Congress last year, emphasized the fact that the real danger from silicosis is not silicosis at all, but tuberculosis. First or even second degree silicosis, uncomplicated by tuberculosis, usually causes relatively slight disability, seldom pronounced enough to interfere with working capacity. No worker should be deprived of an opportunity to earn a living at his regular job because his X-ray shows some signs of nodulation. The job should be cleaned up by approved engineering methods, of course, but discharge of workers who are perfectly capable, simply because of a non-symptomatic condition which hysterical opinion has magnified out of all proportion, is certainly not the solution of the problem. Inert dusts do not produce the typical nodular lesion, nor do they cause any increased susceptibility to tuberculosis. In the cement industry, for exam-

The dragline conveyor is a prolific source of dust ple, only 4 per cent of the X-rays of 1700 employees revealed old tuberculosis lesions and 96 per cent of these lesions were healed or quiescent. Studies of absenteeism over a two-year period, covering the majority of mills in the industry, confirms the X-ray evidence. The mortality rate from tuberculosis of 0.07 per 1000 employees in 1937 is only 8 per cent of the tuberculosis mortality rate of 0.87 per 1,000 employed males established by the National Tuberculosis Association in a comprehensive survey in 1930.

Factors That Control

The various factors which may influence the length of time required to develop silicosis, if we may recapitulate, are (1) intensity of dust concentration, (2) proportion of free silica in the dust, (3) proportion of working time employees spend in the dusty atmosphere, (4) condition of employee's upper respiratory tract, and (5) condition of employee's lungs.

In any case, it is extremely doubtful that first-stage silicosis will develop in less than seven years, except in the presence of active tuberculosis. Dr. Gardner says that for silicosis to develop in five years, the exposure must be intense. The National Silicosis Conference report, to which we have previously referred, says with admirable skepticism, "There are reports of a few cases of the disease developing in as short a period as one and one-half years. In these instances, the individuals were exposed to excessive concentrations of extremely fine silica in almost a pure state." The report then states that exposure to low concentrations of silica may sometimes continue for thirty years before the condition develops to the stage where it can be called silicosis. In such cases, possibly another 15 or 20 years would be needed before any disability would be noticed. A great majority of the cases have had at least seven years' exposure. Thus it will be seen that silicosis is a very slowly developing disease, which, in the absence of infection, is not especially dangerous. In the presence of infection, however, the picture may be different.

Control of Dust Hazards

No attempt has been made to separate the two sections of this paper, as indicated by the title, since the discussion of the problem is too intimately bound up with the methods of solving it. There are, however, some details of prevention which should be mentioned.

It might be worth while to think about the methods of determining dust concentrations. The quick sampling, easy counting devices on the market now probably fill a definite need, but their use is not altogether an unmixed blessing. The standards mentioned in this paper are all based on the United States Public Health Service's impinger technique with light field count. It is a complex technique requiring skill and experience to operate successfully, but it is the standard counting method in the United States and results of short-cut methods have not been shown to be correlative with it. After dust control has been instituted and the impinger technique has shown that concentrations are within safe limits, a simpler technique might be permitted for periodic checks on the efficiency of the control system. But don't be surprised if your counts with the simplified technique soar way above the impinger counts. The dark field illumination will uncover a large number of particles, apparently too small to have any effect, that are screened out by light field methods. The result is similar to the effect of a strong beam of light in a dark room. This difficulty can be overcome to some extent by taking impinger samples and samples by the other technique simultaneously, as soon as dust control equipment is installed, thus getting as much correlation as possible between two techniques at the beginning.

Remove Dust at Source

A general paper of this type is not a suitable place to discuss the relative merits of different types of dust control systems. There are, though, a few principles which can be properly mentioned. Wherever possible, dust should be removed at its source, before it reaches the workroom atmosphere. Methods of accomplishing this vary with the process and should be decided upon by competent engineers after a careful study. In milling processes, closed, dust-tight systems with adequate separators and collectors may be adequate. Water sprays are sometimes effective where they can be used. In the quarry wet drilling is often all that is necessary to bring concentrations down to safe limits. Sometimes more elaborate dust traps are needed, either independently or conjunctly with wet drills.

Some processes are not amenable to control at the source. In such cases employees should be required to use respirators or masks of approved type. All of these methods have their place. The right one for each location must be determined by a thorough engineering survey.

The importance of good housekeeping can not be too strongly emphasized. Much of the dust nuisance can be eliminated by systematic, routine and thorough clean-up programs. The advantages are obvious. The plant is much better looking and, in addition, the atmospheric dust is reduced.

Medical control is equally important. The only sure way to know that a hazard does not exist is the careful observation of the workers over a period of years. Pre-employment examinations are, of course, also important for proper placement of applicants.

Salient Features of Problem

In this paper we have presented some of the salient features of the silicosis problem. We have, first of all, emphasized that only two pneumoconioses are actual diseases, silicosis and asbestosis.

We have pointed out that there are three causative factors of silicosis and all three must be present simultaneously to produce the disease

1. Uncombined silica in small particles, of which the most dangerous is probably quartz.
2. Sufficiently intense concentrations of the dust to be hazardous. This concentration is set at five million particles (light field count) of quartz less than ten microns in greatest diameter, if the quartz constitutes a high percentage of the material. Studies in the cement industry have demonstrated that, in cases, appreciably higher concentrations of quartz can be tolerated when inert dusts, as clay or limestone, are intermixed with silica.
3. Exposure by the employees over a sufficiently long period to high concentrations of silica of the necessary fineness.

The influence of silica on tuberculosis is strong, whereas inert dusts have no effect on this disease. Serious disability from silicosis, especially in the first two stages, usually results from infection, rather than from the uncomplicated disease. If the working environment is adequately clean, a silicotic need not be denied work as long as he is free from infection and is capable of doing his job.

Medical Control Is Important

Methods of control of the disease include pre-employment and periodic medical examinations, removal of dust at point of origin, emphasis on good housekeeping and the use of respiratory pro-

(Continued on page 222)

Huron Establishes Distributing Plant at Green Bay

HURON Portland Cement Company has put into operation that company's twelfth packing and distributing plant at the Leicht dock at Green Bay, Wisconsin. Previously-built distributing plants owned by Huron are located at Detroit, Oswego, Buffalo, Cleveland, Toledo, Wyandotte, Saginaw, Alpena, Muskegon, Milwaukee, and Duluth.

Cement for the Green Bay packing and distributing plant is brought from the Huron's Alpena cement plant in the company's own bulk-cement lake steamers, the largest of which has a cargo capacity of 40,000 bbl.

At Green Bay the bulk cement is transferred to the cement company's boat *Samuel Mitchell*, which is lashed to the dock and will serve temporarily as a "warehouse" until the necessary construction and installations on shore can be completed. The *Samuel Mitchell* brought the first cargo of bulk cement totalling 15,000 bbl. Dredging operations are enlarging the slip in which this boat is docked, and when this phase of the work is completed the floating "warehouse" can be moved further in, thereby enabling other boats to dock directly back of it, to unload their cargo.

A cement packing machine having a capacity of 1,000 sacks an hour has been installed on the dock alongside the *Samuel Mitchell*. From the hold of the ship, cement is pumped into a steel bin over the packing machine, and is fed to the packer for sacking as required, to fill orders from the trade, the cement being forwarded either by rail or by motor truck. Cement can also be shipped from the Green Bay distributing plant in bulk-cement railway hopper cars, although this type of railway rolling stock is not, as yet, generally available. Only a few railways have supplied themselves with such rolling stock, and they have only a small number of these special cars.

With twelve packing and distributing plants operating at ports on the Great Lakes, the cement company's bulk-cement carriers will make regular stops and unload whatever cement is required.

Andreasen's Method for Determination of Fineness

IN a report presented to the Twenty-Second General Meeting of the Association of Japanese Portland Cement Engineers, Prof. Toosaku Yoshioka, of the Imperial University at Kyoto, gave confirmation to the correctness of results from the use of Andreasen's pipette method for the determination of fineness of powdered materials.

From his experience in the fineness determination of Japanese clayey materials for the last three years, he has come to recognize the value of Prof. Andreasen's pipette method as one of the best of present methods for scientific as well as technical determination of fineness of powdered materials.

He tried to introduce this method to the field of cement research and factory control, and explained about the principles, apparatus and manipulation, and concluded that this method would be worth attention for cement chemists because of the simplicity of the apparatus, easiness of manipulation and correctness.

He also mentioned a few points necessary to get fair results; i.e. complete elimination of bubbles adhering to the particles, by placing the suspension in a vacuum vessel, placing the whole apparatus into a thermostat to prevent temperature fluctuations and avoid convection disturbances, and recovery of solvents when ethyleneglycol, alcohol, etc. are used.

The Association of Japanese Portland Cement Engineers has its offices in the Teikoku Building, in Osaka, Japan.

INHALATION OF DUST

(Continued from page 217)

tective equipment where removal of dust from the atmosphere is not possible.

It should be emphasized that control, especially engineering control, of the silicosis hazard is the phase of the problem that is of greater importance to those of us who are interested in the practical methods of eradicating the disease.

Dr. A. A. Riddell of the Ontario Department of Health, whose work in the gold fields of Ontario has won for him an international reputation, put the problem squarely up to the engineers when he said: "Silicosis is an occupational disease declining in importance. Its prevention is not a medical problem. As it occurs exclusively through the inhalation of dust containing silica, its prevention depends on the eliminaton of dusts industrially produced. This is a problem for the industrial engineer. Engineers have met the problem so energetically and with such intelligence that the occurrence of silicosis in many operations now considered hazardous will cease entirely during the next fifteen or twenty years."

Heats of Hydration and Transition of Calcium Sulfate

HEATS of hydration and transition of calcium sulfate are discussed in a detailed report by Edwin S. Newman and Lansing S. Wells, published by the National Bureau of Standards as *Research Paper RP-1107*, and appearing also in the June (1938) issue of the *Journal of Research* of the National Bureau of Standards.

The heats evolved in the hydration to $CaSO_4.2H_2O$ at 25° C. of $CaSO_4.1/2H_2O$ prepared by treating gypsum with steam in the autoclave, and of $CaSO_4$ prepared by heating gypsum at 1,000° C., have been determined and found to be 4,100 plus or minus 30 and 3,900 plus or minus 20 cal/mole, respectively. The heat evolved in the hydration to $CaSO_4.2H_2O$ of soluble anhydrite prepared by dehydrating gypsum at 75° C. is not less than 6,990 cal/mole. During the progress of this work no indications were found of more than two anhydrous forms of calcium sulfate; soluble anhydrite, and a modification formed rapidly at high temperatures, the latter being identical with natural anhydrite. The heat evolved in the transition of soluble anhydrite to natural anhydrite is not less than 3,000 cal/mole.