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ATMOSPHERIC DUST IN CEMENT PLANTS

Some ten years ago the U.S. Public Health Service, in a bulletin on the health of workers in Portland cement, stated that the inhalation of cement dust produced a pneumonoconiosis which, however, had never been followed by symptoms in the fifty-three men investigated. Last year the Portland Cement Association published a report of sickness absenteeism and mortality in eighty-one cement plants for the year 1937, when it was found that some 14,000 employees had shown no evidence of unusual amounts of chronic respiratory illness. More recently Gardner, Durkan, Brumfiel, and Sampson[1] record the results of an investigation of the environmental conditions in seventeen cement plants located in various parts of the U.S.A., and report on the physical and radiographic examinations of all the 2,278 employees in eleven of these. The principal raw materials from which Portland cement is prepared are limestone, shale, clay, sand or sandstone, and blast furnace slag, but there is a considerable variety of substances which may in some regions be substituted for or added to these. The content of free silica (SiO_2) in these primary materials varies very greatly in different regions—for example, limestone varies from 0.3 per cent. to 11 per cent., shale from 19 to 36 per cent., clay from 11 to 38 per cent., sand or sandstone from 32 to 91 per cent., while blast furnace slag has all its silicon present as silicates. A representative sample of a Portland cement had roughly the following composition: tricalcium silicate, 50 per cent.; dicalcium silicate, 19 per cent.; tricalcium aluminate, 13 to 14 per cent.; tetracalcium aluminoferrite, 11 per cent.; calcium sulphate, 3 per cent.; free lime, 1 per cent.; magnesia, 1 per cent.; free silica, 0.01 per cent. The extremely low content of free silica is the rule with these cements, the authors having found by petrographic and chemical analysis of seventeen samples from seventeen plants that the maximum was 0.12 per cent. and the average 0.04 per cent. It is thus reasonable to expect that such silicosis hazard as may exist in cement works is likely to be found not in the handling of the final product but during the making up of the primaries before the firing, which converts the free silica to silicates. In their study of the atmospheric dust these authors made extensive dust counts by the impinger method, using both light and dark fields, the latter to detect any high incidence of very fine dust particles.

In a typical cement plant there are the following principal sections: a quarry or mine, a crusher house, a raw mill, a burning department, a finishing mill, and a packing house. Accessory to these are such units as a coal mill, storage bins or silos, maintenance and repair shops, testing laboratories, bag houses, yards, and railroad equipment. The drilling of holes for the blasting of the rock is not attended by much dust as the drills are lubricated with water, but the drilling for secondary blasting of the larger fragments of rock is done with jack-hammers, so that the men must take advantage of the wind to avoid high concentrations of dust. Dust counts as near the face of the drill worker as possible gave figures varying from 2 to 83 million particles (10 μ and less in diameter) per cubic foot. Shovelling and loading the trucks involve little exposure to dust; counts at the breathing zone of men varied from 0.3 to 9 millions. Clay and shale are too soft to need drilling, and sand or sandstone is usually received in truck loads from other sources. Primary crushing of the rock is done in a gyratory jaw or roll crusher, which is fed by men from the trucks; this gives rise to considerable dust, but most of the particles are large and natural ventilation prevents high concentrations. High counts were obtained at the discharge chutes, but no men are stationed at this point. Secondary crushing is done in hammer mills, sometimes completely enclosed, and creates a good deal of fine dust, but exposure of the men is intermittent. The transport of the crushed rock to the rotary driers and thence to the raw mills is done mechanically, and on the whole exposure of men to dust is not great. In the mills the crushed limestone and various added materials are reduced to such size that 90 per cent. passes a 200-mesh screen. The process may be wet or dry, and in the latter case the dust counts are fairly high (3 to 239 millions) in the preliminary stages and very high in the final (37 to 631 millions). This material, wet or dry, is now transferred to large rotary kilns which are fired to produce temperatures of 2700° to 2800° F. by powdered coal, oil, or gas. The kiln rooms are not specially dusty, and when the material leaves the kiln all the originally free silica has been combined to form calcium silicates. From this stage onwards the workers are never exposed to significant concentrations of free silica, and protective measures are directed against the general problems of dust—for example, mechanical packing, bag sorting, and cleaning machines.

It is pointed out that so far as the quarrying operators are concerned the dust problem is not peculiar to the cement industry, but in the grinding of the shales and clays mixed with limestone the dusts are of unpredictable composition and behaviour. In thirteen out of seventeen raw mills the air-floated dust contained 5 per cent. or more free silica, and in six the free silica varied between 15 and 60 per cent. Fractionation of the air-borne particles near a mill grinding limestone with a shale containing 24 to 36 per cent. quartz showed that about 7 to 30 million particles per cubic foot were 3 μ and less in diameter —that is, were of dangerous dimensions—but other factors have to operate before it can be concluded from such investigation that a silicosis hazard exists—for example, the particles must be dispersed in the air, and probably their surfaces must be relatively

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[1] *J. industr Hyg.*, 1939, **21**, 279.

clean, for quartz particles tend to form aggregate with particles of other substances, thus leading to the formation of larger particles and more readily settling dusts; further, the mashing of the softer clays on to the quartz surfaces leads to particles much less irritating to living tissues.

By physico-chemical investigations alone it is difficult to forecast the degree of silicosis hazard, and hence the crucial test is the clinical and *x*-ray examination of the exposed workers. Of the 2,278 people examined in this way, 1,979 were employed in the plants, where they were exposed to dusts of various kinds. The majority of the men were white Americans of slightly higher age distribution than in most industries. Over 55 per cent. had been engaged in the cement industry for more than ten years and nearly 33 per cent. for more than fifteen years; eighteen men had been employed thus for more than forty-five years. These figures show an unusual employment stability. When compared with the dust hazards in hard rock mining and other silica industries the problem in the cement industry is trivial. The total incidence of first-degree linear exaggeration in the *x*-ray films of the cement group (15.09 per cent.) was less than half that in a group of rock miners, and for the second degree the frequency (2.4 per cent.) was about one-thirteenth. Only eight of the 2,278 employees showed evidence of nodular fibrosis attributable to dust, and in six of these previous employment might have been responsible. The incidence of tuberculosis and other chronic pulmonary infections was less than that in the general population; the tuberculosis occurred in typical form and at the same age periods as in non-exposed persons. The authors conclude that prolonged inhalation of cement dust has no unfavourable effect upon susceptibility to tuberculous infection or upon its subsequent evolution.

INDUSTRIAL HEALTH IN WARTIME

The Industrial Health Research Board, a part of the organization of the Medical Research Council, is in direct succession to the Committee on the Health of Munition Workers which was set up during the last war. A restatement of some of the findings of that committee should be very timely in combating the notion, if it still exists, that efficient output can run parallel with excessive hours of work. It is more than ever necessary, when a new "industrial front" of enormous extent has been assembled, that, in Emerson's phrase, the machine should not unmake the man. The Board has therefore published an Emergency Report[1] summarizing not only the experience gained in the last war but the results of the study of industrial conditions which has been continuously proceeding ever since. In doing so it makes the comment that the need of the moment is not so much for new research as for the application of knowledge already gained. The report devotes a special chapter to industrial fatigue, pointing out once again that an extension of the usual hours of work does not—except for short periods during an emergency—result in a proportional increase in output; on the contrary, it causes the rate of output to fall off with increasing rapidity. An unbroken spell of four and a half to five hours is generally too long. Modern industry has already learned the usefulness of rest pauses as a necessity to health, contentment, and efficiency. Other important questions in the elimination of fatigue are posture while at work, the discovery of the most suitable load for the individual, the value of rhythmic movements, and the abolition of movements which are unnecessary and faulty. In addition to calling for the maintenance of Sundays and holidays, the report suggests that other measures to diminish boredom might include variations of work and the provision of (not too distracting) music. If the Army has its band, why should not the munition workers have their orchestra?—but in many factories the music would be drowned by noise.

On the subject of light and vision the report has a number of recommendations to make. The essentials of artificial lighting are described as a sufficiency of light to enable everything to be seen quickly and accurately, and a controlled distribution in order to avoid glare, to light the surroundings as well as the work, and to eliminate troublesome shadows. Inadequate illumination increases the lag between vision and performance and adds to the amount of spoiled work. It is a common experience that when, after a period of gloom, the lights are turned on, the *tempo* of work is immediately raised. The Board lays down certain standards for illumination which are known to be consistent with a high standard of performance—for rough work, two to four foot-candles; for medium work, requiring discernment of fairly small detail, four to ten foot-candles; and for fine and very fine work, ten to one hundred foot-candles. Good vision for the task is not entirely a question of good lighting, but includes the correction of eye defects and the provision of special optical aids when very fine work has to be done. Heating and ventilation are of great importance, especially in view of conditions created by the "black-out." Both lack of warmth and overheating cause discomfort and therefore inefficiency. The conditions which any system of heating and ventilation has to satisfy are clearly laid down. Ventilation at the rate of not fewer than six air changes per hour is ideal, though it is admitted that in winter this standard may sometimes be impracticable on the ground of heating costs. The air temperature in winter for individuals doing light work should be as nearly as possible 65° F.; for more active work somewhat lower ranges of temperature suffice. In summer it may generally be impossible to keep factory temperatures down to the winter maximum, nor are such temperatures desirable in very warm weather. The supply of fresh air should not be less than about 1,000 cubic feet per person per hour, preferably more, and the relative humidity should not generally exceed 70 per cent., preferably less. On the difficult problem of ventilation in the "black-out" certain special arrangements for different kinds of factories are mentioned.

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[1] *Industrial Health in War.* Emergency Report No. 1 of Industrial Health Research Board. (H.M. Stationery Office. 6d. net.)