

FILE NAME: Union Carbide (UC)

DATE: 1936 Oct

DOC#: UC003

DOCUMENT DESCRIPTION: Transactions of the 25th National Safety Congress

TRANSACTIONS

25th

National Safety Congress

NATIONAL SAFETY COUNCIL, INC.

**ATLANTIC CITY, NEW JERSEY
OCTOBER 5 to OCTOBER 9, 1936**

**Ambassador, Chelsea, Ritz-Carlton Hotels
and Atlantic City Auditorium**

Foreword

THE Transactions of the Twenty-fifth National Safety Congress, 1936, are published by the National Safety Council in two volumes. This, the first, contains the general, the special subject, and the Industrial Section sessions. The second volume contains the sessions of the Child Education, Home Safety, Street and Highway Traffic and Vehicle Fleet Sections.

All industrial members of the Council automatically receive Volume I. Volume II is sent to members believed to be interested chiefly in the sessions it covers. Other Council members, however, may obtain it upon request.

Many members have found it worth while to distribute copies of the Transactions to supervisors, foremen, and others in an administrative or supervisory position who may make practical use of them for reference purposes. The following quantity prices are quoted on extra copies: 1 to 10 copies of the large volume, \$1.50 each; 11 copies or more, \$1.25 each; copies of the smaller volume, 50 cents each.

THE Transactions are published as a condensed record of the proceedings at the National Congress. The papers of each session or division of the Congress have been edited carefully to eliminate extraneous matter and to abbreviate the less essential portions because of space limitations. Thus the material herein presented is not a verbatim report of all the speeches presented at the Congress, but rather an abridged version made as compact as possible, yet without injury to the technical aspects of any address. The original manuscripts are on file in the Council's Bureau of Information, where they are available for additional reference. Where illustrations were sent by the speakers to the Council, these also are on file.

The National Safety Council at its Congresses seeks to eliminate from discussion matters which are not pertinent to the aim of the Congress or which are contrary to Council policies. It cannot accept responsibility for the views expressed either in the papers presented or in the discussions based upon the papers.

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The fundamental Safety Council human life. It sees continuous campaign that is nation to all types of hazards directly or indirectly citizenry. It is a non-sectarian, and affiliations. Since it has won respect institution.

Inseparable from the Council's working conditions and practices in America.

Today there are representing every one of the 400 foreign ships includes firms, individuals, chambers of commerce organizations. Industrial concerns companies, the the railroads in automotive industry sanding import trial field.

Orig

The history of the organization is too long to tell in brief, the 1 Congress was the Association of Engineers in 1884 as a result, the National Safety Council was organized in 1891 with four members in the first year the 1891.

fore long you have to think of something else to maintain the interest of the men.

Mr. Bonsib: Remember that everything that we do is a result of two great principles, pride and fear. Fear gets results, in the way of discipline, but pride is the greatest instinct man has. Lie awake at night thinking of how you can do your work better, and you will think of things that will appeal to the em-

ployees' pride. Pay attention to statistics, but use them correctly. Get statistics along lines that will show you where the trouble is, and what causes it.

With such statistics you can stimulate the competitive instinct, because deep down in his heart every man honestly believes he is just as good as somebody else, and he wants to show it.

Chairman Boulet: The meeting is adjourned.

ADJOURNMENT

Occupational Diseases

FRIDAY MORNING SESSION

October 9, 1936

The session was called to order by the chairman, Dr. Hart E. Fisher, Vice-President for Health, National Safety Council,

and Chief Surgeon, Chicago Rapid Transit Co., Chicago, who presided, introducing the speakers.

The Lesser Known Facts About Common Occupational Diseases

By DR. ROBERT B. HUNT

Medical Advisor, American Mutual Liability Insurance Co., Boston

Probably the leader in the parade of industrial diseases is an acute or chronic inflammation of the skin which we call dermatitis. This disease may present itself in any type of shop, factory or foundry. Any paste, powder, gas or liquid which comes in contact with the employee's skin, even the water supplied by the town in which he lives or works, may be the potential cause of such a skin disturbance.

The wide diversity of causes together with the varying susceptibility of different individuals makes the problem of control difficult.

Much investigation is under way to determine why one person may be susceptible to a certain substance while another is not. It has been proved many times that a poisonous substance formed within the body has been able to prolong the action started by some external influence. A printer developed a marked dermatitis from ink which persisted for two years. Finally food tests were made and showed that he was susceptible to lettuce, which, when removed from his diet cleared the skin. He returned to his usual occupation without a return of symptoms.

The poisoning of allergic substances is usually an accumulative process. It takes time to produce a manifestation of disease, but let any other substance cause the disease, and the irritating food may be of sufficient strength to magnify its action.

All cases of dermatitis cannot be cured by eliminating offending foods, but further investigation along these lines may give us a clue with which to lessen the loss of time from work and the discomfort now produced by industrial dermatitis.

Metals

Lead

The distribution of lead poisoning is quite extensive.

The skin of the body is a protective covering, and as long as it remains intact it does a good job except in the case of tetraethyl lead, which is used in blending gasoline and which is readily absorbed through the skin, having a tendency to create changes in the nervous system. The effect of other forms of lead, through that avenue of entrance, is practically nil, which explains the extremely low poisoning rate in typesetters, painters and others who continually come in contact with metallic lead.

Lead in any form, introduced through the mouth, acts rather slowly when compared with the inhalation of lead dust or fumes. However, no matter what the portal of entry may be, lead is acted upon by the body fluids and so converted that it may eventually be deposited within the bones.

Those bony safe deposit vaults may retain their lead contents for days or for years, and if the exposure is removed, may also free the employee of all signs

and symptoms of lead poisoning. But imagine the surprise of that supposedly cured person when years later, perhaps following some type of infectious disease or the excessive use of alcoholic beverages, he awakes to find that he suffers the aches and pains and paralyses of an acute lead poisoning. As the body fluids alter lead that it may be deposited, so may those fluids attempt to de-lead the body, and too rapid absorption may produce the original disease with all its discomforts.

One can readily see, then, that in some cases investigation of previous occupations is quite necessary to determine the original contact with lead.

Heating of molten lead causes a black scum of lead suboxide to form on its surface, and the heat from the metal discharges the fine powder into the air. Hence, in the process of smelting ores such as zinc, copper and silver, mixed with lead, we find a rather high lead poisoning rate.

Those engaged in the manufacture of lead wire and cables, batteries, glass, pottery and rubber industries, plumbers and users of dry colors offer their share of lead poisoning.

Probably the greatest source of lead poisoning may be found among those who sandpaper, scrape, chip or burn lead paint, for the dust and fumes caused by those activities are rather rapid in their action. Such workers may become incapacitated in a few days because the inhalation of lead dust causes the maximum amount of absorption into the blood stream in the minimum space of time.

Chromium

Chromium is a metal widely used as a foundation for colors, and dusts from its various salts may produce lesions of the skin and mucous membranes of the nose. Chromium plating by electrolysis may cause fumes which are similarly irritating. Although chromium poisoning does not usually cause death, the number of days of absence from work on account of incapacity which it causes is gradually increasing.

Other Metals

The most efficient portals of entry of foreign substances into the body are the

nose and mouth. The smaller the dust (the size of smoke particles for example) the greater the speed of absorption by the blood. Fumes from hot metals carry not only poisons but numerous minute dust particles. This explains the incapacities occurring among those engaged in acetylene and electric cutting and welding. When men are so employed over a prolonged period of time, the constant inhalation of fumes and dust might produce symptoms of the metal upon which they work. In the ship-building trade, particularly in the construction of metal ships, we find occasional cases of metal-fume fever. "Brass chills" and "spelter shakes" from zinc are names applied by the lay people to such diseases. The terrific heat applied to some of our common metals and alloys by acetylene torches produces sufficient fumes to cause a temporary incapacity in 24 hours. Permanent disability from such causes is rare, however.

Diseases Due to Dust

Twenty-five per cent of all workers exposed to high concentrations of inorganic dust are expected to develop changes within their lungs due to that agency. We are at a loss to explain why the other seventy-five per cent are not so affected.

Mining, quarrying, foundry work, grinding, sandblasting, abrasive soap manufacturing, asbestos work, the making of emery and carborundum products and many other occupations offer opportunities for employees to inhale microscopic dust particles and create a foundation for possible future incapacity.

We are interested particularly in those men who work with sandstone, quartz, flint, granite, and sand, because they expose themselves to silica, and the chemical changes between that dust and the body fluids, in the presence of tuberculosis, may and usually do lead to a fatal ending.

It is safe to say, in light of our present knowledge, that the action of other inorganic dusts is much less virulent and incapacitating. That, however, does not allow us to lower the vigilant methods to improve dust control and protect employees, because all dusty occupations are potential trouble makers.

Although the actions of various dusts differ within the body, the exposure to asbestos fibres, present in the weaving and grinding of dry asbestos material, offers another type of dust which may cause fatalities among workers.

The organic dusts from cotton, silk, wool, tobacco, flour and similar substances are practically harmless. Such dusts rarely reach the lungs but may cause irritation of the windpipe and larger air tubes and result at the most in a mild bronchitis.

The factor which should be borne in mind, particularly when dealing with silicosis and asbestosis, relates to the progression of such disease. When changes occur within the lungs as a result of the presence of such dusts, nature forms scar tissue to heal such lesions but may fail to stop when the job is finished. As a result, the continuation of that healing process may lead to such structural changes within the lungs that partial or total incapacity may follow months or years after the employee has been removed from his dusty occupation.

Benzole-Benzene

Benzol is a distillate of coal tar used extensively in industry. It is an essential ingredient in the manufacture of explosives. It is an excellent solvent for grease, oils and cements, and because of that property it is important in many phases of the rubber and cleaning industries. In the manufacture of shoes benzol may be an ingredient of the dressing applied to the leather and of the cement which fastens the heels and soles. Not only in the shoe trade but in other branches of industry where employees work with gummy, sticky material, the workers soon learn of the solvent and cleansing action of this liquid and use it freely for that purpose upon themselves. The subsequent outbreak of skin affections may be the first indication of such unauthorized use.

Benzol is extremely poisonous, entering either through the nose or mouth or absorbed through the skin. Its action within the body is varied and may produce a multitude of signs and symptoms. The bone marrow becomes affected which in turn alters the character of the blood;

hemorrhages are common; it may cause death.

The fumes from benzol are heavier than air and lie near the floor, which is an important point in the engineering problem of ventilation.

The members of the benzene group are absorbed through the skin, and more cases of poisoning are found when men perspire than when their bodies are cool. Probably the answer to that is that the fumes may solidify as they cool and the powder may settle on the skin. The sweat on the body may dissolve this dust so that it is more readily absorbed through the increased surface blood supply.

Chlorinated Hydrocarbons

This group of petroleum derivatives has been known to science for years but during the past decade its advance into the industrial field has been widely distributed and most important. Led by carbon tetrachloride and its chemically associated members, it has furnished industry with refrigerants for ice chests, excellent solvents for rubber, wax, oil and grease, thinners for lacquers and a very fine household necessity for the removal of spots from clothes. Hospitals have been using it more and more for the removal of adhesive plaster.

Due to the non-flammability of carbon tetrachloride, it is used in fire extinguishers. The rapid evaporation produces fumes which may smother a small blaze, but we must not forget that excessive heat of the actual fire may bring about combustion sufficient to produce such byproducts as hydrochloric acid and phosgene gas. Like its associated member, chloroform, it may produce sleep when inhaled by an individual, and only 1/350 of an ounce in a quart of air is necessary to produce such action. That thought must be remembered when a large quantity of these liquid products is spilled on the floor, perhaps accidentally. Action should be started at once before the liquid gasifies, and employees should be notified to keep their heads up to avoid the low ceiling of gas.

Chemists have developed and introduced to industry many new products, the basis of which is the chlorinated hydrocarbons. These derivatives of petro-

to think, inability to draw a personal lesson from the experience of others, overconfidence and a desire to make good on the job. These can only be overcome by careful and systematic handling on the part of the supervisor. His is the responsibility of putting over to the worker the value and advantages resulting from a close observance of rigid safety inspections.

Systematic Organized Safety Effort

There should be little need to make a plea for more concerted action along this line. As safety men, we know how easily the small employer could be put out of business as the result of even a few

accident losses. The larger employer, as well, cannot afford to overlook the situation—his losses, through waste of time, money and materials, will seriously affect his profits and hold his company up to the public as a very inefficient organization. The ever increasing cost of compensation insurance will undoubtedly be a factor in forcing more consideration for well organized safety work. Personally, I emphasize the side of humanity above the dollar and am satisfied from long experience that where humanity rules, the profits will be satisfactory. Where a real safety program is followed, without doubt efficiency and economy of the highest order will also prevail.

The Present Status of Control of Dust and Fumes in Industry

By H. B. MELLER

Managing Director, Air Hygiene Foundation of America, Inc.; Head, Air Pollution Investigation, Mellon Institute of Industrial Research, Pittsburgh, Pa.

The problem divides itself naturally into medical, preventive engineering and legislative phases, and includes consideration of the responsibilities of employer and employee to each other and to the public.

It is axiomatic that, in case of physical disorder, impairment of function or disability, the more thoroughly the cause and course of action are known, the more certainly can possible remedies be applied or preventive measures taken.

In the diseases or affections under consideration, there are facts upon which preventive methods are based, and upon which further studies now in course or contemplated are, at least in part, predicated.

During the development of the present state of knowledge of the influence of some air contaminants on health, naturally many theories were advanced that later scientific work has modified or displaced. However, not always has the correction been as widely and thoroughly disseminated as was the original theory; this condition, perhaps, has led to some confusion in the minds of many who have not followed too closely the evolution of knowledge in this field.

Classification of Dusts

There are available different published classifications of dusts. Included in such classifications are dusts, the exposure to inhalation of which are, or are likely to be, occupational. Those that are inherently toxic when inhaled or otherwise absorbed and which cause systemic poisoning, include lead, arsenic, mercury, manganese. Examples of dusts which have the ability to penetrate the deep lung tissues and to be retained there are quartz, flint, chert, asbestos, talc, coal, iron, clay, slate, and other types of rock dust.

Attention here will be centered upon this last group and upon pneumoconiosis, the general term used to designate lung conditions caused by dust. Silicosis, which is caused by the inhalation of free silica, has been prominent recently in the public press, sometimes in a way that made misunderstanding possible, if not probable.

Aside from silica, many of the insoluble mineral dusts may bring about slight changes in the lung tissues, which may be demonstrated on the roentgenogram if there is silica in the dust that is inhaled. As far as is known today, most of them are relatively or entirely harmless.

Ability of Dusts to Cause Injury

It has been established that the potentiality of silicious dusts to cause lung damage is, with few exceptions, dependent upon their content of free silica (SiO_2). The development of silicosis depends, therefore, upon the concentration of dust containing free silica in the air breathed. In other words, the total amount of free silica breathed and retained seems to be the primary factor; the length of time necessary for a sufficient accumulation is important, but less so than the total load.

Silica occurs also in chemical combination in silicates. Some of these compounds have been proved to be relatively harmless to health, some are still in the realm of doubt, and one—*asbestos*—may cause the industrial disease called *asbestosis*, which is the result of lung damage similar to, but not identical with nor as serious as, that produced by free silica.

Importance of Particle Size. The size of dust particles in the air which an individual may breathe is important. Not often are particles larger than 10 or 12 microns found in the deep lungs, except in the case of *asbestos* dust, where fibers as long as 200 microns have worked their way down lengthwise.

Uncomplicated Silicosis. Silicosis, uncomplicated by an infection, is more of an impairment than a disability. It is not seriously disabling until it reaches an advanced stage, and does not of itself greatly shorten the life of a silicotic.

Silico-Tuberculosis. When a silicotic dies, the immediate cause of death is usually some type of intervening lung infection. It is not known just why the presence of silica in the lungs increases susceptibility to tuberculosis, but when an adult with silicosis is exposed to tuberculosis, an active infection may occur, regardless of the previous state of health. It is thought probable that silica dust can reactivate healed tuberculous lung lesions of the adult type; how long after such lesions have healed the reactivation is possible is not certain. Exposure of silicotics to tuberculosis or of tuberculous individuals to silica dust is serious and should be avoided.

After silicosis has become well established in the lungs, medical science has not found a way to arrest the progress

of the silicotic process toward the stage of disablement except through limiting or preventing further exposure to silica dust. Nor has medical science found a way to prevent tuberculosis from being superimposed upon silicosis, except through control of contact. The course of silico-tuberculosis is chronic and is very difficult to influence by treatment, according to phthisiologists.

Medical Control. As a basis for intelligent determination of the physical fitness of a man for a job in a dusty trade, physical examination, with stereoscopic roentgenograms of the chest, is necessary. Along with this study goes, naturally, the preparation of an occupational history with detail as to the exact nature of previous work and of exposure to industrial dust—not a valueless recording of occupations as “laborer,” “machinist,” etc. Dr. Sayers, of the U. S. Public Health Service, has developed a method of securing information for a proper occupational history; among others, Cummings, of Saranac Laboratory, also has worked out a useful history blank.

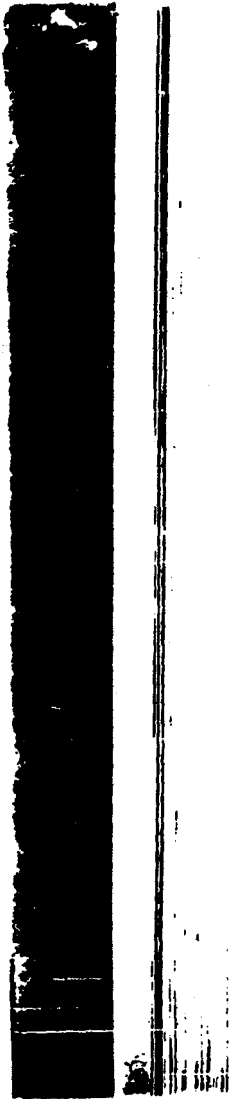
Standards have been developed for the diagnosis of silicosis. There is also a suitable technic for taking roentgenograms of the chest in order to bring out the characteristic lung changes.

From the considerable amount of work that has been done, it is possible to forecast with a reasonable degree of accuracy the silicosis potentiality of various dusts.

Periodic physical examinations, including roentgenograms, are essential if employers are to be enabled accurately to learn the effect of individual exposure and intelligently to transfer affected workmen to lower dust concentrations before serious injury has been done, or to work out a system of rotation where indicated as desirable in order that exposure may be intermittent. Such examinations are helpful also in showing the efficiency of engineering control methods.

The ability to place responsibility in case of claim for injury is no small part of the value of such initial and periodic examinations.

Asbestosis. Clinical experience has shown that the inhalation of a sufficient amount of *asbestos* dust causes a serious type of fibrosis, which is not accompanied



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. E. 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 industries¹ 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 1.3 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 chemie 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.³ 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.⁴

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.⁵

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.⁶

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.⁷

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.⁸

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 reaction 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, 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, the reactions from toxic dusts result from swallowing as well as from inhalation.⁹

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 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. Lying under this classification, and as thought to be of the same order of size, are 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 more microns in diameter. However, it is possible that the larger and heavier dust particles settle due to gravity, and do not remain suspended in the air.

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

1. **NONLIVING ORGANIC DUSTS**—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.

2. **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.¹⁰ 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.¹² 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.¹³

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.¹⁴ Dermatitis occurs among handlers of silk with varying frequency. Sells determined that a rash occurring among workers in a silk factory was due to dust from silk cocoons imported from Africa.¹⁵

Persons engaged in the manufacture of quinine and quinine preparations suffer from skin 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.¹⁶ Dermatitis due to other vegetable dusts such as vanilla, powdered arnica, pyrethrum, etc., have been reported.¹⁷

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.¹⁸

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.¹⁹

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, hor-chair, 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.²⁰ It is unnecessary for the offending dust to reach the depths of the lungs—great 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.²¹

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.²² During the first processes

of cotton spinning, cotton-strippers are exposed to dust arising from cotton husks and debris, which produces a typical form of asthma.²

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, olive wood, California sequoia, etc. All persons who handle these woods are not injured, only those particularly susceptible to the substances they contain becoming affected.²

2. LIVING ORGANIC DUSTS. These contain particles capable of exhibiting the phenomena of life (especially the property of reproduction or multiplication), such as bacteria and fungi. They are usually found in low concentrations and are associated with moistening 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 wool-sorters' disease).²

Cases of tetanus, reported in connection with pite manufacture, were traced to the raw material, the bacillus having been found in the factory dust.² 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.²

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: *Sporo-*

trichum dermatodes), which is scamed 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 basket-makers, the mycelium and spores, in the form of a white mould (hyphomycete) free the rattan canes used, get shaken out when the canes are split, hammered, and causing painful fissures to develop on the skin where they alight.²

A form of asthma or spasmodic cough, suffered by cotton weavers and known as aspergillitis, has been considered due to inhalation of spores of a mildew which some times occurs on the threads.² In a study of silicosis among miners, made by the Public Health Service, a number of cases of typical military calcification were encountered. Unstained smears of these cases examined were positive for fungus, in types of *Aspergillus* fungi being identical. All of the subjects but one were farm teamsters, feedmill workers, or residents of small agricultural towns where grain-marketed. Farmers are exposed to fungi: threshing wheat, haling hay, or handling various small grains.²

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 debris contaminated with mould, etc. Actinomycosis is likely to affect people engaged in commerce: handling, storing, and cleansing of grain (grain distilleries, flour mills, grain crumbing, breweries, and malting houses, etc.).²

II. Inorganic Dusts

Inorganic compounds are of mineral origin, not requiring a living organism to produce them.² A number of dusts are 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,

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.² 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.²

According to Fairhall, perforated nasal septum is a common occurrence among workers with bi-chromate dusts.² In a study made by the U. S. Public Health Service it was found that continuous daily exposure to concentrations of chromic acid dust greater than 1 milligram in 10 cubic meters is likely to cause definite injury to the nasal tissues.² 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.² 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.²

Alkalies 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.² 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 cyanide dust.²

Some of the diseases of dermatitis, scleroderma and can-

cer 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.²

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.² 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.²

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.² 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.² 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.²

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.

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.

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 aluminum, 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 Lanza¹ 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. We may be used to entrap dust and prevent 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 can 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 to the subject of individual protection in dust, and there are many types of respiratory protective devices now available. There are generally of two types: those which provide fresh air from an uncontaminated source and those which rely upon a filter 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 respirators, or other such protective devices, should be used only where exposure to dust is intermittent and brief, or where some unusual condition makes a more adequate dust control impracticable.

Where bacteria or other living dusts are associated with a process, sterilization methods such as increased temperature, ultraviolet radiation, and chemical chlorine or other bactericidal substance 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, so 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.² 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,

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.³ 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.⁴ 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.⁵

"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."⁶

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By Hours of the Day
By Body Part Injured
By Nature of Injury
By General Cause
By major sub-classifications under General Cause
By Primary Basic Causes
By Secondary Contributing Causes

By Foremen in Charge
By Manner of Performance
By Agency (Machine, Material, etc.)
By Part of Agency
By Method of Contact

The figures may be summarized by days of time lost, medical expense, compensation awards, or other associated data.

WEDNESDAY AFTERNOON SESSION

October 13, 1937

Methods for Protection Against Silicosis, and When They Are Justified¹

By DANIEL HARRINGTON

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While the hysteria with regard to silicosis and other occupational diseases has largely subsided and this subject is being more carefully considered and soberly judged, it would be poor policy for any employer to maintain that the storm has ended and that he can relax and revert to conditions as they were some years ago. The fact is that the plan of paying occupational-disease compensation is now in its infancy and can be expected to grow rapidly.

At present while all the States of the Union, including the District of Columbia and excepting only Arkansas and Mississippi, have compensation acts, only the following make provision for occupational diseases to some extent: California, Delaware, Connecticut, District of Columbia, Illinois, Indiana, Kentucky, Massachusetts, Michigan, Minnesota, Missouri, Nebraska, New Jersey, New York, North Carolina, North Dakota, Ohio, Pennsylvania, Rhode Island, Washington, West Virginia, and Wisconsin.

Silicosis is compensable in one way or another in California, Connecticut, District of Columbia, Illinois, Kentucky, Massachusetts, Missouri, New York, North Carolina, North Dakota, Ohio, Pennsylvania, West Virginia, and Wisconsin, and possibly in other States. It will be surprising if comparatively comprehensive occupational-disease legislation is

not on the statute books of nearly every State in the Union within the next five years.

With this situation confronting him, the far-sighted industrialist who has the interest of his organization at heart will immediately start to "put his house in order" by studying possible occupational-disease hazards to his employees and promptly applying known remedial measures or attempting to develop such measures if none exist. Unquestionably one of the most important of the surveys he made relates to dust occurrence.

While the state dust laws and regulations apply primarily to silica dust and resultant silicosis, most of the health hazard concerned, those most familiar with dust occurrence and its possible hazards recognize only that the breathing of large quantities of free silica (SiO₂) is probably the greatest hazard to health likely to be met where dust is involved, but that not only silica dust is harmful to health, but that it occurs in very finely divided form and is breathed in relatively large quantities for or less continuously for a considerable length of time. Moreover, many thoughtful experts on dust harmfulness are now becoming convinced it is to be expected that both will be harmed when human beings are obliged to breathe high concentrations of any kind of dust more or less continuously. Professor Philip Drinker, of Harvard, as chairman of the Preventive Engineering Committee of the Air Hygiene Foundation, has

expressed the considered opinion that the body of outstanding dust experts as a whole is

There is no satisfactory medical answer to this question, but the engineer is making a bad mistake if he lets men breathe heavy dust concentrations of any kind. If no other reason for dust control can be found, then one should read transcripts of some of the recent suits at common law in which fantastic damages for silicosis were granted to men who breathed dust containing little or no silica. The courts and compensation boards are not impressed with subtle distinctions between dusts with 10 per cent and 40 per cent quartz, especially when medical experts are reluctant to make definite statements as to the comparative significance of such differences.

"It would be well to realize that men working in dusty trades suffer far more from respiratory troubles of all kinds than men who work in clean air. The evidence that excessive dustiness of any kind is harmful is beyond argument."

It should also be remembered that the breathing of dust is by no means its only hazard in industrial work that may require compensation payment; and even here the harmful effect of breathing dust is not necessarily confined to the lungs, as some kinds of dust are known to have detrimental health effect on the nose, throat, and bronchial passages as well as (indirectly) on the heart, stomach, and possibly other internal organs. Externally, dust may cause injury to the eyes, ears, and skin; and some dusts, in contact with the perspiration, are absorbed with definite harm to the health of the victim.

Dust Cuts Visibility

Moreover, heavy concentrations of dust in the air reduce visibility materially. Obviously, in industrial occupations in which but small amounts of natural light are available or in which artificial light is used sparingly, any decrease in visibility due to dust concentrations (and the decrease in visibility may, under some circumstances, amount to 75 per cent or more) is likely to result in materially reducing efficiency and safety in the more frequent occurrence of accidents accompanied by an increase in compensation commitments. Some dusts (coal dust, for example) and scores of others, mineral and organic, are explosive and many

are subject to spontaneous combustion with consequent hazards to health, safety, and property. Many dusts have detrimental effects of various kinds on property as distinguished from persons. Machinery, growing vegetation, animals, dwelling houses, and other types of property are damaged by dusts, and compensation of some kind often is obtained from industrial concerns through damage suits or otherwise.

From the viewpoint of respiratory harmfulness, it is generally stated (though actually knowledge on this point is by no means certain) that the particle sizes of dust (such as that of free silica) that affect health adversely upon entering the lungs are those that are less than 10 microns in size, different persons having different ideas as to what the maximum may be—10 microns or 8 or 6, and some say that the harm really is done by particles less than 2 microns in size. As against this, it is stated that fibers of asbestos dust as long as 200 microns have been found in the lungs of men, and that undoubtedly these long asbestos fibers exerted at least some detrimental effect.

Since a micron is only about one twenty-five-thousandth of an inch, or much smaller than the naked eye can see, it is usually assumed that the larger dust particles that can be seen floating in air, and which settle out relatively fast, are not harmful to health. Certainly, this is not so, as the larger particles that float in the air (some of them 100 or more microns in size), if present in considerable quantities clog the air passages to the lungs, some of which have agencies that under ordinary conditions intercept dust particles before they can reach the lungs and this clogging then allows the smaller and probably most dangerous dust to enter the lungs unimpeded.

A common-sense opinion as to what constitutes an atmosphere so dusty that dust-prevention action should be taken is that any atmosphere in which dust can be seen by the naked eye is too dusty, not only for health but also, at least in many cases, for safety and efficiency. If the visible dust is eliminated, much of the invisible or probably most dangerous dust will unquestionably have also been removed and very likely the health as well as other hazards much minimized or even removed.

After the visible dust has been removed, it may be necessary, under some conditions or with some types of dust, to make more in-

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If not it will probably be best for him to be advised of this fact at the outset and given assistance in securing rehabilitation vocational training; after which he may return to his former place of employment qualified to

do some special work. In this case he will be given consideration for reemployment.

He will be happy because he will have overcome a handicap and learned that he can still be independent.

Industrial Tuberculosis—A Public Health Factor

By H. J. SPECTOR, B.S., M.D.

Assistant Health Commissioner and Chief of Medical Section,

St. Louis Health Division, St. Louis, Mo.

The term industrial tuberculosis is somewhat misleading because it may be thought that industry is the direct causative factor in the production of tuberculosis. But tuberculosis is a germ disease, directly caused by the tubercle bacillus. No industry, no matter how harmful it may be to the human body in general, is capable of directly producing the disease tuberculosis without the presence of tubercle bacilli.

How can we explain then the high mortality rate from tuberculosis in certain industries?

To seek an answer to this question, one must consider the subject of so-called industrial tuberculosis from the broader aspect in general, but especially from the viewpoint of possible existing predisposing factors incidental to certain industries. The contributory factors which may play a role in the development of tuberculosis are many in number, but for the sake of clarity may be classified under two main headings, (1) environmental, and (2) social and economic.

Environmental Factors

Industrial environment has long been recognized as a most important contributory factor in the causation of upper respiratory diseases. For instance it is known that employees in dusty trades, and those usually exposed to high temperatures, excessive moisture, to bad weather conditions generally, and to noxious fumes are among the workers who frequently are forced to absent themselves from their employment because of sickness.

1. Inorganic Dust

One of the most serious environmental factors existing, especially in the mining and

some abrasive industries, is the presence of inorganic dust in concentrated form containing abnormal amounts of pure silica. Industries like hard rock mining, quarrying, grinding and sand blasting have a high morbidity and mortality rate from tuberculosis attributable to this cause. Employees exposed to such an atmosphere over a prolonged period of time will develop silicosis and the latter will lead to the development of tuberculosis in many instances.

Asbestosis is a disease similar to silicosis which may contribute to the morbidity and mortality from tuberculosis. However the evidence in this direction is not conclusive.

2. Organic Dust

There has been considerable discussion as to the role of organic dust in the production of tuberculosis. The high mortality rate from tuberculosis in tobacco workers, bakers and tailors was responsible for the early belief that organic dust was a contributory factor in the production of tuberculosis. The work of Landis of Philadelphia which is based on autopsy studies of the lungs of 50 patients who had been exposed for many years to organic dusts, disposed of this concept since none of these patients showed evidence in their lungs of tuberculosis. At the present time it is generally held that organic dusts do not produce a disabling disease of the lungs and are predisposing factors in the development of tuberculosis.

3. Noxious Fumes

The effect of noxious fumes on the lungs and their relation to tuberculosis has been studied by Winternitz of Yale, Metz of U. S. Veterans Bureau and others.

These investigators seem to point out that noxious fumes in great quantities will produce immediate irritation in the upper respiratory tract leading to such serious complications of the lungs as bronchitis, pneumonia and in some cases death of the patient.

Observations on soldiers who were gassed during the world war, made by Metz, indicate further that noxious fumes, when inhaled into the lungs, do not lead to the development of either acute or chronic pulmonary tuberculosis in most instances. From personal observations the writer is inclined to agree with this viewpoint.

Improper Sanitation and Ventilation

Employees exposed to changeable temperatures, to excessive moistures and working in an improperly ventilated and unsanitary room will expose themselves to the risk of lowering their resistance, thus predisposing themselves to the development of tuberculosis as well as other respiratory diseases.

Social and Economic Factors

It is an accepted fact that tuberculosis, being an infectious disease, is capable of producing and actually does produce active tuberculosis in people regardless of their social and economic rank. It is also true that poverty goes hand in hand with tuberculosis and that most tuberculosis will be found in underprivileged people.

This fact has recently been confirmed statistically by Miss Whitney, who in a study of death rates by occupation reveals that the unskilled worker, the one who usually works long hours and most often in an unventilated and unsanitary environment, the one who usually receives meagre compensation for his services, has a very high mortality rate from tuberculosis. On the other hand, the policeman who receives a fair salary and who is usually out of doors with little physical exertion has a comparatively low death rate. While the lawyers, the judges, the bankers, and the manufacturers, representatives of the higher economic bracket of society, have the lowest death rates as seen in the accompanying table.

Of great public health interest is the fact that the servant, the cook and the waiter, representatives of the lower economic rank, have the highest mortality rates. Since these occupations represent frequent sources of infection in the community, the control of

TABLE I

Death rates from tuberculosis per 100,000 gainfully occupied males 15 to 64 years of age in selected states according to economic groups. (1930)

Tuberculosis (Respiratory Form)	
Average, all occupations	87.1
Average, professional group	28.1
Average, lawyers & judges	21.2
Physicians and surgeons	29.4
Average, proprietors, managers & officials	11.8
Bankers, brokers, moneylenders	22.5
Managers and officials	27.9
Builders, building contractors	31.1
Average, clerks & kindred workers	62.1
Real estate agents	28.8
Average, agricultural workers	46.7
Average, skilled worker & foreman	71.2
Molders, foundrymen, casters	155.5
Police	46.7
Average, unskilled workers	193.1
Factory & building construction laborers	221.7
Average, servant classes	175.1
Servants & cooks	156.7
Waiters	169.8

tuberculosis in this economic group becomes a major public health problem.

Miss Whitney's study was based on mortality statistics of males only. Some insight into the morbidity according to occupation can be had from a recent study that we have made in the St. Louis Health Department on 31,990 reported cases of tuberculosis male and female as seen from the viewpoint of occupation.

We found in Table II that the occupations of 19,419 or 60 per cent could be classified under 10 major heads, while the remaining 12,551 could be classified under 695 occupations. It is interesting to note that "house-

TABLE II

Showing occupations of 31,990 reported cases of tuberculosis in city of St. Louis (1929-1931 incl.)

Total No. of Tuberculosis Cases	31,990
Total No. of Occupations	705
60% of Cases in 10 major occupations	
40 of Cases in 695 remaining occupations	
1. Housework	7651
2. Unskilled labor	5119
3. Clerical work	2311
4. Shoe workers	881
5. Porters	661
6. Waiters & Cooks	660
7. Teamsters	639
8. Salesmen	519
9. Students	516
10. Laundresses	480
Total	19,419

8791 or 45% of people in the ten major occupations either did housework or handled food.

Dusts, Fumes, Gases and Vapors

WEDNESDAY MORNING SESSION

October 12, 1938

Assembling in the Grand Ballroom of The Stevens Hotel, this meeting was called to order by Chairman Walter S. Paine, Manager, Engineering and Inspection Department, Aetna Casualty & Surety Com-

pany, Hartford, Conn., and Vice-President for Engineering, National Safety Council. Chairman Paine briefly outlined the session objectives, and then introduced the speakers.

Recent Developments in Detecting Hazardous Dusts, Fumes, Gases and Vapors

By WARREN A. COOK

Superintendent, Engineering Department, Zurich General Accident and Liability Insurance Company, Ltd., Chicago

In discussing the determination of injurious dusts, fumes, gases and vapors, I am very sure that you are not interested so much in a meticulous dissertation on such phases of the subject as whether the logarithm of the reciprocal of the hydrogen ion should be 9.5 or 9.0 for the determination of lead by the dithizone method, but rather in a discussion of this matter along broad lines, pointing out what types of potentially injurious materials should be looked for, whether determination of them is in order, a brief discussion on some of the more important and common methods of determination, and interpretation of the results obtained.

Foolhardy to "Work in the Dark"

Working in the dark without any means of illumination where there may be hazardous conditions serious enough to cause loss of life or severe injury would be considered most foolhardy; yet every day men conduct their operations in atmospheres containing dusts, gases, and vapors which may cause death or severe injury to health without be-

ing able to see or otherwise perceive the potentially hazardous condition.

Most gases and vapors can no more be seen than the well-known black cat in the coal cellar. Some of them cannot even be detected by odor, though odor is itself no reliable criterion as is evidenced by the gas, hydrogen sulfide, which has a most obnoxious odor but has caused many a case of poisoning.

How, then, are we to know whether the atmosphere in which we work is safe or injurious? Are we to wait until we see the effects of unhealthful or irrespirable atmospheres on our men or is it not more intelligent to determine, within the limitations of modern methods and practical applications, just what sort of atmosphere we are subjected to?

The importance of having facts before us is well illustrated by an atmospheric condition where a life could be snuffed out in a few minutes, even though the more common situation is where excessive exposures may require weeks, months or years to cause their injurious effects.

Thirteen years ago this month a powder crew was walking down the tunnel of a new water supply system of a Connecticut city. Their duty was to inspect the roof and the face, to see that all the shots were fired. On approaching the tunnel heading immediately after the blast, they found that flying rock had broken the compressed air line, which had been left turned on in order to blow the smoke and gas away from the face of the tunnel. The crew, consequently, ran into a heavy blanket of smoke, but they were hardened workers, used to smoke and gas, and a little smoke, even though they knew it contained carbon monoxide, did not hold them back.

They found the roof intact. But four of the holes had not fired. Caps with 3-foot fuses were inserted in sticks of dynamite, one for each of the holes. The gas condition by the time this work had been accomplished was beginning to make these men feel a bit groggy. Following the usual practice, the powder foreman sent the rest of the men back down the tunnel before he lighted the fuses.

The men walked back through the smoke to the car, about a quarter of a mile down the tunnel. There they waited for the foreman. Seconds passed. The time stretched to a minute. Down the tunnel came the boom of the blast—but no foreman. The men rushed to the heading and found the foreman stretched on the tunnel floor, nearly covered with rock from the blast, where he had collapsed from the effects of the carbon monoxide.

This is a true story up to a certain point, but I have omitted a part of the story, and the ending, I am glad to say, is pure fiction. The part of the story which I omitted was that carbon monoxide determinations were being taken when these men got up to the heading, and a concentration of 3 per cent carbon monoxide was shown to be present by means of the Hoozanite carbon monoxide detector. With such a high concentration, it was realized by the man making the determinations that it would not take long for exposed persons to collapse. He informed the crew of the condition and hurried them back to the car to wait until the smoke and gas had cleared enough to permit them to work safely and fire the blast.

The difference between fact and fiction in this case, between a brief delay and a fatal

case of carbon monoxide poisoning, is the ready availability of a simple means of determining the carbon monoxide concentration on the job.

The present tendency in development of methods of determination of injurious materials in air is toward such simple, quick acting devices. As many of you know, the Hoozanite carbon monoxide detector operates merely by pressing a rubber bulb a few times and comparing a purple color which develops in presence of carbon monoxide with a standard color scale mounted on the instrument, an operation which requires about a minute. Instruments of this type are especially important for cases which may cause acute poisoning such as carbon monoxide, hydrogen cyanide, and hydrogen sulphide.

An instrument for determination of hydrogen cyanide, similar to the Hoozanite carbon monoxide detector, has recently been developed by the United States Bureau of Mine Workers, and, together with a number of other of these simple detectors, is now available commercially. Determination of such materials can accordingly be made much more widely than formerly when laborious chemical laboratory methods were necessary.

Potentially Hazardous Materials

The first step in an organized endeavor to avoid environmental conditions which may cause injury to health is a listing of materials, used or produced, which under certain conditions are deleterious. It was found in a study by the United States Public Health Service of potential hazard in a typical industrial area (1) that a considerable percentage, nearly 20 per cent, of the workers were exposed potentially to carbon monoxide. The report by no means intimated that this percentage of workers were being poisoned by carbon monoxide, but rather that it things went wrong and a concentration of the gas built up to injurious proportions these men might become poisoned.

So I suggest that you go through your plants and see what operations involve potentially injurious materials. Of the dusts those which may produce silicosis occur not only in the well-known industries where major studies of conditions have been conducted but in other industries as well though usually to a lesser extent. In silver

ware manufacturing, for example, one man may be exposed day after day to tripoli dust in making up a polishing compound for use within the plant. A list of industries in which such dust exposures may exist is given in the report of the National Silicosis Conference.²

The toxic dusts and fumes are more readily spotted. We recognize and guard against lead exposure in storage battery plants, but often overlook such an operation as where red lead is being mixed with a vehicle by a worker in one corner of the top floor of the plant to color lettering on a steel part. It is not so much whether a pound of lead or a ton is used in a day, but the extent to which it contaminates the air breathed by the worker.

Carbon monoxide, hydrogen sulphide, hydrogen cyanide have been mentioned as examples of gases. The first of these occurs where producer gas or water gas is used. The last named should be looked for where fumigating may be done from time to time. Where dry ice is used in quantity or fermentation processes are conducted, carbon dioxide is liberated and has caused deaths usually at the bottom of confined areas such as ships' holds and fermentation tanks.

Vapors are present wherever organic solvents are used. Death may result quickly where high concentrations exist as has occurred when a drum of solvent was dropped on a basement storage room floor and split open, and again where carbon tetrachloride was being used for fumigating a flour mill and the fumigator sprinkled the liquid in the basement as his last operation. It was his last.

Injury from continued exposure to solvent vapor at concentrations which cause their effect after weeks of exposure is the more common condition. The various solvents differ widely in the concentration of vapor necessary to cause injury. These are divided into groups in accordance with their toxicity in a paper delivered before the Northwestern University Symposium on Occupational Diseases a year ago.³

Where Should Determinations Be Made?

After going over your plants and learning where potentially hazardous materials are present, it is my suggestion that, before making actual determinations of concentra-

tions in air or instituting control measures, you make a thorough survey of the conditions and divide the various operations where these materials are present into groups: (1) those which are obviously safe; (2) those which are admittedly causing injury to health or are worse than good industrial practice dictates; (3) those conditions where it is not readily discernible by general observation whether the exposure is within safe limits.

Certain conditions we know definitely and can say definitely will not cause injury to health. I would not say that these are to be forgotten, but at least they need not be the subject of initial action. If, for example, a gas containing 30 or 40 per cent carbon monoxide is used for hot plates, and those hot plates are connected with rigid conduit rather than with rubber tubing, you can feel reasonably safe that the carbon monoxide exposure is within safe limits, and I would not recommend that determinations be made. Where spray painting is being done in a well ventilated booth in such a manner that there is no excessive rebound into the face of the sprayer, determinations of vapor or pigment need not be made even though the odor of the solvent is detectable. From time to time it may be well for state authorities to check some of these lesser exposures, but there is a considerable number of such exposures which can be accepted as safe.

The second group of exposures—that where conditions are admittedly severe—is another where determinations are not essential. Institute control measures immediately. If there are clouds of dust containing free silica in your plant, go to work on them. If excessive lead absorption is shown by development of symptoms or by high basophilic aggregation percentages, reduce the lead exposure. It may be desirable to make determinations even in these cases either to provide a before-and-after picture of exposures to show what improvement is effected or to obtain a clear picture of just what part of an operation is responsible for the excessive exposure to the end that control measures can be more specifically applied. This latter use of air analysis data is of especial value where the materials are invisible as is the case with gases, vapors and even some of the more toxic dusts such as quartz and lead.

The principal use for determination of

sible for any difficulties which have been encountered. I cannot conceive of any rehabilitation worker, after having spent considerable time in studying, analyzing, and training one of his clients, being willing to shrug his shoulders and say to the employment office, "There, now this is your problem"; nor can I imagine any employment service worker terminating his interview with a physically disabled person with a remark such as, "Well, you're crippled; the State Rehabilitation Service will have

to take care of you."

To me, it will always have to be a responsibility of both agencies and means of disclosing opportunities suitable employment for the physically disabled can, perhaps, best be summed up offering this recipe: To equal quantities a knowledge of the applicant's ability, the job requirements add an unmeasured amount of initiative, perseverance, intelligent cooperation and hard work and success will be assured.

ADJOURNMENT

Occupational Disease

THURSDAY MORNING SESSION

October 13, 1938

The session for the discussion of outstanding problems in the field of occupational disease was called to order by the Hon. P. J. Angsten, Chairman, the Illinois Industrial Commission, Chicago, who pre-

sided. The Chairman emphasized the importance of the selected subjects to be presented by eminent speakers, and promptly introduced the first scheduled speaker.

The Trend of Occupational Disease Legislation

By HENRY D. SAYER

Manager of the Casualty Department, Association of Casualty and Surety Executives

Let us consider the differences between the accidental injury and the occupational disease. For these distinctions are important and must constantly be borne in mind when we consider either legislation on the subject of disease, or engineering methods of prevention or control.

Generally speaking, accidents occur at a specific moment in point of time, and, from the standpoint of fixing liability under any policy of insurance, it is in the future; that is to say, at the moment of the acceptance of liability under any insurance contract the accident for which liability may be assumed has not yet happened. That truthfully is not so with the occupational disease. Insurance by its very nature can only assume liabilities that have yet to occur—not those that have already accrued.

Again, speaking generally, the industrial accident is something that can be seen—seen though unforeseen. It may be visualized and described in words, setting forth specifically the time, place and manner of happening. It can then be determined, after the happening of the event, whether it was preventable or inevitable; blame, if any, can be placed; the worker involved, or his supervisor or superintendent, can be shown negligent; and effective measures can be taken to guard against a like future happening.

But some will say, truly, not all accidents happen in the manner described; that not always are they held to occur only at a specific moment or under circumstances where they can be visualized and described. By administrative and court decisions, it is true in some jurisdictions that the definition of "accident" has been greatly broadened. We find the entrance of disease germs into the human system without visible trauma, with resulting sickness or death, and even the specific time and place not definitely known, except that it is shown to have probably occurred in the employment, being held to be an accident.

(*Thiers vs. Hull*, 178 App. Div. 30, 133 N.Y. 767, an anthrax case; *Vanden vs. New York Liner Co.*, 161 Wis. 320, 1926, an epidemic case, and others.)

Poisoning of the body through the effects of a deleterious or toxic substance used in the employment, the dangers of which were unknown to the worker, the employer having been negligent in safeguarding properly the use of such substance, has been held to be the result of an industrial accident.

(*Victory Sparkler & Specialty Co. vs. Franks*, 147 Maryland, 368; and the very recent case of *Black vs. Creston Auto Co.*, Iowa Supreme Court, August 5, 1938, 281, N.W. 189.)

And where negligence of the employer has been shown, an injury to health, even though not occurring through a happening at a given time and place, but by repeated



Industrial Hygiene

Industrial Dusts—What Every Supervisor Should Know

By L. E. HAMLIN, M.D.

Medical Dir., American Brake Shoe Company, Chicago, Ill.

Manufacturing procedures are capable of generating varying amounts of dust. Some may be visible, invisible, dangerous or harmless. It is therefore important that these dusts be properly classified in order to protect the health of employees and provide safe environments in which they may carry out their daily occupations.

Obviously, the supervisor should have some knowledge of industrial dusts since the responsibility for enforcing measures imposed for their control usually falls upon his shoulders. Unless he has a good idea of the actual risks confronting him, he will be at a disadvantage in securing cooperation from those under his direction. Ability to answer questions concerning plant hazards in a convincing manner is a very important feature in any dust control program, and if the supervisor cannot explain the necessity of avoiding exposure to toxic materials the worker under his charge is very unlikely to pay attention to it.

On the other hand, a brief explanation that carries the ring of sincerity and truth can frequently correct unnecessary misunderstanding. For example, a capable young employee was worried about contracting silicosis because he worked in a plant where at times there appeared to be considerable dust in the atmosphere. He did not know that this dust was free from silica or other harmful ingredient, but his argument did.

Knowledge of his own department enabled the supervisor to convince the workman that not only was the dust inert but also that work was under way for the installation of new ventilating equipment which would remove the particles that were already present. The man was satisfied and the company was able to retain the services of a valuable employee.

Some of the fundamental facts that every supervisor should know about in-

dustrial dusts? Dust is formed by reducing earthy materials to small size. Processes like grinding, crushing, blasting, and drilling produce dust particles of sizes from the sub-microscopic to the visible.

Fumes are formed from combustion, sublimation and condensation. Those from burning or melting lead or zinc are typical examples. The size of the particles is generally below one micron. (A micron is 1/25,000th of an inch.)

Smoke is usually of organic origin from such things as burning tobacco, wood, oil or coal. The particle size is usually below a half micron.

Mists or fogs are formed by condensation of water vapor and the particle or droplet size varies widely.

The most important item to the supervisor is the realization that he may be dealing with a dust which can produce bodily harm. His first consideration should be "How is the man himself affected? Is the dust present in sufficient amounts in the air to be a source of danger? Does it exist in the pure state or is it mixed with other dusts? What is the actual count of particles per cubic foot of air, and what percentage of these is of respirable size (below 10 microns and especially those below three microns? How long does it take to develop occupational disease of the lungs from exposure to dust?"

All this may appear to be outside the scope of the supervisor's activities since after all his job is concerned primarily with production. However, most industries place the responsibility for carrying out safety measures on the foreman and it is apparent that his department will suffer if these are not properly enforced. Safety therefore includes precautions against occupational disease as well as accidents so that some knowledge of methods for controlling exposure from dangerous dusts, toxic fumes or other

harmful materials is a proper part of the supervisor's armament.

It is not advocated that his duties be so expanded as to encroach upon the field of the industrial hygienist but it is reasonable and logical to suggest that he equip himself with the essential details concerning occupational risks in the department he manages. This information can be readily obtained from his company medical department or through other agencies such as the Division of Public Health of state and federal governments. These bureaus welcome inquiry of this type and their services are usually available without charge.

Much confusion and misunderstanding exists about the capacity of various dusts arising from occupational procedures to cause physical disability. Exaggerated reports and misrepresentation by individuals unfamiliar with their specific properties have incriminated certain materials known to be quite inactive and absolved others proven to possess harmful qualities. Experience accumulated through years of intensive study and research indicates that the great majority of industrial dusts have little effect on health other than their nuisance value and contribution toward poor housekeeping.

However, the fact that they are unlikely to cause occupational disease should not be used as an excuse to do nothing about them. A good working environment demands that they be removed in spite of their innocuous characteristics and the smart supervisor will do all he can to accomplish their elimination.

The wide assortment of dusts met with in industry makes their classification into "harmful" and "inert" categories difficult. Those arising from organic sources such as animal and vegetable products as a rule do not cause serious harm but are capable of producing local irritation like dermatitis or skin rashes, dental conditions, and inflammation of the eyes and the mucous membrane lining of the upper air passages.

The majority of harmful dusts encountered in manufacturing processes are inorganic in character. The specific effect on health varies. Chromium, cadmium, arsenic, and their compounds produce local irritation as do the organic dusts but they can also cause general intoxication if present in sufficient amounts. The dusts or fumes derived from

the heavy metals like lead, mercury, manganese can be highly toxic and from these substances has been known for many years.

Recently serious and even fatal has been found to occur from exposure to beryllium and some of its compounds. Another occupational condition "Shaver's Disease" has produced severe lung disease from the fumes arising from the fumes of the chief ore of aluminum, in the form of artificial abrasives.

Generally speaking, the particle size of dust is most dangerous in the range of 1 to 3 microns in diameter. Particles larger than these seldom reach the alveoli or terminal air sacs of the lungs. The protective mechanism of the nose and large bronchi. There is also evidence that particles below one-half micron in size may be retained in the lungs in sufficient quantities to result in disease. This means that the visible dust in a workplace may not be as dangerous as the dust particles which are not seen by the naked eye.

Industrial hygienists emphasize this also point out that although the amount of visible dust in the atmosphere in the vicinity of a certain job appears great, it does not necessarily mean that the workman is inhaling significant quantities of harmful dusts. The exposure may be minor, of brief duration, or the breathing level of the employee may be sufficiently clear that no undue risk is involved.

With the exception of beryllium and bauxite few of the aforementioned dusts cause damage to lung tissue and as pointed out previously, not every person exposed does develop occupational disease.

At the present time it is generally held that the most important sources of industrial disease of the lungs are from combined silica and asbestos. Silica, silicon dioxide which makes up about 60 per cent of the rocks and minerals of the earth's crust, is the specific cause of the ailment affecting the lungs of men in dusty trades, known as silicosis.

It is very important to recognize that this widely known condition can be acquired from any material

also that it happens only in those smaller than ten microns in diameter have been inhaled over a long time, such as from two to ten years, with an average of ten years. "Silica" usually means quartz, but there are many varieties. There are also forms of free silica.

or fibrosis of the lungs results from the action of uncombined silica. The characteristic nodular shadows on the x-ray roentgenograms of those affected by silicosis is the only way the disease can be detected as it causes no symptoms in the early, uncomplicated stage.

Some dusts may produce x-ray patterns which are difficult to differentiate from silicosis. Some unrelated illnesses may resemble silicosis. The x-ray picture obtained after the inhalation of iron oxide dusts, among some welders and grinders, is very similar to those seen in silicosis. Since iron dust (siderosis) is harmless, the similarity of such misdiagnosis are obvious.

Industry with industrial diseases of the lungs by those charged with evaluating them properly has resulted in employees becoming progressively alarmed, forsaking their jobs and forfeiting seniority while industry still has good workmen and production. It

has also paid unjust claims for disability. In a situation of this sort the supervisor suffers along with the rest since his department is bound to be affected by these conditions.

To attempt to tell the supervisor all he should know about the extensive subject of industrial dusts is an impossible assignment. Suffice it to say that the more he learns about them through his own volition, the better his qualifications for his job will be. Through such enterprise he will enter a new field of endeavor and discover a fascinating experience which will pay dividends both to himself and his company.

The complexity of problems which confront the director of any department in today's exacting requirements presents a formidable challenge to his resources, and this, along with the working man's reasonable insistence on a better place to work, demonstrates that a knowledge of industrial hygiene may well be a most important factor in the efficient discharge of his duties.

The best treatment of any disease associated with industry is not to let it happen in the first place. The problem is for engineers rather than physicians, but, regardless of the one on whom the burden falls, the final outcome depends upon the interest and efficiency of the man who manages a department.

Occupational Dermatitis: Teamwork in Engineering and Medical Control

By WALTER F. SCHOLTZ

Supv., Industrial Hygiene, Allis-Chalmers Mfg. Co., West Allis, Wis.

We have accepted the challenge that occupational dermatitis presents to industrial hygiene and accordingly it can be stated that with proper care and intensive educational programs, occupational dermatitis can be avoided and great savings effected. Through the institution and maintenance of control measures workmen can be protected against dermatitis producing oils, greases, etc. The ideal control measures protect workmen all along the line—from the manufacturing of the basic material to the completed fabricated part.

cognizant of the benefits of good preventive measures that they are not only relying on the worker alone, but are seeking the teamwork of everyone concerned.

Since the proof of the pudding is in the eating, I would like to state what has been done through a concentrated program of occupational dermatitis control and prevention which started in 1943 at the West Allis works of our company. This concentrated program has resulted in a 74 per cent decrease and a reduction from 10.3 to 2.7 in the number of cases per million manhours of exposure.

Table 1 continued

Propyl acetate	200
Tetrachloroethane	5
Tetrachloroethylene (perchloroethylene)	100
Toluene (toluol)	200
Trichloroethylene	100
Turpentine	100
Xylene (xylo)	200

Table 2

Some Common Solvents and Their Relative Volatility

(Volatility increases as the volatility index increases)

Substance	Volatility Index
Acetone	21
Amyl acetate	4
Amyl alcohol	2
Benzene	13
Butyl acetate	7
Butyl alcohol	9
Carbon disulfide	23
Carbon tetrachloride	16
Chloroform	17
Dichloroethylene	22
Ethyl acetate	15
Ethyl alcohol	14
Ethylene dichloride	12
Ethyl ether	24
Methyl acetate	20
Methyl alcohol	18
Methyl ethyl ether	25
Naphtha (petroleum)	19
Propyl acetate	10
Tetrachloroethane	3
Tetrachloroethylene (perchloroethylene)	6
Toluene (toluol)	8
Trichloroethylene	11
Turpentine	1
Xylene (xylo)	5

Table 3
Ventilation Rate Design Data for a Number of Common Solvents

Substance	Molecular weight	Specific gravity	Boiling point, °F.	Evaporation rate, lb. per cu. ft. per min.
Acetone	58	0.79	133.0	13.40
Acrylonitrile	53	0.80	164.0	10.00
Amyl acetate	130	0.87	155.0	15.00
Amyl alcohol	88	0.82	143.0	14.00
Benzol	78	0.88	142.0	14.00
Butanone	72	0.81	116.0	21.00
Butyl acetate	116	0.88	166.0	16.00
Butyl alcohol	74	0.81	123.0	22.00
Butyl cellosolve	118	0.90	164.0	16.00
Carbon disulfide	76	1.26	157.0	15.00
Carbon tetrachloride	153	1.58	219.0	11.00
Cellosolve	90	0.93	213.0	11.00
Cellosolve acetate	132	0.97	200.0	12.00
Chloroform	119	1.50	200.0	12.00
Cyclohexanol	100	0.96	198.0	12.00
Cyclohexanone	98	0.95	190.0	13.00
Dichlorobenzene	147	1.32	217.0	11.00
Dichloroethylene	97	1.25	200.0	12.00
Dichloroethyl ether	143	1.22	182.0	13.00
Dioxane	98	1.03	148.0	14.00
Ethyl acetate	88	0.89	110.0	23.00
Ethyl alcohol	74	0.81	123.0	22.00
Ethylene dichloride	99	1.26	122.0	24.00
Ethyl ether	74	0.72	111.0	25.00
Methyl acetate	74	0.94	126.0	21.00
Methyl alcohol	32	0.79	100.0	27.00
Methyl cellosolve	76	0.96	180.0	18.00
Monochlorobenzene	113	1.11	160.0	19.00
Naphtha (petroleum)	110	0.75	170.0	20.00
Perchloroethylene	166	1.62	219.0	11.00
Propyl acetate	102	0.87	190.0	17.00
Propyl alcohol	60	0.79	160.0	20.00
Shallol solvent	150	0.80	190.0	17.00
Styrene monomer	104	0.91	183.0	18.00
Toluol	92	0.86	173.0	19.00
Trichloroethylene	131	1.48	200.0	12.00
Turpentine	136	0.87	200.0	12.00
Xylo	106	0.88	180.0	19.00

The Importance of Non-Siliceous Dust in Industrial Operations

By EDWARD C. J. URBAN

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A common concern related to the health of workers in mining, tunnelling, granite quarrying, in the foundry industry and in all of the other so called "dusty trades" for some years in the past, has been for the protection of the workers from breathing or home particulate matter, arising as the direct result of their occupations, which might cause disease.

It has been shown by geo-chemical study that eight primary elements make up 98 per cent of the earth's crust—this is based on the standard assumption for the outer 10 miles of thickness. In the order of their prevalence these are: oxygen, silicon, aluminum, iron, magnesium, calcium, sodium and potassium. The chief element, oxygen is present in 47.2 per cent of all rocks. Silicon (Si) constitutes 28 per cent. The remaining six elements combined, total but 24.8 per cent.

It has been further determined that eight compounds or simple combinations of these basic elements are present in 97.6 per cent of the lithosphere. The principal compound is silicon dioxide (SiO₂) which occurs in about 60 per cent of all rocks. The remaining compounds are chiefly oxides of the other seven elements previously mentioned.

Chemically silicon dioxide is plainly acidic while the metallic oxides are basic in character. In nature, silicon dioxide occurs in two main forms. Twelve per cent exists as the definite independent compound, Free Silica. The remaining 48 per cent of the silicon dioxide occurs in complex chemical combination with the basic oxides as "silicates." These silicates are the chief rock forming minerals and several hundred species have been identified.

There are many varieties of Free Silica. The types which are present more commonly in industrial atmospheres can be classed as being either crystalline or amorphous.

In Free Crystalline Silica the atoms are arranged in repeated uniform patterns giving the particles a definite structure. Quartz is the form which has been formed at temperatures above 573 degrees C. and is the

most common. It occurs as the ordinary crystalline form or as cryptocrystalline chalcedony, flint, chert or jasper.

The two high temperature varieties of crystalline free silica are Tridymite which results from heating above 870 degrees C. and Cristobalite from heating above 1470 degrees C. Both of these are not common in nature but do occur in industrial processes which involve high temperatures.

In Free Amorphous Silica the atoms are arranged in a non-uniform manner and as a result, the particles have no definite structure. Several varieties of Opal occur. In this class may be included natural diatomaceous earth. A distinction however, must be made between the natural mineral as it is found in place and the diatomaceous earth which for industrial reasons has been heated to high temperatures. This latter product can contain Cristobalite in varying quantities. Vitreous Silica is silicon dioxide which was heated to a fusion temperature with the mineral still retaining its amorphous state.

During the past several years technological advancements and industrial demands have created a variety of new artificially produced amorphous silicas. These synthetic products are for use as filters, insulation, diffusion coatings for incandescent lights, in strengthening cotton thread, a substitute for certain materials in vulcanized rubber and as water repellent coatings for cloth.

It is a well recognized fact, substantiated by laboratory research and observations in industry that free crystalline silica as quartz is the specific causative agent of the pulmonary disease Silicosis. Further, it has been common practice in the consideration of industrial dust exposures which involved a silica hazard to imply that quartz was present and that it was the chemical substance of chief concern. Because of the preponderance of quartz in the rock minerals of the earth and our lack of knowledge relating to the toxicity of other Silicon dioxide forms, this view was to be expected.

Recent studies, particularly those made at The Saranac Laboratory, however, have

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requirements which may be different from those of ordinary dusts must be devised.

It may appear that this discussion has related mainly to dusts containing silica. Most of the views which have been presented, however, can be applied equally as well to other materials. Even with substances which have been considered inherently inert, it should be recognized that certain factors may operate to alter this condition.

Referring again to Shavers disease, powdered metallic aluminum and hydrated aluminum have been used as therapeutic agents in the control of silicosis on the theory that particulate quartz is inhibited by these materials. On the other hand, recent laboratory studies intended to duplicate Shavers disease at the University of Toronto have demonstrated that sub-microscopic alumina by itself or in combination with silica fume can cause lung changes. As an opposite, with asbestos the fibres longer than 10-20 microns appear to cause disease while the finer particles do not.

New industrial processes are being developed which utilize heat and high energy releases. In effect, new methods of disintegration have been created. The effluents from such processes may have properties

entirely different from the materials employed. Such factors may have been induced as change in particle size, area, surface coatings, electrical adsorption and absorption qualities alter their behavior.

Increased production activity through advanced mechanization is a significant factor in creating correspondingly denser clouds of dustiness. The experience in the mines in England and more recently in this country are examples. Carbon has long been considered inert. Pulmonary changes in lungs of coal miners have occurred. Authorities feel that the carbonaceous component of the coal itself is responsible.

It would appear that the terms "hazard," or "siliceous dusts" need clarification since some forms of free silica than quartz may be capable of producing reactions which are different from the action of quartz itself.

Of increasing concern in certain work environments are the sub-microscopic particles and considerable research work is being done to determine their significance. A matter of no small importance in regard is that these small particles exhibit properties different from the materials from which they originated.

Know the Facts— Electrical Hazards

Interlocking For Safety

By A. L. RICKE

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Let's start with some words we'll be using. "Interlock" is just a fancy word meaning that when one thing takes place, something else happens, or something is prevented from happening. From this definition, we can see that there is an interlock between the push button and faster, better, easier operation of electric switches can produce. An example is a two-hand electric trip for push button control. Operators have increased production as much as one-third, simply because they felt safe and the electric switches worked more easily than mechanical trips. This type of machine interlock is the choice of state safety commissions and insurance companies.

The principles of electric interlocks are simple. An electric switch which turns on the light when your refrigerator door is opened is an example.

"Limit switch" is another common term. It is a switch which stops motion or gives a signal when something moves to a certain place. A switch fastened to a lathe bed which will turn off the motor when the workhead is coming against it, is a limit switch. Such use of limit switches to stop machines from damaging themselves is one of the commonest and best-paying tricks. It is as easy to put on any machine as to design into new equipment.

This is typical of electric interlocks and limit switches which do things automatically that could be done by hand. Usually they tell the position of a machine part, or the reading of a pressure gauge or a temperature measuring device more accurately than can be done by eye. They recognize things quickly and accurately than we don't forget. Neither are they about what to do next. On the other hand, a blinking light or a bell can tell you to get off the hand brake

before driving your car. That is such a "nontorgetting" interlock.

This memory-jogging use is just one of the ways that switches produce safety. In some ways they think for the operator, as well as act for his hands and eyes. They can make a machine refuse to run until all is in order; they can stop a machine when something is wrong; they can compel things to be done in the right order. This means safety to the operator and to equipment. It can also insure product quality.

We see electric interlocks and limit switches in machines as different from each other as juke boxes and automatic pilots on airplanes. They are in automatic gear shifts on automobiles and in dial telephone equipment. This success, for so many purposes, depends on well-known basic principles combined with using the best type of switch for the particular job. This is as true in working over an old machine to make it automatic, or to provide safety, as in designing new equipment. On either kind of job, use of the right switch can make the difference between a machine which gives long, reliable, safe service, and one which is always in trouble.

Three Fundamental Kinds of Switches

There are three general kinds of electric switches used in interlock and limit work.

The one longest used is simple contacts, which are moved without snap action. Usually such contacts are mounted on leaf springs. Another form uses bars on the face of a cylinder which turns under fixed contacts or brushes. Their simplicity recommends such units, and they serve well to switch small amounts of power when precision is not required, and there is plenty of operating force and motion. Picking up your telephone works such a switch.