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# TRANSACTIONS

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**Incorporated**

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The Cleveland, Carter and Statler Hotels

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# Dust in Industry

## FRIDAY AFTERNOON SESSION

### October 5, 1934

The session devoted to a discussion of Dust in Industry was called to order by Dr. E. G. Meiter, Director, Industrial Hygiene Laboratory, Employers Mutual Liability Insurance Co., Milwaukee, who presided. Dr. Meiter briefly welcomed the delegates and then introduced the first speaker.

## Types of Dust That Cause Occupational Diseases

By LEROY U. GARDNER, M.D.

Director, Saranac Laboratory for the Study of Tuberculosis, of the Edward L. Trudeau Foundation, Saranac Lake, N. Y.

The speaker said in part: Experience has demonstrated that the lung tissues can tolerate very large amounts of most kinds of foreign dust particles without serious interference with function. The lung may be intensely pigmented by colored dusts with no evidence that respiration is impaired. But dusts composed, in whole or in part, of silica have been shown to be dangerous because they stimulate the growth of the connective tissues of the lungs and bring about the formation of scar tissue. This destroys the normal elasticity of the organ which is necessary for respiration and it thickens the delicate membranes so that a free interchange of gasses is impeded. Fortunately, these results only follow the prolonged inhalation of very large quantities of silica.

Experiments have demonstrated that the injection of silica into the tissues of animals kills the cells where the substance lodges and excites an inflammation. When healing takes place a very dense and characteristic kind of scar tissue forms. Most non-siliceous dusts produce no inflammation and very little scar. It has been shown that such changes do not follow the injection of silica unless the particles are very fine, three microns or less in diameter, and unless enough of them localize in one area. With larger particles the rate of reaction is so slow that little change occurs within a year. As a general rule, the finer the particles, the more rapid the cellular response. The reaction to fine silica begins within four or five hours and it continues for a period of years.

If the silica is combined with bases in the form of silicates, it rarely produces such active and progressive changes. The silicate of magnesium, asbestos, does cause the formation of scar tissue in experimental animals and in the human lung, but most other silicates are not generally recognized as irritating. Recently it has been claimed that a hydrated silicate of aluminum and potassium, called sericite, is responsible for most of the cases of silicosis. This silicate, a transformed feldspar, is often associated with quartz and it has been identified in the lungs of persons suffering from silicosis. However, at least two types of sericite have failed to excite significant changes when injected into animals. Experiments with this substance are still in progress. Kaolin, an alumino-silicate of potash, has also produced quite characteristic changes in the lungs of rabbits. But our present knowledge does not permit us to assume that silicates as a class will produce serious tissue damage.

Most observers now believe that uncombined silica, or quartz, is poisonous to the tissues because it is slowly dissolved in the fluids of the body. Certainly the majority of the experimental observations suggest a chemical injury, but it is difficult to understand how enough of such an insoluble substance as quartz could be dissolved within eight hours to produce a well marked, acute inflammation. If solubility were the only factor one should discover a more active response after the injection of the more readily soluble silicates, but such is not the case. Formerly it was held that silica produced its effect mechanically. The hard sharp quartz particles were believed to abraid the lung surfaces and excite the formation of scar tissue as a manifestation of healing. This theory is no longer tenable for when animals are injected with other hard, sharp particles like diamond, carborundum or aluminum oxide, there is no inflammation and practically no formation of scar tissue. Ultimately it may be shown that the irritation of silica is due to some unrecognized property possibly related to its atomic structure.

When quartz particles are inhaled they produce three specific effects which are not excited by any other type of dust yet studied. They alter the behavior of the pulmonary phagocytes; they stimulate the formation of circumscribed nodules of scar tissue; and they subsequently increase the susceptibility of the lung to infection, especially tuberculous infection.

Phagocytes that ingest too many quartz particles are killed by this irritating substance. As the cells die they liberate their burden and several new phagocytes come out to take it up again. By a repetition of this process enough phagocytes accumulate so that many of them ingest only a few particles. Under such circumstances the stimulus is not strong enough to kill but merely accelerates the motility of the cells. They naturally tend to leave the air spaces, enter the lymphatic vessels and accumulate in the lymph nodes. This process becomes more rapid under the influence of the irritating silica and very considerable numbers of particles are consequently localized in the nodes.

After six or eight years the quartz in the nodes has caused a marked overgrowth of the fibrous elements in these structures. Ultimately the reaction develops to such an extent that the node is entirely replaced by a mass of coarse, glassy scar tissue fibres, often several times as large as the original node. Such nodules encroach upon and compress the lymphatic vessels. The drainage system of the lung is choked and effective removal of subsequently inhaled dust is gradually diminished. Dust now accumulates around the lymph vessels and sheets of scar tissue develop in this location.

These preliminary changes do not constitute the disease, silicosis; they involve only the lymphatic system. The respiratory tissues are not appreciably affected. In good stero X-ray films these preliminary changes may be visualized as a thickening and beading of the shadows cast by the blood vessels together with a widening of the shadow of the root of the lung. The blood vessels are thickened because the most important lymphatic vessels course through their walls. The beading is due to the minute nodules of silicotic scar tissue in the lymph nodes within the lung. The root shadow is widened because of the silicotic reaction in the lymph nodes in this location.

If still more dust is inhaled it can no longer be effectively carried off through the lymph vessels. The phagocytes now carry it into the walls of the air spaces. Often the cells group themselves in nodules but sometimes they are scattered. In these locations the silica again stimulates the formation of scar tissue. The result is a general thickening of the septa between the spaces and nodulation throughout the functional portion of the lung. This change seriously interferes with function as interchange of gas cannot take place through the thickened walls of the air spaces and the tissues lose their normal elasticity. Less involved air spaces dilate and their walls stretch, producing the condition known as emphysema, which is also incompatible with effective respiration.

With the formation of silicotic nodules in the functioning parts of the lung the disease, silicosis, is said to begin. On the X-ray film such nodules cast clear cut, round shadows. As they increase in number and size they blot out the formerly accentuated linear shadows of the blood vessels. In a well marked case both lung fields may be thickly seeded with hundreds of such sharply defined, rounded, nodular shadows. Where there is emphysema, often at the bases, no markings are visible and the film appears black.

The condition of silicosis is a progressive one and it continues to develop after a man has left his dusty occupation. Serious results only follow, however, when he leaves with many nodules in the lung tissue itself. As such nodules increase in size they replace important functional elements. Obviously the continued growth of only a few nodules situated in the lymphatic system could have little effect other than to increase the obstruction already present.

The serious part of silicosis is its frequent complication by tuberculosis. This may arise from reactivation of a pre-existant latent infection or it may result from a new infection from without. The danger of infection increases with the amount of silicosis present. The course of the infection in the silicotic is usually chronic and it often fails to produce characteristic symptoms for months or years after its onset. Many times it is accidentally discovered in routine X-ray examination of groups of active workmen. However, evidences of disability are much more marked in silicotic individuals with infection than in those with uncomplicated disease. Occasionally tuberculosis may run a very acute course in the silicotic subject but this is also true in other persons. The cause of the susceptibility of the silicotic lung to tuberculosis is not perfectly understood, but it would seem that the action of the silica on the tissues creates a medium favorable for the growth of the bacteria. The tubercle bacilli multiply and a slowly progressive tissue reaction ensues, but the usual clinical symptoms of tuberculosis are often held in abeyance for a long time because the chances for absorption of poisonous products of infection are minimized by the obstructed lymphatic system. It is also possible that some of these poisons may be absorbed on the silica particles, as Cummins has suggested. Ultimately the infection gains the upper hand, symptoms develop and death from tuberculosis ensues.

The only other type of dust which is generally recognized as a cause of severe pulmonary injury is asbestos, a silicate of magnesium. This substance is fibrous in character and is more readily soluble than quartz. Apparently the protective upper respiratory mechanisms seem inadequate to prevent the inhalation of many such fibres and even quite long ones may penetrate into the finer bronchial tubes. These structures have irregularities in their walls which seem to hold the fibrous dusts. In this location the asbestos particles are surrounded and ingested by phagocytes. The cells do not seem to be particularly irritated for they are not especially numerous nor do they migrate rapidly into clumps as in the case of phagocytes dealing with quartz. Apparently most of them carry their burden of asbestos fragments directly into the walls of the tubes in which they lie. The mildly irritating dust sets up a proliferation of the connective tissue cells in the walls resulting in collar-like thickening of the tubes. Contraction of the new connective tissue narrows or closes the tube and thereby shuts off the ingress of air to the more peripheral air spaces. These spaces then collapse, a condition known as atelectasis. This in itself is a cause of fibrosis or scarring of lung tissue. The result is a fibrosis of numerous relatively small areas in the lung due to the collar-like constricting fibrosis about many small terminal bronchial tubes. The lymphatic system seems to play little part in disposing of asbestos dust and very insignificant amounts of this dust are found in the lymph nodes.

Not a few cases of asbestosis die of tuberculosis or bronchopneumonia but the prevalence of the former infection is probably much less common than in silicosis. Surveys of large groups of asbestos workers fail to reveal such a high incidence of tuberculosis as found in similar studies on silica workers.

The inhalation of unusual amounts of non-siliceous dusts apparently fails to produce significant alterations in the lung. It is of course possible that injurious ones may ultimately be discovered, but none are recognized today. The non-siliceous particles enter the lung and are ingested by phagocytes as in the case of quartz. The cells are not stimulated to move very rapidly and as a consequence many of them remain within the air spaces for a long time. Some, particularly those containing relatively few particles, make their way into the lymphatic system and accumulate in the lymph nodes. In sufficient concentration, or perhaps because they are mixed with small amounts of silica, they set up a low grade, non-progressive chronic inflammation. But this reaction results only in a little thickening in the lymph nodes and about the lymphatic vessels. The lung tissue may be variously pigmented, black from coal or red from iron, but there is no formation of scar tissue that interferes with function. The susceptibility to tuberculosis of the person with such pigmentation is not increased but it is apparently quite definite that pneumonia is unduly prevalent in coal miners and that chronic bronchitis results from the inhalation of cement. The X-ray films of men working in non-siliceous dusts shows either nothing at all or a more or less marked accentuation of the linear shadows cast by the blood vessels. This, of course, is due to the chronic inflammatory changes about the lymphatic trunks in walls of blood vessels.

The effects of mixtures of free silica and non-siliceous materials are less clearly defined and should receive more serious attention. It would seem unwise to assume, as has been done in the past, that the non-siliceous substances serve only as inert diluents and that only the quartz component of a dust is of significance. Experimental and clinical data are accumulating which suggest that at least some other dusts may materially modify the action of quartz, both in its capacity to produce nodular fibrosis in the lungs and to increase the susceptibility to tuberculosis. For example, animals inhaling heavy concentrations of a mixture of equal parts of pure silica and hematite dust for eight hours a day over a period of 14 months have shown not even the slightest indication of nodule formation in the lung, whereas pure quartz dust, inhaled for only two hours a day, produces definite nodulation. It also seems to be true that animals inhaling such a mixture are much less susceptible to tuberculosis than those exposed to pure quartz. In the case of the human iron miner, some lungs show definite silicotic nodulation, others only a very few nodules and many no nodules at all. All exhibit heavy deposits of iron particles with a cellular connective tissue reaction. When these findings can be correlated with chemical analysis of the lung tissues and the approximate amount of rock work which these miners have performed, some relationship between the exposure to silica and the fibrous nodule formation may be established. Tuberculosis in these iron miners is apparently less prevalent and much less severe than in men exposed to pure silica. What has been said of iron miners is also probably true of foundry workers and coal miners. It is generally accepted that men in the latter occupation have less tuberculosis than the average for the age period; Cummins believes that they have the infection but that it is so atypical and benign in its manifestations that it escapes diagnosis.

Mention should also be made of mixed dusts like certain slates and granite containing large amounts of free silica in combination with silicates. Experimentally these substances behave atypically and do not produce nodular fibrosis unless there is complicating infection. The same may also be true in human beings. Unquestionably such dusts are capable of producing typical silicotic nodules and they predispose to tuberculosis. From a theoretical standpoint they should receive much more intensive study to clarify our views on the whole subject. At the present time it appears that the action of their quartz component is modified and partially neutralized by the other substances which they contain.

## Using Exhaust Systems and Respiratory Equipment To Protect Workers Exposed to Dust

**By STUART W. GURNEY and DAVID S. BEYER**

**Liberty Mutual Insurance Company, Boston**

The speaker said in part: A number of our states have had references to dust elimination in their labor laws for a good many years, but no state has as yet thoroughly enforced these laws. The codes of five states which we investigated provide that grinding, buffing and polishing wheels should be exhausted, although two of the states exempt from these provisions wheels on which water is used.

This seems ill-advised, since a study of wet and dry grinding in Connecticut by Winslow and Greenburg has shown that the application of water does not by any means eliminate the dust hazard.

It may be remarked that, with everything else equal, a high static suction will give a higher velocity at the point of origin of the dust, fume or gas than a low one; but this alone is not a measure of the effectiveness of any exhaust system. Wisconsin has adopted the principle of specifying a limit to the number of dust particles of respirable size per cubic foot of air. After all, this is what we are primarily interested in, to keep the dust contamination down to a point where it will not be harmful.

These variations and conflicting provisions in state codes merely reflect the general lack of authoritative standards. It is accordingly fortunate that definite steps are now being taken by the American Standards Association to develop the proper basis for such codes. There are two committees working on this problem; the Ventilation Code Committee, sponsored by the American Society of Heating & Ventilating Engineers, and the Exhaust Code Committee, sponsored by the International Association of Industrial Accident Boards and Commissions. It is also arranged to appoint sub-committees to take up five specific subjects: Abrasive cleaning, chromium plating, granite cutting, rock drilling, and spray coating. In addition, a Sub-Committee on Fundamental Principles of Design and Operation and Maintenance of Exhaust Systems will be appointed.

The two most important considerations in an effective exhaust system are: 1. Velocity of air flow; 2. Arrangement of the inlets (from the standpoint of nearness to the dust source, shape, etc.).

Many an installation that is otherwise all right fails to remove the dust successfully merely because there is not enough air being drawn through the system. In a series of tests that were conducted under actual working conditions by Theodore F. Hatch, Department of Industrial Hygiene, Harvard School of Public Health. a machine used in dressing stone was employed, and it was noted that with an air flow through the hood of 230 cubic feet per minute, there were over one hundred million dust particles in the surrounding air. When the air flow was increased to a little over 250 cubic feet per minute, the dust concentration had dropped to forty million, a marked improvement. As the air flow was further increased, the drop in dust concentration was relatively slower, and it took a volume of about 380 cubic feet per minute to bring the dust concentration down to ten or fifteen million particles per cubic foot, which was considered reasonably safe for this type of dust.

It is accordingly possible sometimes to take an installation that is not satisfactory and, if the remainder of the system is well designed, by merely speeding up the blower or adding a larger one, to bring about the desired results.

Another very important consideration is to get the inlets of the exhaust system as close as possible to the source of the dust. The drop in efficiency as we get further away from the inlet is really surprising to one who has not studied the principles involved. It should be remembered that if we have the open end of an exhaust pipe or air duct in operation, the air tends to flow in from all sides, even from behind the opening. As we move away from the end of the pipe, the velocity drops very rapidly, so that even at a distance of five inches from the hood the velocity may be less than 10 per cent of that right at the hood inlet. This is the most important consideration to keep in mind and one which is frequently lost sight of in designing exhaust systems. It is not uncommon to see an exhaust inlet a few inches in diameter with which the person making the installation hoped to draw dust from a distance of several feet, but the air flow even a foot or two away from the entrance to the inlet may be negligible.

Still another important consideration having to do with the design of the inlet, is the addition of a flange. The effect of this flange is to cut down the air that would flow in from behind the opening, thus drawing it nearly all from the front. Thus the efficiency of the system is substantially increased and the scope of the exhaust extended appreciably, without increasing the power consumption or otherwise adding to the expense of keeping up the system.

There are also other considerations of perhaps lesser importance. For example. air cannot be "pulled" from a distance by merely directing an exhaust pipe toward the point in question, but it can be "pushed" or blown, directionally, for a considerable distance. This principle may be used advantageously in directing the dust toward the opening of the exhaust inlet and thus getting the desired results with a lower exhaust velocity and power consumption than would be required if suction alone were depended upon. This principle has been applied effectively in drilling material containing asbestos, where the exhaust inlet is placed at one side of the drill and a small air jet at the opposite side of the drill, blowing across the table, turns the particles that would fly out from this side and directs them back into the exhaust system. It is also being applied to foundry shake-out work.

Other considerations in designing exhaust systems include the elimination of unnecessary bends or curves, the provision of clean-out doors, and the proper construction of joints. Where there is a general ventilating installation and one or more exhaust systems, care must be taken to see that they do not conflict with each other.

After an exhaust system has been installed it should be tested by taking actual dust counts to see that the dust is really being cut down to the desired point, and such counts should be taken at intervals after the installation has been made, to see that it is still functioning properly.

The fact that the dust particles that cause the trouble are so small that they are invisible under ordinary conditions (less than 10 microns or 1/2500th of an inch in diameter) often makes it hard to convince the practical plant manager that there is any dust present; it also makes it impossible to tell, without the use of special instruments, whether the completed exhaust system is actually removing the dust.

It might seem like an insult to one's intelligence to say that after an exhaust system has once been installed it should be maintained in good operating condition. However, the numerous cases one encounters in the plants where this obvious necessity is not carried out, indicates that it is really one of the major considerations in connection with the elimination of dust or fumes. Cases are not unknown where the blower has in some manner become reversed so that the air is being ejected and diffusing the dust, rather than drawing it in; other instances where the efficiency of the system has been lowered or its value nullified by clogging up, disconnection or wearing out of the piping, etc., are all too common.

One concern, of which the writers have knowledge, has a "U" tube permanently installed in one of its main exhaust systems so that the foreman or safety man can tell at a glance whether there are any changes that would indicate a break-down in the system. All such installations should have regular inspections by some competent person as a routine part of their upkeep.

It will be sufficient here to discuss respiratory equipment very briefly. The simplest form of this equipment is the filter respirator. Such respirators have a definite value for temporary use such as sweeping up, cleaning out bins, shoveling materials, etc., but they require careful fitting and constant supervision to see that they are being properly used.

It is our opinion, after watching the sincere efforts in a number of plants to enforce the use of these respirators, that it is rather impracticable to require them to be used on full-time operation. One notices the men, under these conditions, surreptitiously pushing the respirator aside and gasping in free air like a fish out of water. Certainly, if they are to be used any considerable length of time, frequent rest periods should be allowed where the men can get out into the free air for a few minutes refreshment.

There are also the large air-fed helmets, with which most of us are familiar, used for sandblasting, etc., which have been carried to a high state of perfection for the purposes to which they are adapted.

We believe, however, that much more use could be made advantageously of the type of apparatus that lies midway between the filter respirator and the air-fed helmet, namely, the light, air-fed respirator which covers the nose and mouth and leaves the rest of the face exposed. With a light hose attachment, this device offers considerable freedom of movement, and if air outlets were supplied so the hose could be quickly transferred from one outlet to another it would seem to be practicable to use them over a considerable area. They afford the advantages of a pure air supply without excessive weight and without the restriction to breathing that is imposed by the filter respirator.

# The Medical Supervision of Workers Exposed to Dust

By W. J. McCONNELL, M.D.

Assistant Medical Director, Metropolitan Life Insurance Co., New York City

The speaker said in part: The harmfulness of dusts varies widely in accordance with the physical and chemical natures of each individual substance. Certain dusts are soluble or slightly soluble in the body fluids and their harmful effects are proportional to the toxicity of the compounds formed. Lead, mercury, and arsenic are examples of poisonous dust. Other dusts exert their harmful effects locally on the skin and mucous membranes and through irritation to the respiratory passages. Chronic acid and alkalies are examples. Attention recently has been called to the probably harmful effect of dusts arising from radio-active ores. A fourth group of dusts which are insoluble or very difficultly soluble in the body fluids may initiate harmful pathological lung conditions. These may be subdivided into non-fibrosis and fibrosis producing dusts. The organic dusts, mainly the vegetable fibers, such as cotton, jute, hemp, etc., are non-fibrosis producing dusts. The fibrosis producing dusts are limited, so far as we have evidence, to a few of the inorganic mineral dusts, such as free silica, crystalline silicon, quartz, and certain combined silicates. Of the fibrosis producing dusts, those having a high percentage of free silica are admittedly the most important because exposure over a period of years to such dusts distinctly predisposes the individual to tuberculosis.

The effectiveness of dust control measures in preventing diseases produced by dusts can be determined only by careful physical examination of the workers so exposed under the guidance of competent medical supervision. The benefits which accrue to the employer and employee, alike, as a result of the physical examination of all applicants for employment, as well as periodical examination of those already engaged, would indicate very careful consideration by industry of a program for control of sickness. Such a procedure protects the employer from engaging an applicant already physically or mentally impaired who later may claim disability for a condition either not associated with employment or contracted during a previous employment. The applicant's physical and mental condition is established and by keeping record of his subsequent illnesses and accidents, the question of responsibility for injuries and sickness need never arise.

The applicant is protected from engaging in work for which he is physically ill adapted which, if undertaken, might easily bring about serious impairment of his health. For example, an applicant with an arrested tuberculosis who seeks work in a certain dusty occupation, if allowed to engage in such work might readily convert an inactive tuberculosis into an active one; thereby endangering life or at least seriously impairing the applicant's future efficiency and earning capacity. Whereas the same applicant if assigned to a position that involves no such exposure, might be expected to continue for years as a useful and productive workman. The examination of applicants for employment likewise protects those that are already employed from the risks of communicable diseases such as tuberculosis and various acute respiratory and other infections being introduced into their midst by a new applicant.

Many of the younger individuals who seek employment have never before received a thorough physical examination and consequently are unaware of the defects from which they suffer. As a result of physical examinations, many defects are located which may be removed or corrected before they have caused irreparable damage, thereby increasing the efficiency of the worker and often averting definite and finally chronic diseases. Furthermore, incipient tuberculosis, unsuspected diseases of the heart, kidneys, and a host of other diseases of a similar nature, are discovered and the applicant referred for proper medical care and treatment which otherwise might have been postponed until too late.

Of even more importance than the initial physical examination of applicants is the periodic examination and care of old employees by an industry. Such a procedure serves to check the efficiency of preventive measures designed to prevent occupational diseases. It offers the most effective way of controlling the health of large groups of workers by discovering early not only occupational diseases, but many other conditions that go undiscovered until the worker is acutely ill or becomes disabled. If the various contagious conditions go unrecognized others become infected, thereby causing serious economic loss, as well as endangering the health of a group of individuals.

The information obtained from physical examinations affords the medical supervisor the opportunity to make certain that employees are engaged in suitable work out of which they are getting maximum results, to correct the effects of undue exposure to harmful environmental conditions, and generally to lessen all occupational hazards. As a public health measure, it is impossible to over-estimate the value of periodic examinations in establishing interest in sickness prevention.

The set-up of a proper program for medical control of workers exposed to dust depends upon the number of employees involved and individual plant conditions. A series of articles under the title of "The Medical Department Manual" by Dr. Hart E. Fisher, appearing in current numbers of "Industrial Medicine," gives a comprehensive account of the organization and operation of a medical department.

1. The establishment of a medical department with adequate facilities and medical personnel who have qualified in the field of industrial medicine. A process analysis of all operations in the plant should be made and the medical supervisor should list all possible health hazards and familiarize himself with their physiological effects. If necessary, he should conduct research studies to determine the harmful effects of new substances introduced into plant processes about which little is known. In cooperation with other departments, he should investigate the extent of the hazards and devise measures of control.

2. The routine examination of all applicants for employment. The procedure should include a detailed history of the applicant's previous illnesses and accidents classified under (a) diseases of childhood, (b) general infectious diseases, (c) respiratory diseases, (d) venereal diseases, and (e) accidents and resulting physical defects. A detailed history of previous occupations engaged in is very important. A mere statement of the type of industry in which the applicant was engaged has slight value, if any. The exact duties performed in each occupation should be noted and information ascertained as to the probable length of exposure to hazardous substances. After the history has been taken and a photograph for identification purposes (if part of routine) is made, the applicant should be directed to the examining room where he is instructed to remove his clothing for physical examination. This examination should be made as complete as is considered necessary to determine the applicant's physical condition.

If the applicant has been or will be exposed to dusts which induce lung diseases, an X-ray picture of the chest is an important part of the examination. This part of the examination may be referred to an experienced roentgenologist, as the value of this method of diagnosis depends upon the type of pictures taken and the experience of the reader who interprets them. The examining physician also may need additional information obtained by laboratory analyses of the blood, sputum, and the urine. These aids to diagnosis should be provided or made available when desirable.

3. The rating and placement of applicants. In cooperation with the personnel department, the applicant should be rated and placed, not only on his training and past experiences, but also on his physical and mental abilities to fill vacancies occurring from time to time. The record of his physical and mental examination should be the confidential property of the medical department.

4. Periodical physical examinations. The frequency of periodical examinations necessarily must depend upon individual circumstances according to the need for such examinations as determined by the supervising physician. Where physical examinations are made for the first time, the employees of long standing should be given ample explanation of the benefits of such examinations and be given assurances that their jobs are secure.

5. Provision for the disabled. Employees who develop disabilities during the course of employment should be re-assigned to occupations which will not interfere with or aggravate the disability, or they should be provided for in other ways.

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Shortly after the inauguration of a program designed to control a known dust hazard, it will become evident that marked improvements can be effected without incurring an impractical expenditure. Personnel problems will arise, due to the reluctance of labor to accept new procedures, and in the end, these problems must be dealt with by educating workmen to recognize the necessity for introducing methods to control dust hazards. The question of what men should be told regarding their physical examinations should follow the practice adopted by any reputable physician in dealing with individual cases. As industry becomes more familiar with this problem, it will discover the serious need for further research.

Since silicosis is a true occupational disease, disability resulting from or attributable to it should be compensable in the same manner as other injuries sustained as the result of employment. Only the intelligent cooperation of industry will bring about the formulation of reasonable occupational disease legislation and its fair administration.

## Silicosis from the Operators' Standpoint

**By G. C. BATEMAN**

**Secretary, Ontario Mining Association, Toronto, Ont., Canada**

The speaker said in part: It is important to know what causes silicosis, but unless a knowledge of the cause leads to a cure, it is not nearly as important from the operators' viewpoint as the knowledge of how to reduce the incidence. With all the research work that has been going on throughout the world for many years, we still do not know the cause and we still have no cure, but we have learned a lot about how to reduce the incidence.

The silicosis provisions of the Ontario Mines Act and the Compensation Act were passed in 1926. These provided for the examination of all men employed in positions in mines where they were exposed to silica dust, for all such workers to be the holders of medical certificates certifying as to freedom from tuberculosis of the respiratory organs, and also for compensation to men affected by silicosis.

This legislation was introduced as a result of a survey in Northern Ontario mining camps which indicated that silicosis had made alarming progress among the miners. There being no reason at that time to question the results of this survey, the operators agreed to do all that was asked of them and cooperated fully with the Government in the steps considered necessary to meet the situation.

When this legislation was first introduced in Ontario, we were advised that men with a moderate degree of silicosis, while not physically disabled, were better out of the industry and that they should be paid a lump sum which would assist them in rehabilitating themselves in some other occupation.

We were further advised that if we took active steps to clean up the situation then existing, pension the more serious cases and remove men in the early stages of silicosis from underground, the situation would be well in hand, the first expense would be the heaviest, and that from then our liability would be practically limited to the anteprimary cases as they developed.

When the 1926 Amendments were approved by the mines it was our understanding that men in the anteprimary stage had suffered no impairment of working capacity and that the $500 payment was a compassionate allowance for rehabilitation and not for disability. We further understood that with the payment of $500 to these men our responsibility in respect to them would be practically ended. It developed, however, that the legal position was different. The Compensation Board cannot make an award except for disability and where disability has once been established the claimant can come back for review on evidence of further disability. It is generally accepted that silicosis predisposes a man to tuberculosis. It followed, therefore, that with secondary silicosis as defined in the Act, if any anteprimary silicotic at any future time and from any cause whatsoever developed tuberculosis, his condition was considered to be the result of his original disability and he was entitled to total disability compensation at an average cost of $12,000 per case.

When, therefore, an award of $500 was made the Compensation Board immediately set up a prospective reserve for progression of an additional $11,500, with the result that we had an estimated liability to the end of 1932 of several million dollars, most of which was outstanding.

With the passage of time it also became apparent that the removal of the men from underground employment in the early stages of silicosis did not have the results anticipated. The payment of a lump sum award did not in most cases serve the end expected. As a general rule this money was expended for other things and the men made little effort to rehabilitate themselves. A certain number of men classified as silicotic continued in their underground employment and we found practically no difference in the rate of progression in those who continued as compared with those who were taken out of the mines. Some of this may have been due to the altered economic status, but even if the economic status had remained the same, we were forced to the conclusion that there was little if any benefit to the men by removing them from underground work, unless of course, there was evidence of an onset of tuberculosis.

It should, of course, be understood that during this time active efforts were made by the mines to improve ventilation and to allay dust. Without this the above statement would not hold true. Steps were also taken by the mines to provide that men in the early stages of silicosis were placed where the conditions underground were most favorable.

Our experience also indicated that the early stages of silicosis do not necessarily mean an impairment of working capacity. This is all the more important on account of the difficulty of diagnosing silicosis in its early stages, as there is no sharp line of demarcation between the pre-anteprimary and the anteprimary, or between anteprimary and primary stages, and as a matter of fact, we believe that there is a great deal more uncertainty in the diagnosis of silicosis than the medical men are willing to admit. The determination is largely a matter of personal judgment and therefore subject to error.

A great deal of what may be read into an X-ray film depends upon the technique in taking the film. Certain other diseases and chest conditions will also give in the film an appearance simulating that of silicosis and we believe it is safe to say that without a definite knowledge of occupational history the diagnosis of silicosis in its earlier stages would be practically impossible.

In view of these conditions, it was felt that the industry was carrying an unfair burden and in 1933 the Act was amended. The anteprimary and primary classifications were deleted, compensation was made payable only for disability, which means actual impairment of working capacity, men with a moderate degree of silicosis were allowed to continue underground work and the industry was relieved from unlimited liability in respect to progression by providing that the claimant must make and establish his claim for disability within two years of leaving the employment at which he was exposed to dust, to entitle him to compensation.

As I said before, silicosis is essentially an employer's problem. It is in many places an important item in his cost of production and to a considerable degree it is a controllable item of expense. If the employer simply leaves the matter in the hands of the doctors, he will have no one to blame but himself over what it costs him. The opinion of the ordinary practitioner and even of the roentgenologist and expert chest and lung man may be of little value. Only the opinion of those doctors who have had special training in the diagnosis of silicosis from both clinical and X-ray examinations should be accepted, and even those opinions cannot be accepted in all cases.

We do not say this with any intention of criticizing the members of the medical profession, but where the matter is so important and costly to industry, where so little is actually known about the disease, and where there is still an element of uncertainty in the diagnosis of silicosis in its earlier stages, too much care cannot be exercised, and the closest scrutiny by industry which has to pay the bills is most necessary. The best results can only be obtained by the employers and the doctors working together, but the employer must consider it as one of his particular problems.

I have also stated that in the absence of any cure it is much more important to know how to reduce the incidence than to know the cause. We believe the chief preventive measures are as follows:

1. Improvement in fundamental working conditions in the matter of ventilation and allaying dust.

2. A rigid initial examination to keep out of the industry those men whose physical condition would indicate a type most susceptible to silicosis and tuberculosis.

3. Control of tuberculosis not only among employees, but also among those with whom they come in contact.

It goes without saying that if silicosis is caused by the inhalation of dust, the removal of dust will remove the cause. This means ventilation and lots of it, and where possible the wetting down of dusty places. In mining operations the chief source of dust is believed to be from blasting, therefore the time interval before men return to a blasted face is important.

Ventilation and water will remove the visible dust from the air, but it is not the visible dust that causes the damage. It is the dust that ranges between one-half and five microns that is dangerous and is so difficult to remove, and the quantity in the air can only be determined by some method of sampling.

We would consider it a mistake to have either the type of sampling apparatus or the permissible dust count defined by law. This may be all right on the Rand in South Africa where conditions are more or less standard, but it is not advisable in the United States or Canada, where conditions vary so greatly. For one thing, we do not know what constitutes harmful dust and there is no standard practice for the treatment of dust sample slides. The untreated slide of a sample taken near a carbide lamp in an otherwise dust-free atmosphere, would show an apparent very high dust count. Dust sampling, however, should be a part of the regular routine, using the type of apparatus best suited to the particular conditions, and this will show whether the atmosphere is good, fair or poor.

Next to ventilation and the laying of dust, the most important measure is to carefully select the type of men to be allowed to work in the industry. This requires a rigid initial examination which should include a complete physical examination and X-ray. By this means men with the type of chest which would indicate their susceptibility to tuberculosis and silicosis can be eliminated. The complete physical examination should also have a beneficial effect on the accident rate.

Uncomplicated silicosis is not a big problem, but silicosis and tuberculosis combined represent a very real problem. The measures for the control of tuberculosis are well known. Particular care should be taken that men with tuberculosis be withdrawn from the industry and given proper care and treatment. Places where the employees live should also be supervised to see that they are not exposed to tubercular contacts.

## Some Aspects of the Silicosis Problem

By DR. H. H. MOORE and DR. M. J. KELLY

**Medical Staff, Hollinger Consolidated Gold Mines, Ltd., Timmins, Ontario, Canada**

The speaker said in part: In 1928 the Ontario Mining Act was amended to provide physical examination on employment and yearly thereafter, or twice yearly if indicated, of all underground men. To be employed the workman must hold an official certificate good for twelve months, stating that he is free from disease of the respiratory organs. This certificate must be renewed at each annual examination. In the meantime, an amendment to the Workmen's Compensation Act provided for the appointment of medical officers working under the supervision of the Compensation Board to conduct these examinations. Cases of silicosis arising at these examinations are submitted to the Workmen's Compensation Board if the total exposure to silica of five years in Ontario mines is verified. In addition to this routine with silicotics, there is a close check kept on the possible undue progress in the fibrosis in any case and if necessary steps are taken to remove such a case from harmful contact with silica.

The act in its present form was passed in 1933 and served to clear the situation which had become involved by the tie-up of large sums of money in reserve funds against possible future claims by men adjudged silicotic previously, but who had since been lost sight of or who were carrying on at work showing a minimum or no disability.

From the workman's point of view, the new act is a great step forward, as it allows a man to continue at his usual duties underground as long as he is able to work without any serious degree of discomfort. Previously, a workman was advised to quit underground work when a certain stage of fibrosis had been reached, regardless of his ability to carry on, and sacrificed his rights to compensation if he continued to work.

In the X-ray examination of the chests of the 2007 men employed at the Hollinger mines during 1933, determinations are graded as follows: *Normal* is a chest showing little or no fibrosis, where the condition of the lung is better than the average for the age. *M. F.* or "More Fibrosis" is a chest which is normally found in the average adult at the age of the miner under consideration. *M. F. P.*, "More Fibrosis Plus" is a chest showing slightly more fibrosis than normal for the particular age. *M. F. P. P.* or "More Fibrosis Plus Plus" is a chest showing considerably more fibrosis than normal and is a pre-silicotic stage. Silicotics are that group which show a great deal of fibrosis and taking into consideration the mining history and consequent exposure to silica, are thus termed. Admittedly, disability may or may not be present. This last group ranges from the early silicotics with a minimum of disability to the late complicated or secondary cases with marked disability and tuberculosis. It must be added that a large number of men at the commencement of employment at the Hollinger, and without previous mining experience or contact with silica, show chests of M. F. P. rating. Following are the results of this examination:

| | | |
|---|---|---|
| Normal | 33 | 1.4% |
| M. F. | 920 | 40.8% |
| M. F. P. | 932 | 41.4% |
| M. F. P. P. | 98 | 4.3% |
| Silicotics | 24 | 1.1% |

Average contact with silica of men working and M. F. P. P. .............. 12 years.
Silicotic .................. 15 years.

Next is an analysis of the changes in chest rating in 1933.

| | | | |
|---|---|---|---|
| Normal | to M. F. | 11 | |
| Normal | to M. F. P. | 3 | |
| M. F. | to M. F. P. | 207 | |
| M. F. P. | to M. F. P. P. | 9 | |
| M. F. P. P. | to T. B. | 1 | |
| M. F. P. P. | to A. P. | | |
| A. P. | to P. | 231 | |
| M. F. | to Normal | 11 | |
| M. F. P. | to M. F. | 231 | |
| M. F. P. P. | to M. F. | 1 | |
| M. F. P. P. | to M. F. P. | 20 | |
| T. B. ? | to M. F. | 1 | |
| T. B. ? | to M. F. P. | 1 | |
| A. P. | to M. F. P. P. | 1 | |
| P. | to A. P. | 266 | Total 497 |

These figures cover approximately 500 men in whom there was some change in chest rating during the year, and the direction of the change. The remaining 1500 men show no change from the previous year. It will be observed that 231 men showed an increase in fibrosis rating, while 266 show chests which are improved. The explanation given for the group which shows improvement is, in the first place, that some concurrent bronchial or upper respiratory infection had complicated the picture at the previous annual examination and so caused a more advanced rating to be given. The second explanation is that constant improvement in radiological technic is making diagnosis more accurate.

It would seem, therefore, that on the whole the situation is showing considerable improvement from this viewpoint. During 1933 no case progressed from the pre-silicotic to the silicotic stage. In the years up to 1933, 120 men had been rated silicotic and the total cost to the Hollinger involved a sum of $915,950, which figure includes the progressive and contingent funds set aside to cover future costs and possible future claims.

Two objects have been kept in mind during the many years of study of the dust problem at the Hollinger Mine.

1. The collection of complete data regarding the nature of air breathed by workmen in different occupations, its chemical composition, temperature, humidity, dust content and rate of flow.

2. Working tests of all practical methods of improving the condition of such air.

In searching to adapt a method for the determination of air dustiness, it was realized that no instrument has been devised which would measure the dust content of the air with scientific precision. Furthermore, it was felt that the principal object of making determinations was to ascertain if the dust count of the air was undesirably high, and if such a condition was found, to devise a method of reducing it. Hence, for practical purposes, the instrument which possesses a high efficiency in the range of desirable concentrations and gives a quick indication of dangerous quantities of dust is most desirable. The circular Konimeter, invented by Sir Robert Kotze and introduced to the Miners' Phthisis Prevention Committee of South Africa in 1916, has therefore been used in the Porcupine District for the past eight years.

A summary of our investigations along this line may be given as follows:

1. About 900 of the underground force are engaged in work which will produce dangerous dust if measures of control are not applied.

2. Of this number a little over 400 are engaged in shoveling broken ore into cars and the average dust exposure does not exceed 300 particles if the muck piles are kept thoroughly wet and blasting carefully restricted.

3. The remaining 500 men are engaged in drilling and blasting operations and are subjected to severe potential hazard. Men engaged in stopes who do not have to return to the working faces have an average exposure of about 1200 particles, while using the ordinary type drills. It is felt that the use of the "dustless" type of drifter will reduce the concentration of dust to somewhere near 300 particles.

4. The men engaged in development drifts are exposed to the same concentrations of dust, namely, 1200 particles. Where possible, two development drifts are worked simultaneously by the one crew, so that the men do not have to go back through the dense dust after blasting the cut. There are only a few exceptions to this rule and when necessary to go back to load the remaining holes, the men are provided with the special respirator.

5. The high dust concentrations in the vicinity of stopers we hope to deal with by the use of compressed air masks. Also the practice of driving adjacent raises simultaneously has reduced the hazard after blasting.

With the constant improvement and maintenance of general health conditions kept always to the fore as most desirable and necessary in aiding in the solution of the silicosis problem, the men at the Hollinger Mine are cared for under a contract medical system. The facilities and service at mine, office and hospital are most complete and efficient and in combination with the annual or semi-annual check made by the medical staff of the Compensation Board, health of the workers is under constant supervision.

Men who report with such conditions as non-tuberculous or non-silicotic chest trouble, with focal infection in teeth, tonsils, sinuses, etc., are singled out and treated and observed and where necessary changes in occupation are made or rest and vacation periods advised.

At the mine, constant improvements have been made and at present the following is the routine. A worker coming off shift removes all his mining clothing, usually wet, and racks them on a set of hooks attached to a chain and pulley. These wet clothes are pulled up to a height of 15 to 20 feet and hang thus in a hot, dry atmosphere for 14 to 15 hours, during which they are thoroughly dried. After undressing the miner passes through a series of shower baths of temperatures varying from hot to cold. After drying he proceeds to his locker where he has placed his street clothes before the beginning of the shift.

With a view to reducing the infection of silicotics with tuberculosis, a clinic has been established in Timmins. An experienced public health nurse is employied full time and it is her duty to visit all tuberculosis suspects and patients, all contacts with these cases and contacts with silicotics to arrange for their examination and supervision and if necessary for treatment. Weekly clinics are held at which such patients are examined clinically, radiologically and by bacteriological and biological tests.

Since January of 1933, approximately 30 dangerous cases of tuberculosis have been removed from the district to a sanitarium and many more less severe cases placed on bed rest at home or on restricted activity. It is felt that by removing these cases from contact with silicotics, that within a comparatively short time tuberuclosis will be moderately well controlled and since tuberculous infection is necessary to precipitate secondary silicosis, this movement, it will be appreciated, is an excellent one.

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