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Municipal Auditorium

Industrial Dusts

WEDNESDAY MORNING SESSION

October 13, 1937

The meeting was called to order by Chairman A. S. Regula, Executive Secretary, Industrial Relations Counselors, Inc., New York City, and Vice-President for Engineering, National Safety Council, who introduced the speakers.

What Industrial Dusts Are Harmful? Why?

By SENIOR SURGEON R. R. SAYERS

Chief, Division of Industrial Hygiene, U. S. Public Health Service

While dusts exist everywhere in the atmosphere, it has been recognized for centuries that workers in certain dusty occupations are less healthy than those not so exposed. The number of persons exposed in dusty occupations comprises one of the largest industrial groups. The occupational diseases of workers in dusty atmospheres have been found to be due to entrance of dust into the system by inhalation, by ingestion, by direct absorption through the skin, by irritation of the skin, or by a combination of the foregoing.

The suspensions of particulate matter in air have been broadly termed dusts, fumes, and smokes. Such a classification is necessarily arbitrary, since the line of demarcation between them is not very sharp, and the chief differentiation is based on the size of the particles. Investigations by the Public Health Service in dusty industries[1] revealed that about 70 per cent of the dust particles examined were between 1 and 3 microns in size, only about 20 per cent were less than 1 micron, and the median size was 13 microns. Industrial dusts are mainly less than 10 microns in size. However, fibrous dusts in the air, such as asbestos, have been found to contain particles as large as 200-300 microns in the greatest diameter.

While, generally speaking, according to Collis, dusts are more injurious as their chemical composition differs from that of the human body, or from the elements of which the body is normally composed,[2] it is difficult to establish a comprehensive definition for *toxic* dusts. Sollmann,[3] after analysis of various definitions for poison, felt that it is very difficult to give a definition which will not be ambiguous in some cases, but believed that the following covers most of the points which must be considered in classing a substance as such:

> "A poison is any substance which, acting directly through its inherent chemic properties, and by its ordinary action, is capable of destroying life, or of seriously endangering health, when it is applied to the body, externally, or in moderate doses (to 50 Gm.) internally."

Some dusts are known to be poisonous, while others, in the concentrations usually encountered, are comparatively harmless. However, it may be stated that *breathing* dust in high concentration is not desirable.

According to Fairhall, the damage arising from the inhalation of toxic dust may be either local or remote, and depends upon whether the material is a protoplasmic poison, whether it is caustic in reaction, or whether it is absorbed into the blood stream and carried to other centers which are in turn affected.[4]

It is now well established that exposure to certain kinds of dusts, such as those containing considerable quantities of free silica, has increased the morbidity and mortality rate from respiratory diseases; while metallic dusts, such as lead and its compounds, have been associated with general systemic poisoning.[*] Dusts may be swallowed with saliva, water, or food, and direct poisoning has been traced to absorption by this method; other dusts may act as irritants and produce affections of the skin, irritate mucous membranes of nose, eyes and throat, often causing inflammatory diseases of these organs.[*]

Some inorganic dusts are able to penetrate the deep lung tissues and are sufficiently insoluble to be retained there. Some of these may be active in the human tissues, causing definite and permanent injury, while others are inert and may be retained for years, apparently without serious damage; some are gradually absorbed without causing pathological changes.[*]

All inhaled particles are soluble, at least to a small extent. If harmless, cell activity is stimulated so that phagocytes remove the dust. If the solute is toxic, the viability of the phagocyte is affected and an ineffective accumulation results. At the same time, further solute may diffuse into neighboring tissues, setting up an irritation and subsequent fibrosis. The nature as well as the solubility of the solute is an important factor, but of two substances of approximately equal toxicity, the more soluble form causes the greater damage. However, substances of such low solubility as silica may ultimately produce extensive injury.[*]

Kettle has stated that harmful dusts, if inhaled into the lungs, may activate a latent tuberculous infection; they may exaggerate an active tuberculous lesion or a coincident infection. If sufficient quantities of a harmless dust are inhaled, some of it remains in the lungs and causes a mild degree of fibrosis merely through mechanical irritation, but such fibrosis is never sufficient to interfere with the function of the lung.[*]

Some writers state that while the influence of nonpoisonous dusts on health is a debatable subject, abnormally high death rates from bronchitis and pneumonia are sometimes attributed to chronic exposure to nontoxic dusts. Large amounts of dust are occasionally found in supposedly normal lungs, at autopsy.[*]

According to Drinker, there are four different types of reaction produced in man by the inhalation of dust. The first and most important are the pneumoconioses, such as silicosis and asbestosis, which cause specific lung pathology and often are followed by pulmonary tuberculosis. The second type of reaction is caused by toxic dusts like lead, cadmium, and radium. A third type of malady follows the inhalation of finely divided metallic fume particles such as zinc oxide, and is known as metal fume fever. The fourth reaction, allergic in character, is caused by breathing organic dusts such as pollen and certain types of pulverized wood and flour. In all four cases the sole cause of the disability may be dust inhalation, but the reactions from toxic dusts result from swallowing as well as from inhalation.[*]

For various reasons it is difficult to set up an absolute classification for dusts. Opinion is *rapidly changing regarding* so-called inert or harmless dusts and further investigation may prove some of them to be injurious. Some dusts may have both a toxic and an irritant action; while on the other hand, the poisoning resulting from exposure to a dust may be the combined effect of more than one mode of entrance into the body. However, the following classification of dusts, according to physical characteristics and physiological effect, is used for convenience.

I. Organic Dusts

Organic dusts are those which contain carbon, and were originally supposed to come from organized substances derived from animal or plant life. Living dusts come under this classification, and are thought to be of the same order of size as industrial dusts, with which they are frequently associated. Bacteria are usually between 0.5 and 3 microns, except in a few cases, such as the anthrax bacillus, which ranges from 1 to 1.25 micron in breadth and 4.5 to 10 microns in length and 10 or 12 microns in diameter. However it is possible that the larger and heavier varieties, like the larger and heavier dust particles, settle due to gravity, and do not remain suspended in the air.

Many thousands of organic substances, carbon-containing, are made synthetically by chemical processes, such as dyestuffs, explosives, etc.

1. *NONLIVING ORGANIC DUSTS.* As the name implies, these are comprised of nonviable particles, which may or may not be inherently toxic or irritant, but which nevertheless produce untoward effects in the human organism. "Allergic" dusts, or those to which only certain persons are or may

become hypersensitive, with resulting asthma, rhinitis, or other disturbances, are included in this classification

a. *Toxic and/or Irritant* Toxic or irritant dusts are all organic dusts which produce untoward symptoms, either systemic or local. Those producing local symptoms are usually described as irritant; those producing general or systemic symptoms are termed toxic. A dust may be both toxic and irritant.

In reported cases of injury or death following inhalation of dust from organic compounds, among the chief offenders are paranitraniline, the dinitrobenzenes, chlorodinitrobenzenes, trinitrophenol, and nitronaphthalene. Eye damage due to inflammation of the cornea has occurred among workers exposed to methyl violet dust. The dust from paraphenylene diamine derivatives is particularly irritating and dangerous, causing not only a severe form of dermatitis where the dust comes in contact with the skin, but also producing acute inflammation of the mucous membrane of the respiratory passages.[4] Toxic dusts may be generated during the handling of powdered dyes and in preliminary dyeing operations, particularly the hydro-extractor process, where particles are disseminated in all directions.[11] Coal tar and indigo dyes are substances most frequently used.

Cases of amblyopia have been reported from exposure to inhalation of tobacco dust.[29] It has been found that inhaled tobacco dust exerts a nicotine action on the organism fifteen times greater than that produced by the same quantity of smoked tobacco with an equal nicotine content.[29]

Severe dermatitis is experienced by many workers handling powder containing T.N.T., which is used in making high explosives. Picric acid, which is also used for this purpose, requires drying, and in this latter state has been found to produce a dermatitis. Picric acid is also the oldest synthetic organic dyestuff.[30] Dermatitis occurs among handlers of silk with varying frequency. Salls determined that a rash occurring among workers in a silk factory was due to dust from silk cocoons imported from Africa.[31]

Persons engaged in the manufacture of quinine and quinine preparations suffer from this phenomena, which occur for the most part on exposed parts of the body, and may be caused by ingestion or by quinine dust, or powder form of the preparation, exerting a direct irritating effect on the skin.[32] Dermatitis due to other vegetable dusts such as vanilla, powdered arnica, pyrethrum, etc., have been reported.[33]

Dental lesions, of occupational origin, have been reported among workers in sugar. The gingivitis caused by sugar dust is classified as *purely mechanical*, with later-developing caries. Digestive disorders, respiratory conditions, and cutaneous conditions (especially of the face) were also found.[11]

Dock workers, transporters of grain, workers in grain and flour mills, etc are exposed to dusts during their work. Dusts from cereals may contain many impurities, which may cause an irritating action on the respiratory passages, as well as inflammation of the skin. Digestive disturbances, dental defects, diminution in hearing, and conjunctivitis have been observed among millers, and have been attributed to the dusts to which such workers are exposed.[34]

b. *Allergic* Many apparently innocuous substances may produce reactions in persons of peculiar personal susceptibility. The term "allergy" is used to describe this condition of hypersensitiveness or susceptibility, and allergic phenomena most frequently manifest themselves in skin reactions. However, they may cause acute reactions elsewhere in the body. When the respiratory tract is involved we have such well known diseases as hay fever or asthma. These diseases may develop as a result of hypersensitiveness to such substances as pollens from plants, horsehair, rabbit's fur, furs, feathers, etc.

For instance, furriers, workers in clothing industries who are exposed to wool dust, etc., may suffer from hay fever or asthma.[35] It is unnecessary for the offending dust to reach the depths of the lungs—giant pollens for example are reported to produce their effect after being caught in the upper respiratory passages. Should such an offending substance be finely ground it could reach the alveoli and as a result probably all physiologic reactions would be accelerated.[36]

In a survey of a plant where resin is mixed, ground, and molded, it was found that 80 per cent of the occupational dermatitis there was due to hypersensitivity to hexamethylenetetramine and formaldehyde contained in the dust to which the workers were exposed.[11] During the first processes of cotton spinning, cotton-strippers are exposed to dust arising from cotton husks and débris, which produces a typical form of asthma.[8]

Ordinary wood dust has been of interest due to its purely mechanical action, but still greater care is required in handling certain kinds, especially woods coming from abroad, because of the essential oils impregnating them, which when freed in the dust may affect the health of the workers concerned. Some of the woods capable of causing skin lesions are Brazil wood, satinwood, teakwood, cumaru or tonka wood, black ebony wood, West Indian mahogany, Japanese tagayasan, coccoloba, chestnutwood, olivewood, California sequoia, etc. All persons who handle these woods are not injured, only those particularly susceptible to the substances they contain becoming affected.[20]

2. *LIVING ORGANIC DUSTS.* These contain particles capable of exhibiting the phenomena of life[7] (especially the property of reproduction or multiplication), such as bacteria and fungi. They are usually found in low concentrations and are associated with nonliving dusts in the air.

a. *Bacteria.* One of the most important among these is the anthrax bacillus, which is contained in the dust from skins, furs, wool, and animal hair, horns, hoofs, bones, etc. This disease may occur in two forms: *cutaneous* (in which the organism affects the skin), and *pulmonary* (when it is inhaled, as in the form of anthrax known as woolsorters' disease).[11]

Cases of tetanus reported in connection with jute manufacture, were traced to the raw material, the bacillus having been found in the factory dust.[20] Diphtheria, tuberculosis, smallpox, typhoid, or other bacillus-produced diseases, may result from exposure to infected dusts.

Bacterial sensitization can be the cause of any of the allergic diseases, namely, asthma, perennial, hay fever, urticaria, angioneurotic edema, eczema, or migraine headaches.[24]

b. *Fungi.* Dusts containing the mycelia and spores of parasitic fungi give rise to annoyance and discomfort. "Maltster's" itch from the dust alone has been reported. In Provence, reeds used for ceilings are stacked while still wet and undergo fermentation; they become covered with a white powder (a dry fungus of the Mucor family, Sporotrichum dermatodes), which is scattered when the bark is stripped off. This powder is irritating to the skin and mucous membranes. Mycelia and spores of moulds are commonly found to cause rashes: for instance, the black powder coming from macerated sugarcane stalks. Among basketmakers, the mycelium and spores, in the form of a white mould (hyphomycete) from the rhattan canes used, get shaken out when the canes are split, hammered, and cut, causing painful fissures to develop on the skin where they alight.[14]

A form of asthma or spasmodic cough, suffered by cotton weavers and known as aspergillosis, has been considered due to inhalation of spores of a mildew which sometimes occurs on the threads.[20] In a study of silicosis among miners, made by the Public Health Service, a number of cases of typical miliary calcification were encountered. Unstained smears of those cases examined were positive for fungus, two types of Aspergillus fungi being identified. All of the subjects but one were farmers, teamsters, feedmill workers, or residents of small agricultural towns where grain is marketed. Farmers are exposed to fungi in threshing wheat, baling hay, or handling various small grains.[16]

Some other fungus diseases such as actinomycosis and blastomycosis are associated with occupational exposure to dust. The former occurs among workers handling straw, hay, grass, vegetable débris contaminated with mould, etc. Actinomycosis is likely to affect people engaged in commercial handling, storing, and cleansing of grain (grain distilleries, flour mills, grain crushing, breweries, and malting houses, etc.).[20]

II. Inorganic Dusts

Inorganic compounds are of mineral origin, not requiring a living organism to produce them.[7] A number of dusts not usually classed as toxic may, under some conditions, produce untoward effects on the human organism. Classified under inorganic are toxic and/or irritant, fibrosis-producing, and nonfibrosis-producing dusts.

a. *Toxic and/or Irritant.* Toxic dusts are those which are inherently toxic when inhaled, ingested, or otherwise absorbed. Among those which produce systemic poisoning, some of which are also irritant, are the dusts from heavy metals and their salts, such as lead, mercury, arsenic, cadmium, zinc, etc. Irritant dusts are injurious by reason of their strong irritative or corrosive properties.

As a rule, inhaled irritant substances immediately cause a reaction in the upper respiratory tract of such severity that they are prevented from reaching the lungs, although they may cause lung damage by extension of inflammation if the mucous membrane is corroded.[1] Lime, calcium oxide, and the di-chromates are examples of irritant dusts. An inorganic dust may possess both toxic and irritant properties, and the poisoning produced may be the combined effect of more than one mode of entrance into the body.

Of the directly poisonous dusts, the most widely prevalent are those of certain lead compounds, particularly the oxide, carbonate and the chromate. The dust is readily absorbed by the mucous membrane; some dust passes into the stomach and is dissolved by the gastric juice.[1]

According to Fairhall, perforated nasal septum is a common occurrence among workers with bi-chromate dusts.[4] In a study made by the U. S. Public Health Service it was found that continuous daily exposure to concentrations of chromic acid mist greater than 1 milligram in 10 cubic meters is likely to cause definite injury to the nasal tissues.[10] It is believed that a similar concentration of the dust would be equally toxic.

In the case of poisoning from some heavy metals, exposure may be to both dust and vapor. For instance, investigations have shown the safe limit of *total* exposure to lead oxide dust and fumes to be less than 15 mg. per 10 cubic meters of air, except for prolonged exposure.[10] In exposure to mercury dust and vapor, it was shown that the incidence of chronic mercurialism increases rapidly with increasing mercury concentration, after such concentration exceeds 2.0 mg per 10 cubic meters.[10]

Alkalis and metallic oxides are common causes of dermatoses. Lye, potash and lime are known to cause irritation to plasterers, cement-makers, bricklayers, masons, stonecutters, modellers, and metal platers.[11] Ulceration and perforation of the nasal septum occur among workers exposed to the dust of soda ash; systemic poisoning also occurs from inhalation of calcium cyanimide dust.[11]

Cases of dermatitis, scleroderma and cancer are reported to have been caused by exposure to dust of arsenic compounds. Certain aluminum salts are skin irritants and aluminum dusts may contribute to the infection of skin and mucous membranes, through mechanical action.[10]

b. Fibrosis-Producing Dusts. The most important of these are the inorganic, slightly soluble dusts which cause fibrous changes in the lung tissues, some of which are serious, and some of which cause little or no disability.[1] So far as is known, no inorganic substances other than silicon derivatives cause more than a very moderate degree of fibrosis of the lung. Moreover, there seems to be no evidence that any other constituent of ordinary dusts can influence so unfavorably a pulmonary infection.[1]

Although other dusts, when inhaled in sufficient concentrations over a long period of time, have been shown capable of producing a pulmonary fibrosis, nevertheless, the pneumoconiosis characterized by nodular fibrosis has to date been shown clinically and experimentally to be associated only with the inhalation of dusts containing free silica.

Since this dust, to exert its harmful action, must enter the finer divisions of the lung, the particle size of the atmospheric dust may bear a definite relationship to the injurious effect produced. The silica must be present in the air in particles small enough to enter the finer air spaces and of such dimensions that the phagocytic cells may engulf them. The greater majority of particles found upon microscopic examination of the lung fall within the limits of from 1 to 3 microns.[11] Examples of siliceous dusts are granite, quartz, sand, pumice, slate, etc.

In a recent study among anthracite miners, the correlations between exposure to dust (which contained silica) and the evidence of constitutional changes left little doubt as to the etiological significance of the dust in the air breathed. Like correlations were found between the silica exposure and the extent of pulmonary changes.[10] When the inhaled dust consists of silica combined with bases, silicates, some degree of change in the pulmonary tissue may result. In this respect asbestos dust seems to be unique among silicates in the prevalence and severity of the disease it causes.[10]

The chief distinction between silicosis and conditions due to simple reactions caused by other dusts is the active proliferative reaction in the tissues which results in progressive nodulation. Silicosis, when once established, strongly predisposes the lungs to infection, especially with the tubercle bacillus. Chronic interstitial pneumonia, chronic bronchitis, and emphysema are frequent complications of advanced degrees of silicosis.

The relation of the acute respiratory infections to the reaction due to dusts other than free silica has never been established, though a heightened incidence has often been shown statistically in workers in dusty trades. It is fairly certain that a dust damaged lung, whatever the cause, fares much worse if an acute infection does supervene upon it.[7]

In a study conducted by the U. S. Public Health Service among marble finishers in Vermont, it was found that marble dust when inhaled in the concentrations found in the examined plants produced a mild, bilateral, linear fibrosis in some cases, but no serious lung changes were noted and there was no disability due to the dust, even after years of exposure.[8]

c. *Nonfibrosis-Producing Dusts.* These are inert, that is, they do not cause fibrous tissue to be produced, but may become encapsulated or lie free in the tissues; or they are absorbed without production of fibrous tissue. Included among them are alundum, coal, corundum, emery, limestone, magnesite, marble, plaster of paris (gypsum), and polisher's rouge.

Dust Control

Engineering and medical control are the two most important factors in combating the industrial dust hazard, and are to a large extent complementary.

Engineering Control. As Lanza[9] has stated in a recent paper, "It is a basic principle in dealing with a dust hazard that the dust should be attacked at its point of origin and thus prevented from being disseminated into the atmosphere." After the dust has been spread throughout the air it is difficult to deal with it, and reliance must be placed on individual protection, which is never wholly satisfactory.

Lanza further cites various methods used in controlling dust. These will be reviewed but briefly, since a paper dealing with the subject of dust control in detail, will follow on this program.

Dust may be entrapped at its source by suction devices and thus removed and collected. Familiar examples are exhaust hoods in grinding operations, and the devices used in rock drilling.

Generally speaking, the exhaust ventilation method, where applicable, is to be preferred in controlling a dust hazard. Water may be used to entrap dust and prevent its dispersal, and under certain circumstances it may be of advantage to combine the use of water and the use of suction. Sometimes a dusty process can be completely enclosed in a sealed room or compartment. It must be remembered, however, that any mechanical device of this kind offers adequate protection only if it is properly designed, installed, and maintained.

A great deal of attention has been given the subject of individual protection from dust, and there are many types of respiratory protective devices now available. These are generally of two types: those which provide fresh air from an uncontaminated source and those which rely upon a filtering medium for removing dust from the air breathed. Where the use of such a device is indicated, only one of the types approved by the U. S. Bureau of Mines should be used. As a rule, it may be said that masks, respirators, or other such protective device should be used only where exposure to the dust is intermittent and brief, or where some unusual condition makes a more adequate dust control impracticable.[10]

Where bacteria or other living dusts in the air are associated with a process, sterilization methods such as increased temperature, ultraviolet radiation, and chemicals like chlorine or other bactericidal substances, may be of use. Pasteurization temperature (about 140° F.) will kill most organisms except those bearing spores. Steam disinfection is used for horsehair, and proves to be practicable if the temperature does not exceed 230° F. Wool fibres, however, lose their elasticity by steam disinfection, and the "Duckering" process now used in England includes soaking of the wool in a formaldehyde solution, and drying in a current of air at a temperature of 160° F.[11] There are few occupations in which there would be a sufficient concentration of dead bacteria to cause untoward effects in man.

In the case of dusts producing external irritation, auxiliary protective measures may include the use of protective clothing, gloves, goggles and aprons; as well as protective salves, ointments, or other compounds to delay or diminish the irritant action. General rules for hygiene and good housekeeping should also be observed.

Medical Control. Equally important, and closely interrelated with the engineering phase, is medical control of occupational hazards. In addition to directing the proper placement of new workers, and guarding the health of all employees, medical control is a check on the efficacy of the engineering control methods already instituted, or a measure of the need for new protective devices.

It has been stated that "Industry has found that the best way to treat industrial injuries and illness is to *prevent them*," and medical control, through preemployment and periodic physical examinations, is one of the most important factors in such prevention.

The preemployment examination is made to determine the employee's physical and mental fitness for work. It serves to disclose the presence of any contagious disease, reveals any minor physical defects which might later become serious, or whether the examinee's condition precludes his employment in certain or in all types of work. It should be remembered that such preemployment examinations are not to be made for the purpose of eliminating an employee, but rather for allocating him to the type of work for which he is physically suited. A worker should be given employment unless totally unfit, or unless his disability, even though slight, would cause him to be a hazard to himself or his associates. Furthermore, the practice of preemployment examinations should be extended to include executives and officials of industrial organizations.

"The purpose of periodic physical examinations is to secure and maintain physical fitness and thereby lengthen work spans." Reexamination of employees sometimes results in the discovery of defects and disabilities which were not observed at the time of employment. In such cases, an occupational adjustment should be made to provide continued employment, but remove the risk of permanent injury.

Reexamination of employees is required by law in certain occupations in which the handling of poisonous or otherwise deleterious substances may result in the contraction of disease." Since some occupational diseases tend to clear up and recur, records of previous occupations should be included in the physical examinations. The frequency of examinations should be determined by the medical director, unless otherwise specified by law. Those exposed to known occupational disease hazards may have weekly or monthly examinations."

"It should always be kept in mind that the basic principle of physical examinations in industry is to keep men on the job and not allow the physical examination to be merely a weeding out process."

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The Engineer's Part in Eliminating Dust Hazards

By ARTHUR S. JOHNSON

Assistant to Manager, Engineering Department, American Mutual Liability Insurance Co., Boston, Mass.

When one realizes that control of the dust hazard depends upon the combined contributions of the physician and the engineer, he appreciates that the solution requires scientific treatment. By scientific treatment I mean the technical analysis of the hazard to discover the causes which contribute to injury or ill health, and the development of control methods which obey physical law and physiology, and which will be directed at causes that admit of most immediate and economical treatment.

That goes for handling the dust hazard in a given plant. It goes double for acquiring knowledge *to the end that the whole problem* may reach ultimate solution. Right now our knowledge of the problem is in big chunks, loosely put together and largely empirical.

There are estimates only to judge the magnitude of the dust health problem, and it is so closely associated with other health problems that a clean-cut estimate of it alone is impossible. We do know that it is great in the aggregate, and for the individual plant it may be very bothersome and expensive.

What actually makes quartz dust cause silicosis is not known. *It does*, so the air breathed by workmen must not contain harmful quantities of respirable quartz dust. Inexpensive methods for making the air clean are still in the realm of dreams. Much work must be done to know more about silicosis and more how to make atmospheres safe *inexpensively*. As an accident prevention job, dust control lies almost entirely within the administrative responsibility. The control measures are capital expenditures of considerable size.

A plant with a dust hazard is sick. It needs an expert diagnosis and scientific treatment, which may include expensive major operations. Home remedies are seldom much good, and supervision and employee safety consciousness alone cannot accomplish anything. There may be observed in countless shops installations for exhausting dust which are derisively called "tin knocker" jobs in which the horsepower dissipated is out of all proportion to the air-borne dust moved. Tonnage efficiency of material moved may be the proper yardstick for pneumatic conveyors but if the material to be moved is air, contaminated with nearly weightless particles of dust, the entire health hazard can lie in the half of one per cent of material not moved.

I do not mean that unless a dust supression job was engineered it can be no good. There are many good installations that were never figured at all but grew like Topsy. The re-

sulting freedom from dustiness was so satisfactory that efficiency held little interest to the owner. This is exceptional, *however, and* I offer the opinion that dust suppression jobs *should be engineered*.

A *dust-suppression installation* is a safety device designed and operated to provide protection against possible disease and provide a sense of security which must be absolute. Its safety is not rushing air and rattling chips but a minimal residual dustiness. There is no more pathetic defeat for a dust control job than to find faith in its effectiveness so low that workers must wear respirators to find the reasonable safety that was expected from the hoods, ducts and fans.

Diagnosis and Control

Let us examine some of the features by which we recognize this dust hazard problem leaving out the *socio-legal* aspects.

In order to develop more fully the engineer's place in this dust control program, it seems desirable to separate as sharply as we can the diagnostic considerations from those which deal with control. In the first compartment we can place all the analytical components which describe the hazard and its exposure, the probability of its producing ill health and all the rest of the medical and industrial hygiene facts which make out a case against the existing dust. In the second compartment place the knowledge of physics and engineering necessary to plan the dust control program and so design it that when installed its performance follows prediction that the probability of industrial disease is reduced to insignificance.

The Industrial Hygienist

Our first feature of interest would naturally be the specific and relative toxicity of silica, silica-bearing and other dusts which make up the dust health hazard. Much might be said to advantage about the quality and quantity of hazard in many dusts. The acquiring of this knowledge has been, and must remain a medical problem. It involves gross and microscopic pathology and x-rays, and experimental animals. Engineers do not talk that language. Industrial hygienists do; they are a happy combination, half doctor and half engineer. Many of them are quite capable of handling the dust health hazard in all its phases of investigation and control. For the purpose of this discussion I throw their interest in with the doctors.

I want to go so far in my opinion as to state that the engineer should not attempt to define the quality of health hazard in a given plant or industry, nor should he establish threshold limits of safe or permissible dustiness. *This may be debatable, but I shall* contend that the engineer who writes the specifications of hazard and dust tolerance is really an *industrial hygienist*, and is using a very much broader knowledge than engineering alone.

In the first case the quality of the health hazard is an opinion arrived at after studying all the environmental conditions including the general sanitation, occupational analysis and a scientific analysis of the dust exposures. In the exploration of dust exposures, the *nature of dusty operations must be viewed* from physical, chemical and mechanical aspects, the determinations of dustiness must be not only counted and classified by particulate sizes, but chemically and mineralogically analyzed. The plant layout must be studied *with respect to dust production and distribution*, and the housekeeping and existing dust control equipment evaluated. The presence of specific hazards, such as *toxic gases*, abnormal temperature and humidity conditions, etc., must be explored for their complicating effect upon the whole picture. This is distinctly an industrial hygiene job, and some of the most critical data requires only medical viewpoint. This is absolute in the case of tuberculosis study and the qualifying of men for employment.

So far, *not one atom of* engineering to suppress dust is involved. It is entirely analysis of hazard. The diagnosis must be that the dustiness is *hazardous to health* or that it is safe. If it is hazardous, it must be brought down to a specified residue. If it isn't, leave it alone. On the second *point, if the hygienists can not specify threshold limits graduated* upward for relatively less hazardous dusts, let the engineer not worry about it. The diagnosis is dust which is harmful and too much of it. The remedy is control of the dust. The engineer designs controls which will produce the lowest practical residual dustiness. *He should not attempt to write his own* specifications of threshold limits or permissible dustiness. This may be an important goal in the study of dust health hazards.

Safe Limits

At the present time the medical men and hygienists believe that quartz dust is safe below five million particles. They seem willing to graduate upward to 20 million for medium silica and 50 million for low silica percentages. Five million particles is virtually dust free, and is very difficult and expensive to achieve and maintain. The declaration of safety of the installations must *remain in the* hands of the medical and hygiene groups in whose hands now lies the responsibility for determining the hazard.

We now enter the chapter of our discussion intended to demonstrate that dust control is an engineering job, that it must be given scientific treatment, not guess work, applying engineering methods which are based upon a knowledge of physical law, the behavior of dust, the performance of air-moving machinery, etc.

Prerequisite Knowledge

Let *me* recite briefly, a few of the things which, in my opinion, the engineer should know to do this job correctly. He must know how to make a survey. Surveys depend upon sampling, and sampling is not a catch-as-catch-can proposition. It involves the place, the time, the frequency, the amount in a sample, and the number of samples so that maximum, minimum and average data mean something, so that credibility can be given them.

For the type of sample involved he must know how to weigh or count respirable dust, as distinguished from large masses of non-respirable dust which complicate the picture. He must know how to observe the sources of dust floods as distinguished from conditions of normal dustiness. He must know the sources of dust and the principles involved in the dispersion of dust. He must determine how much dust enters the problem because it is part of the material, and what dust is created in the process by the fracturing of the material.

Any less survey cannot tell the engineer what his task of dust control is. To visualize that task intelligently he should know the physics of Brownian motion, laws of resistance to the motion of particles moving in air, both when the air is in turbulence and for stream-line motion. He should know terminal velocities, movements due to centrifugal motion; flocculation and the effects of air motion and the effects of humidification on it. He must know all about the difficulties of wetting and what is known about overcoming these difficulties. He should know the several electrical phenomena which bear upon dust behavior.

Those are all principles of physics which explain the behavior of dust and upon which engineering practice must be based. They must be understood and be taken into account. Dust control is not a matter only of general ventilation; the engineer must study the production as well as the dispersion. The problem should be analyzed to determine the applicability of segregation, enclosure, wetting, local exhaust and general ventilation.

In some instances, substitution of non-hazardous material, or non-dust-producing operations may have specific application, and they should be explored first. This implies plant engineering. I am convinced that many bad installations are bad because *plant engineering* was not used. In the designing of exhaust systems installed to capture the dust at the points of generation, the physical behavior of air moving toward *hoods* and *in ducts must* be known, and that knowledge used. Each system must consist of collection hoods, piping, air-cleaning plant and a source of suction. Before selecting a hood for a job the engineer must know dust dispersion by dynamic projection as well as dust dispersion by air currents, and design the hood accordingly.

Knowledge Needed

The aero-dynamic characteristics of suction hoods appear to be little known because little thought was given to them in designing thousands of hoods which can be found everywhere in industry. All the possibility for entrapping dust and much of the efficiency of the system lies in this factor. Air velocity, static suction, and rate of air flow are all related, and they must be known. It is essential to use high velocity of air in certain types of exhaust systems to entrap dust projected at high velocities as in the case of a granite surfacing machine, and low velocities must be used in others, as in the case of cleaning asbestos fibre of dust to prevent wasting material.

Quantity of air and its velocity must be determined, then the piping should be designed to take into account the behavior of air-flow through pipes at low and high velocities. Where the problem is complicated by the large sized particles which go along with the fine dust, how these behave must be taken into account. Pressure losses are very important elements in the design of an exhaust system. Loss at the hoods, loss at the bends, and loss in the ducts must not be guessed at. Pipe design must take into account the gage of the metal and reinforcing to withstand pressures and erosion.

The selection of a fan and its motive power is a matter of calculation, not guess work. Power consumption in the system is calculable, fans follow certain laws, so the engineer must know the behavior of axial flow, propeller type, radial flow, paddle wheel and other fan performance.

More physics and engineering calculation goes into the air-cleaning apparatus. The selection of gravitation, inertial or filtration method depends upon what the dust is, the calculation for any methods requires knowledge of discharge through stacks, the determination of sizes of settling chambers, the behavior of cyclones. The use or non-use of a filter, and if so, what type, how it should perform, how big it should be, what kind of resistance and how much each kind offers, to say nothing of their proper location with relation to cleaning, accessibility, etc., are all items for accurate engineering determination.

Apparatus to check the behavior of installations must be known and used. Performance cannot be left to guess work. Supplying sufficient air to be exhausted is part of the problem. The same may be said of heating.

Do I give the problem too severe a build-up? I think not. Remember these two things:

1. You are dealing with hazardous material so small in size and so little of it by weight that it is as invisible as the air that bears it.

2. Physical laws involved in the behavior of dust and air do not permit inexpensive methods of control. I am acquainted with budgets set up for this purpose which amount to more than a quarter of a million dollars and I know of many where 60 to 80 thousand dollars is involved.

The need for this much engineering is recognized by *men who know*. Already much has been done toward getting the knowledge into handbook shape. Perhaps the best job of this sort to date is "Fundamentals Relating to the Design and Operation of Exhaust Systems" developed under American Standards Association procedure.

The Doctor's Part in Controlling Dust Hazards

By A. D. LAZENBY, M.D., F.A.C.S.

Chief Surgeon, Maryland Casualty Co., Baltimore, Maryland

Considerable confusion has existed in the ...st as to just what is the physician's func...on in the prevention of dust diseases, and ...st what is the engineer's. It is very ob...ous upon even casual thought that the ...o sciences must work hand in hand in ...eir efforts to solve the problem.

The physician through his special training ...st be able to tell the engineer what dusts ...e dangerous and what are not. He must ...ow how those dusts enter the body and ...e manner in which they do their harm. He ...st be trained in the examination of per...s who are to be *employed to work in* ...t, and to discover those who are already ...eased, or are peculiarly susceptible to ...t disease. He must be able to detect the ...t signs of disease in workers who are ...osed to dust, and must be prepared to recognize the disease when it is fully developed.

It is not necessarily the physician's function to analyze dust. That is a task for the chemist and the petrographer. It is not the physician's function to count the particles of dust in a given industrial atmosphere. That, in reality, is the function of the engineer. It is not the physician's function to devise ventilating equipment for the removal of dust, nor even to be more than an adviser as to the means that must be adopted to render the atmosphere safe.

The physician nevertheless must correlate with his medical knowledge and with his studies of the industrial worker the findings of the engineer. A diagnosis of silicosis, for example, requires not merely characteristic occupational history and characteristic phys...

cal findings, but the knowledge as well that the patient has been exposed to hazardous dusts in dangerous concentrations.

All dusts when inhaled in excessive quantities may be considered as *harmful*, but only a few can be regarded as dangerous. From the standpoint of their dangerous properties, they may be divided into three general groups.

1. Those which are dangerous because of their poisonous action, such as lead, arsenic, mercury, and similar substances.

2. Those which cause only irritation in the respiratory tract, resulting in such conditions as bronchitis or local inflammation; such substances as vegetable fibre, cork dust, flour, starch, and other relatively innocuous organic or inorganic materials.

3. Those which tend to produce fibrosis of the lungs, thereby predisposing to respiratory infections, especially tuberculosis, such dusts as asbestos, silica dioxide or magnesium silicate.

I shall confine my remarks chiefly to dusts occurring in the latter category.

It *has been generally* believed that the harmful effects of dusts inhaled into the lungs depended more upon their physical structure *than upon their chemical*. It was believed, for example, that silica dioxide, or quartz, was particularly harmful because of its crystalline structure, and the hardness *and sharpness* of its particles. This conception is now known to be faulty. The dusts which cause their damage by mechanical interference with function are the dusts which are relatively innocuous, whose symptoms are transitory, and *which subside upon* removal from exposure to the dust.

Chemical Effect Is Harmful

The disease of particular interest to us today, silicosis, owes its harmful effects very largely to a harmful chemical reaction occurring between silica dioxide and the body tissues. It so happens that silica dioxide is decidedly a tissue irritant to the body, regardless of the part of the body it invades, it causes local irritation, local destruction of tissue, and the replacement of that tissue by scars.

Thus, given a dust containing silica dioxide in sufficient concentration, in sizes small enough to permit its entrance to the ultimate air spaces in the lungs, we have a situation which offers danger to the worker.

We have no real knowledge as to true figures, but as a simple rule, we can adopt for practical purposes the thought that the human body can withstand successfully a concentration of dust containing 100 per cent silica dioxide *in a particulate size less than* 10 microns, in a concentration not in excess of 5,000,000 particles per cubic foot. If we decrease the percentage of silica dioxide present in the dust, we can correspondingly increase the concentration with comparative safety. We must, of course, take into account the portion of the worker's time spent in the dusty atmosphere.

To arrive at a rough conception of a safe atmosphere, we multiply the percentage of free silica in a *given dust by the* total number of particles per cubic foot. If the result is under 5,000,000 the condition may be considered relatively safe. If the result is over 5,000,000 the condition must be regarded as unsafe.

Bear in mind too that silicosis is essentially a disease of great chronicity. Except in a few exceptional instances it will require from seven to thirty years for a worker to develop advanced silicosis. It is evident too *that coincident* dusts may either retard the development of silicosis or hasten it. Recent research seems to indicate that the admixture of aluminum dust to a silicious dust will greatly inhibit the reaction of the latter; whereas a silicious dust combined with some alkaline coincident dusts may hasten the development of silicosis.

Much research is now under way in problems such as this. We have never learned how to cure silicosis, but we are learning rapidly how to prevent it. Our knowledge in this respect seems to be limited *to the removal* of dust from the breathing zone of the worker. Later discoveries may show us how to modify existing dusts with contaminant dusts that will render silica dioxide innocuous.

Owing to its very great chronicity, it is only the rare case who actually develops disabling silicosis during his industrial lifetime. It is realized, of course, that exceptional instances take place, but the coincident ravages of age *usually keep pace* with the effects of dust, so that much of the disability usually attributed to silicosis is often, in fact, actually attributable to other diseases or incapacities which advancing years bring in their wake. To me the *great peril* of silicosis, the peril not only to the *industrial* *worker himself, but* his family, co-workers and the public generally, is the accompany*ing susceptibility to tuberculosis.*

Complicated by Tuberculosis

Silicosis per se does not kill. Tuberculosis as a complicating factor of silicosis rarely recovers despite treatment, and the individual so afflicted is not only totally disabled himself, but a definite menace to all with whom he comes in contact, *particularly the fellow worker who may have silicosis.* So perhaps the most important places *in which the services of the physician in a dusty* trade are necessary are—first, along lines of discovering and barring from exposure to a silicious dust those persons who may already have arrested tuberculosis; and *secondly*, discovering those persons already exposed to dust, possibly already silicotic, in whom tuberculous *infections may have* developed.

It is well recognized that no individual should be exposed to dust containing silica dioxide until he has undergone a thorough physical examination, including carefully made and interpreted x-ray films of his *chest. It is likewise obvious to anyone* familiar with silicosis that no person who is exposed to silicious dust should be denied *the privilege of frequent physical examina*tions and x-rays of the chest, not entirely to discover the existence of possible silicosis, but to discover a coincident tuberculosis *if such exists.*

A man so diseased should, in protection to *himself* and to all with whom he comes in contact, be removed from industry. Let me emphasize the uselessness of a physical examination, unless it be accompanied by properly taken x-ray films, except in cases *of gross* tuberculosis.

It is the function of the physician, therefore, to conduct in a thorough and an intelligent manner the pre-employment examination of all persons who are to be engaged in a dusty trade. The purpose of this *examination should be threefold. First*, to discover and bar from employment in dust, any person who is suffering from tuberculosis in an active, a quiescent or an arrested state.

A possible exception might be made in individuals suffering from a so called healed primary complex, or a healed childhood in*fection. It is* well known that exposure to silica dioxide is very likely to excite into activity a tuberculous lesion which may be *quiescent or arrested*, and once such a lesion is reactivated, the chances of recovery are remote.

The second problem which confronts the physician at the pre-employment physical examination is whether a given individual is, by reason of secondary physical defects, more susceptible to the development of silicosis than a normal. Is he suffering from diseases *of the* nose or upper respiratory tract, such as chronic sinusitis, disease of the lungs or air passages, or obstructions which produce mouth breathing?

We must remember that silica dioxide is not dangerous until it reaches the lungs, and that the normal individual retains in the nose and the upper air passages a large quantity of the dust inhaled from the atmos*phere. In instances* where this nasal retention is disturbed, exposure to silica dioxide dust may be dangerous to that individual, where it would not be to another.

It is believed that certain diseases of the heart and circulation, of the kidneys, possibly syphilis, chronic coincident diseases of the lungs, all *may render a man more* susceptible to silicosis than normal. The physician at his pre-employment examination must follow certain established criteria in this respect, and bar from exposure to dangerous dusts those persons who through existing disease may be more ready prey to silicosis or tuberculosis.

Re-Examination Needed

After the applicant for employment has successfully passed his physical examination and is engaged in a dusty trade, the duty of the physician is not yet ended. This workman must be periodically re-examined, first to discover the early appearances of pul*monary* fibrosis, but what is even more important, to detect the early evidences of complicating tuberculous infection.

A man should not be dismissed from em*ployment in a dusty trade merely because he* has evidences of non-disabling silicosis. Workers in dusty trades, especially stone *cutters, moulders*, pottery workers, and similar craftsmen, are usually highly skilled, and it seems *unfortunate* from a social and economic point of view to deny them employment so long as they are physically able to carry on, especially since the actual disabling qualities of silicosis are in doubt.

They should be denied employment in a dusty trade if that condition is found at pre-employment examination, but they should not be barred from continuing an employment in which they are already engaged. Of course, in such instances you, as engineers, must realize that you have failed, because if you had kept the breathing zone of the worker free from dangerous dusts, silicosis would not be present on physical examination.

In this work of preventing dust diseases in industry, it should be evident that the closest and most intelligent cooperation between the physician and the engineer is necessary. The physician must, through his knowledge and research, tell the engineer what dusts, or, for that matter, what other substances used in industry are harmful. He must tell the engineer how such dusts or other materials enter the body, how they leave the body and what they do in their passages through or their residence in the body.

Must Make Analyses

The engineer must in turn tell the physician of the harmful dusts and other substances surrounding his workers. He must make chemical and petrographic analyses of the dusts, and other indicated analyses of the atmosphere in the workshop. He must make dust counts and check his counts at regular intervals, conferring with the physician in an effort to discover whether, in the light of their joint knowledge, working conditions are dangerous. He must develop and install carefully designed ventilating equipment. He must arrange for modification of chemical and other industrial processes, where such modification is possible, and must bend his efforts toward removing from the danger zone of the worker the offending substance, whatever it may be.

Too many engineers construe this function loosely. They pass on to the physician as his responsibility certain functions which essentially are theirs; such functions as dust analyses, dust counts, and similar technical duties. All too often it is considered adequate merely to install a fan.

Ventilating devices in dusty work rooms must be constructed only after careful engineering study has given a knowledge of the physical properties of the air and of substances polluting it. It is possible to calculate to a very fine point the volume of air that must be removed from a given spot to remove the dust originating at that place, and the engineer must approach his task from just as scientific an angle as the physician approaches his.

There is no room in industry for haphazard methods on the part of either the physician or the engineer.

ADJOURNMENT

Industrial Fumes, Gases and Vapors

THURSDAY MORNING SESSION

October 14, 1937

The meeting was called to order by Voyta Wrabetz, Chairman, Industrial Commission of Wisconsin, Madison, who presided and introduced the speakers

Injurious Effects of Metal Fumes and How to Prevent Them

By ROY R. JONES, M.D.

Division of Labor Standards, U. S. Department of Labor, Washington, D. C.

The inhalation of metal fumes is a common cause of illness among certain occupational groups. Two very different systemic reactions may result from breathing air containing particulate metal or metal compounds: (a) metal fume fever, an acute, transitory, non-fatal disease causing slight or temporary disability; (b) systemic metal poisoning, mild, severe, or even fatal in its effect. The same occupational exposure may produce both reactions, metal fume fever developing following the worker's early exposure, chronic systemic poisoning developing later as a result of prolonged exposure.

We may consider metal fumes as solid particles generated by condensation from metal in a gaseous state. Condensation is usually accompanied by oxidation.

There are two chief physical characteristics of metal fumes which bear a direct relationship to the ease with which they may be absorbed: (a) The solid particles are much finer than atmospheric dust, probably averaging less than .5 micron in diameter; (b) they tend to flocculate and settle out of the air as dust. The finer the solid particles suspended in the air, the longer the time required for them to settle out. Many of the coarser dust particles in the air are trapped in the upper respiratory tract and by the ciliated cells lining the trachea and bronchi, while the finer particles may be carried to the terminal air spaces of the lungs. Here they are taken up by the phagocytic cells and are eliminated chiefly by way of the blood and lymph.

Sayers and his associates[1] found that only about 15 per cent of inhaled particulate matter, such as lead dust from automobile exhaust gas, was retained in the lungs, the remainder passing out with the exhaled air. Drinker and his associates[2] and Brown[3] made quantitative measurements of fumes retained in the lungs. They found a direct relationship between the percentage of fumes retained and the size of the particle and the density of the fumes breathed. They also showed that slow deep breathing increased the reaction resulting from inhaling zinc fumes. Such breathing should increase the percentage of particulate matter retained.

Hazardous Processes

For convenience we may place the more common occupational environments which are likely to afford a harmful exposure to metal fumes in three large groups:

1. Smelting of ores and refining of metals.
2. Employment at processes handling molten metal such as molding, cutting, and welding operations.
3. Salvage and cleaning operations, including the burning of metals or metal covered objects, especially by means of acetylene torch or electric arc.

In the first class, the ores or metals processed provide the source for the generation

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*Deceased

On the basis of the human element being the major problem in the elimination of accidents and their attendant injuries, the safety program must be designed to emphasize to the supervision and workers the necessity of being safety-minded at all times. The most effective influence in selling any proposition is an appeal to the self-interest of the individual. If he becomes convinced that he can personally benefit by the elimination of accidents, he is apt to accept the safety program and become a safety booster.

The hazards incident to maintenance work can be minimized by methods which anticipate and reduce the number of breakdown jobs. This reduces the amount of work and corresponding man hour exposure, and allows most of the work to be done on a planned basis. The most essential practice in such a program is systematic, thorough and frequent inspection of all equipment, with a follow-up system which will insure that unsatisfactory conditions are corrected as promptly as production allows or economic considerations dictate.

If the maintenance foreman's territory is small this inspection can be made personally. However, the usual division of a steel mill maintenance foreman is too extensive and too many other demands are made upon his time to allow personal attention to all items of equipment. It is then necessary to delegate this important function to operators, oilers, engineers and electricians who are in a position to observe the condition of each piece of apparatus.

In power houses, boiler houses, pumping stations and similar station jobs the engineers, oilers, pump tenders and electrical operators are primarily occupied with operation of the equipment and close and continual observation is automatically obtained. Such close observation is accepted as necessary due to the importance to production and the fact that little spare capacity is provided. Likewise, the standard of maintenance is high, being kept as far as possible on a preventive basis. The jobs are usually well planned, the crews experienced and efficient, and all tools and special equipment at hand, resulting in efficient and safe performance.

The majority of mill auxiliary equipment does not get the same degree of attention and maintenance. Here the operator, in general, has no interest in the apparatus, except that it respond to the controls, and little or no responsibility for keeping the unit in operating condition—hence the necessary, fully organized maintenance crew to take care of such equipment. The only exception to this is the craneman who may have limited responsibilities as to the inspection, lubrication and adjustment of his machine, and certain other machine operators.

Overhead traveling cranes, gantry cranes, repair trolleys and various types of hoists comprise a class of equipment which require special attention from the standpoint of inspection and preventive maintenance. Due to the hazards of falling material, whether casual material, broken parts of the equipment, or loads dropped due to failure of mechanisms, every precaution must be taken to keep this class of equipment in good repair. It has been found desirable to supplement the work of the foreman and repairmen charged with the proper maintenance of such equipment by the use of Crane Inspectors.

The crane inspector goes over all equipment in detail, recording all items of a mechanical or electrical nature which need adjustment or replacement. This survey provides a double check and does not lessen in any degree the responsibility of the abovementioned foremen and repairmen. Copies of these reports are forwarded to the superintendent and foreman involved, as well as to the Plant Safety Department head. All recommended repairs or alterations must be disposed of, either by being carried to completion, or by being rejected for cause.

The inspection covers cleanliness and orderliness of the equipment in the interest of minimized fire hazard and increased safety of operators and repairmen. Safety equipment, such as sanders, fire extinguishers, hand lines, safety belts, gongs, warning lights, light extension cords, gear guards etc. is checked. Loose or scrap material on the cranes, approaches or runways is not tolerated. Loose, worn or broken parts are itemized and recommended for correction.

Inspections at intervals of one to two months have been found sufficient for average conditions, with more attention given to particularly hard-worked cranes. Unusual operating conditions, or failures of parts may make it desirable for the inspector to make special checks and reports when requested.

ADJOURNMENT

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V. O. Murray, The Union Pacific Coal Co., Rock Springs, Wyo
R. B. Paul, New Jersey Zinc Co., New York, N. Y.
John T. Ryan, Mine Safety Appliances Co., Pittsburgh, Pa
L. T. Sicka, St. Joseph Lead Co., Bonne Terre, Mo
John Treweek, Homestake Mining Co., Lead, S. D.

TUESDAY AFTERNOON SESSION

October 12, 1937

The session was called to order by General Chairman C. W. Gibbs, Harwick Coal and Coke Co., Pittsburgh, Pa., who introduced the speakers.

The Relationship of Safety to Efficiency in Mining

By JAMES K. RICHARDSON

Safety Director, Climax Molybdenum Company, Climax, Colorado

No person will deny that there can be but two ways of doing work—a right way and a wrong way. The whole scheme of mining methods is basically a question of safety and efficiency. If the ore cannot be extracted economically the system is abandoned. If the ore cannot be extracted without endangering the lives of the employees the system is abandoned. Unquestionably the latter thought has often been overlooked. We cannot, however, overlook the fact that anything that kills or maims men is morally wrong. Furthermore, if our process or method tears up machines it is surely not efficient.

Low cost production is the true basis of efficiency. The major item on any cost sheet is labor. A property that achieves a low unit cost due to a cheapness acquired by low wages with the consequent low type personnel will not long exist! The reason is obvious—although the daily labor cost is low the ultimate job cost is high. These poor workers are the men that efficient organizations refuse to tolerate—the "cream of the crop" are hired in their place.

When a mine gets a reputation for unsafe working conditions you will notice an influx of poor workers. The good men leave—the poor ones stay. The reason is that the poor worker realizes he cannot get work in an organization that demands efficiency and ability. Each of us has talked to various employees coming from other properties. You hear that "such and such" a company kills men daily, or that someone is always getting hurt. These reports may or may not be exaggerated—but where there is smoke there is fire! If your property gets such a reputation among the laboring men LOOK OUT.

The basic principles of accident prevention are: Supervision, education, and discipline. It is not necessary to discuss these principles. However, it is true that too much of each day's work is lost by the working men, due to unsafe conditions. If the workman must spend half his day remedying faulty conditions, replacing staging left by a previous shift, "blowing out" his working place, or any one of a thousand similar circumstances, you know production costs are rising.

The efficient mining organization is today standardizing every task. These standards are built up from the study of the task and are adopted if efficient and safe. Such jobs are easily supervised and it is easy to educate the employee in the manner of working. When an employee knows how to do a job he seldom is injured.

From my personal standpoint I believe that the standardizing of jobs is the biggest step an organization can make toward improving underground or surface efficiency. I also believe that on the standard tasks the accident risk has been lessened 50 per cent. Every task is done the same way yet there is enough variation of conditions in mining practice so that it does not tolerate a man becoming mechanical. When a workman knows he must keep a definite standard regardless of the work being done, he attempts to meet those requirements. He knows that the preceding shifts must meet the same requirements and therefore he is able to take up his work safely, exactly where it was left by his predecessor. He can thus devote his full time to work without fear of slipshod methods applied previous to his arrival.

I believe that a task well done, regardless of the job, is more easily maintained than a haphazard piece of construction. When a job is safe, all components of that job are in first class condition. We can, then, surely count on lower maintenance costs on first class jobs and when the operator looks over his cost sheets, repair costs are the major items. All of us have seen timbermen tearing out old timber and replacing with new. Had this timber been properly placed and properly considered at first, the new job would not have been necessary.

Unquestionably we have all had experience with faulty ventilation. I recall certain underground fires that could have been controlled and loss of life averted had ventilation been considered a major problem in the original layout. The major portion of our small metal mines are notoriously poorly ventilated. Many men are "gassed," causing them to fall from high raises to death or certain injury; others contract pulmonary diseases more readily and are disabled. Some are injured because of their inability to see their work clearly. These things are all due to a faulty ventilating condition, and any injury causes certain losses in production regardless of its seriousness, nor can it be denied that unless breathable air is available the normal efficiency of employees is decreased.

In one particular property I recall certain additional work obtained merely by establishing proper ventilation. A total of 150 machine shifts was being put in each day in a stoping area and prior to correct ventilation the average amount of hole drilled per machine was 86 feet. After the ventilation was improved the average was increased to 1.8 feet. Loaders who had originally pulled approximately 76 cars consistently passed the 100 mark. Footages in development work rose from 2.6 per machine to 3.8 feet. Loss of time from pulmonary disorders dropped to a negligible figure, and the accident frequency fell 28 per cent.

Another important factor in accident prevention is correct illumination. Those mines which have done away with the old carbide