DUST PRODUCING OPERATIONS

IN THE

PRODUCTION OF PETROLEUM PRODUCTS AND ASSOCIATED ACTIVITIES

A MEDICO-SAFETY SURVEY

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FOREWORD

Because it is the duty of industry to protect its employees and because no comprehensive survey of the hazards incident to occupational dust problems had yet been made, it was felt that here was an opportunity to render a serivce to the petroleum industry and its employees by making such a survey.

It is hoped that the information presented in this bulletin will assist in finding proper answers to some of the many questions which have recently arisen concerning the health hazards of employees whose work involves exposure to dusts of various origin.

An attempt has been made to consolidate opinions from the most experienced students of occupational-dust problems to show the relative hazards of dusts and the duration of exposure which may prove harmful to the worker.

Furthermore, a study of the prevalence of dust particles occurring in various operations in the petroleum industry has been made and included in this report; also a description of the protective devices and equipment provided for the protection of the workmen.

This report should serve as a guide to operating executives and safety engineers in handling personnel and in providing adequate protection in dusty occupations. It should also resolve many of the fears and questions of industrial workers in these occupations.

The study confirms an opinion that dusty occupations, thoroughly understood and intelligently handled should result in no serious disability.

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MEDICO - SAFETY MEMORANDUM

DUST PRODUCING OPERATIONS IN THE PRODUCTION OF PETROLEUM PRODUCTS AND ASSOCIATED ACTIVITIES

INTRODUCTION - Long looked upon as objectionable, dust today is also recogniz-ed as dangerous - especially with regard to occupational disease (Pneumoconiosis) and dust explosions. Since the dust encountered in the production of Petroleum products and associated operations are non-explosive under ordinary working conditions, no further attention will be devoted to this phase of the dust hazard.

Studies have revealed that the time element (exposure) and the concentration and size of the dust particles are major factors in producing health hazards. Here-tofore difficulty has been encountered in determining actual dust concentrations and sizes of the particles, but recently developed instruments such as the Zeiss Koni-meter and the Bausch & Lomb Dust Counter make it possible to obtain dust counts and estimate size of dust particles which, while not absolutely accurate, are indicative of the dustiness of the area.

The data presented in this memorandum are based upon material taken from the available literature on the subject, upon field investigations and conferences with technical specialists and upon 1008 actual dust counts made with a Zeiss Konimeter, using a 20 to 30 micron (a micron is about 1/25,000 of an inch) porcelain filter.

In the report of the Preventive Engineering Committee of the Air Hygiene Foundation, Professor Philip Drinker of Harvard, chairman, and other technical specialists on the Committee write:

"If the breathing of dust causes disability of any sort - silicosis is only one manifestation - then it follows that there must be some degree of air cleanliness from which no disability will result to the average man during the average working period.

"There is no satisfactory medical answer at present to this question, but the engineer is making a bad mistake if he lets men breathe heavy dust concen-trations of any material. 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 alleged 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% and 40% 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 do men who work in clean air. The evidence that excessive dustiness of any kind is harmful is beyond argu-ment".

PART I - DUST AS A HEALTH HAZARD

I - WHY IS THE DUST PROBLEM SO IMPORTANT? - Although the subject of the health of workers in dusty trades has been receiving considerable attention from students of industrial hygiene for a number of years, the seriousness of this problem was not fully realized until it was brought sharply to our attention by the constantly growing country-wide wave of lawsuits instituted in behalf of the victims in our common law courts, by the magnitude of the generous verdicts awarded by the juries and by a recent decision of the Federal Circuit Court reversing the substantial award of a jury in a New Jersey case (Pennsylvania Pulverizing Company vs. Eldred G. Butler). Owing to these developments, the problem cannot be ignored or brushed aside as merely another form of "racketeering" by unscrupulous lawyers and conspiring doctors. Dodging the issue cannot provide the needed solution because even the most unscrupulous lawyers cannot create a pathologic lung at will and, furthermore, even the most skeptic of coroners frequently finds himself corroborating a diagnosis by his postmortem examination. Enlightened industrialists and the medical profession as well as the bench and bar, have come to the realization that exposure to certain kinds of dust, such as those containing considerable amounts of quartz (silica), has increased the unhealthy bodily condition and death rate from respiratory diseases; while metallic dusts, such as lead and its compounds, have been associated with general systemic poisoning of workers. "Silicosis" is now a definitely recognized disease which is destined to become one of the foremost and most serious of occupational diseases of the future because the number of workers in dusty trades is larger than almost any other group exposed to a single known industrial hazard. The McCaffrey Act, which became effective September 1, 1935, amending the New York Compensation Law, included silicosis as an occupational disease subject to compensation.

Sixteen states, as well as those of the Federal Government and of Hawaii, Puerto Rico, and the Philippine Islands (U.S. Dept. of Labor Bull. No. 625, Bur. Labor Statistics), have Workmen's Compensation Acts which include compensation for occupational diseases, either expressly or by judicial interpretation, or specific occupational disease acts.

II - WHAT IS MEANT BY "DUST"? - According to Webster's Unabridged Dictionary, "Dust" may be defined as fine, dry particles of earth or other matter so comminuted that they may be raised and wafted by the wind; that which is crumbled to minute portions; fine powder. As pointed out by Philip Drinker in a paper read before the Chemical Section of the National Safety Congress (held in Atlantic City, October, 1936), dusts include all types of dry earthy particles small enough to be blown about by ordinary air currents. Dust suspensions may be generated as the result of grinding blasting, or comminuting process; or they may result from the handling of finely divided materials as in mixing processes, in sweeping, or the blowing about of wood flour, plant pollens, or common road dust. There is no chemical limitation implied by the term "dust" while the range in size of dust particles extends from the sub-microscopic to small sand grains. Mr. D. Harrington, Chief Health and Safety Branch, U. S. Bureau of Mines advises that dust as applied to health and respiratory conditions may be wet as well as dry. Under some conditions, such for example as in wet drilling in mines, the escaping air from the drill hole may (in fact generally does) contain a certain amount of entrapped solid material which undoubtedly is wet rather than dry, yet it remains in the air sufficiently long in some instances at least to be breathed by the workers to contribute to possible health trouble. The size of dust of importance from a hygienic standpoint are those under ten microns. In fact, the sizes found in industrial atmospheres are under two microns for the larger majority of particles, say 90 to 95 per cent. Physiologically, there are almost as many different classifications of dust as there are authors on the subject. However, according to Professor Drinker ("Dust, Fumes and Smoke". International Labor Office, Occupation and Health Vol. 1, 930, P. 603) all of these classifications are without much practical importance, since in daily practice in industry the harmful effect is exercised more frequently by dusts mostly of mixed origin. Besides, what is most important is the physical and chemical constitution ~~of the~~ dusts and consequently their action on the system.

III - WHAT ARE THE PHYSIOLOGICAL EFFECTS PRODUCED BY THE INHALATION OF DUST? - To be harmful from a respiratory viewpoint, dust must be of sufficient finess to pass through the nasal filters and be retained in the alveoli (minute air sacs) of the lungs. Particles found in autopsied lungs are of the order of one micron (a micron is 1/1000 of a millimeter or about 1/25,000 of an inch) or less in size - about the size of the common bacteria. Some dust particles found in lungs are as large as five or six microns although these sizes are rather exceptional.

There are five distinct types of reaction produced in man as the result of inhaling dust. These reactions may be broadly classified, based on the primary cause, as follows:

(a) Those which result in lung fibrosis, commonly referred to as pneumoconiosis. These dusts contain free silica, asbestos, etc. However, it is not necessary for fibrous tissue to be formed in order for the disease to be classed as "Pneumoconiosis".

(b) Those which are toxic and are absorbed into the blood stream such as lead, cadmium, etc.

(c) Those which result in what is commonly referred to as metal fume fever; such as zinc oxide, etc.

(d) Those which are allergic in character, such organic dusts as pollen, pulverized wood and flour, etc. The breathing of pulverized wood and flour is frequently associated with tuberculosis.

(e) Those commonly referred to as "nuisance dusts". These may cause irritation of the respiratory tract or passages and may cause considerable discomfort, also headaches of the dry "nasal" passage or sinus type and exposure to them may be associated with a high incidence of respiratory illness.

The rate and extent of these reactions are dependent upon the resistance of the individual, the exposure period (concentration of particles and length of exposure) temperature and humidity of the air, rate of work, and the percentage of ingredients which are harmful.

Owing to the length of time required to obtain a reaction by inhalation methods, the United States Bureau of Mines and the Public Health Service adopted about twelve years ago, a method of injecting small quantities of the dusts to be studied into the peritoneal cavity of guinea pigs. ("Response of Peritoneal Tissue of Dusts Introduced as Foreign Bodies" by Dr. John W. Miller, Dr. R. R. Sayers and Wm. P. Yant, Jour. Amer. Med. Assoc. Sept. 22, 1934 - Vol. 103, pps. 907-911). It was found that identical reactions occur in each animal injected with the same dust under the same conditions and examined in the same time interval after injection. These reactions were essentially the same microscopically as that produced in the lungs and the gross appearance of the dust nodules was sufficiently differentiated to afford a means of classifying the physiological response to the dusts. There are three types of reaction:

An absorption or dissolution of the dust.
A proliferative reaction.
An inert reaction.

In the inert reaction, the dust neither caused an increase in the size of the nodules nor disappeared from the tissues; instead there was more or less a change in its distribution. Soapstone, carborundum (Silicon Carbide), ~~jeweler's~~ rouge (Ferric Oxide), anthracite coal, bituminous coal and certain filter clays have inert reactions. Calcite, limestone, precipitated calcium carbonate, gypsum, and Portland Cement exhibited an absorption reaction. Quartz, chat, certain filter clays and flint produced a proliferative reaction.

The physiological response to the injected dusts were found sufficiently well marked in 90 days to determine the type of reaction, particularly where the reaction was one of absorption or proliferation. Since the reaction elicited by dust was constant and uniform in all of the animals injected with the dust, it is believed that this response of peritoneal tissue to various dusts can be used as a test to determine the possible harmfulness of industrial dusts.

The fibrosis-producing properties of a Georgia filter clay (30-60 mesh grade) a sample of American contact clay and a German contact clay were tested by the Intraperitoneal Method, under the direction of Dr. R. R. Sayers, Medical Officer in Charge, U.S. Public Health Service. The Georgia filter clay showed an inert reaction with a slight tendency towards a proliferation in the 90-day test. The American contact clay showed an inert reaction with evidence of some slight absorption or disappearance of some part of dust in the 180-day tests. The German contact clay caused the formation of light yellowish-brown nodules and as the interval between the injection and the examination increased the nodules became somewhat flattened, but the amount of dust and the approximate size of the nodule remained the same throughout the entire period (90-days) of the test. This can be considered an inert reaction; but as the dust does not disappear from the peritoneum it should be considered as potentially harmful though not as dangerous as pure silica.

In commenting on the results of the tests with the Georgia filter clay and the American contact clay, Doctor Sayers advised that the results of the test indicated that the filter clay is more harmful than the American contact clay because the dust remains inert in the tissues as this was the largest portion of the dust and the inert appearance of the lesions was the most prominent. The modification of the reaction in the filter clay can be attributed to the presence of 5-10 per cent. quartz (Petrographic), Gypsum in the American contact clay may account for the slight absorptive reaction. Doctor Sayers advises that an inert dust, if breathed in sufficient concentration, may be harmful. These tests were made in accordance with the procedure described in Reprint #1608, Public Health Reports, Vol. 49, No. 3, January 19, 1934, pps. 80-89.

The inhalation of dust gives rise to "Pneumoconiosis" a term derived from the Greek <u>pneumon</u>, lungs and <u>konis</u>, dust, and used to designate a pathological condition of the lungs caused by the inhalation of any dust. It includes SILICOSIS, a chronic disease of the lungs caused by the inhalation of minute particles of free silica (SiO_2) dust which produces a permanent incapacitating alteration of the lung tissue; ANTHRACOSIS, the black lung of the miner due to coal dust; ANTHRACO-SILICOSIS, the newest of our mineral dust affections and introduced by the United States Public Health Service as a result of their studies in the Anthracite District of Pennsylvania. This affection is the result of breathing anthracite coal dust that contains silica. The common name for the affection is "Miners' Asthma"; CHALICOSIS, the gray-black lung of the stone-cutter due to stone dust; ASBESTOSIS, in asbestos workers due to asbestos dust; SIDEROSIS, due to breathing dusts of iron ore (The lungs are yellow or red from metallic oxides generally of iron.); BYSSINOSIS, due to cotton particles and vegetable fibre dust, and PNEUMONOULTRAMICROSCOPICSILICOVOLCANOKONIOSIS, a special form of silicosis caused by ultra-microscopic particles of siliceous volcanic dust. Silicosis, Asbestosis, and Silico-Anthracosis are the only three forms of pneumoconiosis which require practical attention.

of exposure to silicate dust.

Asbestosis - According to authorities cited by Drinker & Hatch in their book "Industrial Dusts", the pathology produced by asbestos is not like that of silicosis. Dr. L. U. Gardner of Saranac Lake is of the opinion that the asbestos fibers group about the neck of an alveolus and shut it off, causing what is known as "Atelectasis". There is no definite migration or transportation of the dust particles to the lymph nodes and no fibrous nodules. As the atelectatic areas increase the reduction in lung area causes serious dyspnea or laborered breathing. Dr. A. J. Lanza (U.S.Health Repts., 50; 1 - 1935) suggests that the enlarged hearts noted frequently in his cases of second stage Asbestosis may be due to the increased load on the heart. It takes more work to pump blood through the fibrosed than through the normal lung. Recent pathological studies from human lungs from cases of asbestosis have indicated a diffuse type of interstitial fibrosis with a certain amount of emphysema.

IV - WHAT IS THE MAXIMUM PERMISSABLE DUST CONCENTRATION? - There appears to be a wide variation in the maximum concentration of dust which might be inhaled without subsequent injury to workmen. Some dusts (as lead) are determined by chemical methods and the concentrations in air are recorded gravimetrically as milligrams per cubic meter. However, the available information on the amount of lead dust that is harmful and the methods of determining lead are better and more accurate than those for silica dust. It is rather well agreed that an intake of about 1.5 milligrams of lead a day, whether this is acquired by breathing dust or by drinking water that contains lead, is the maximum allowable quantity. Others (as silica, where size is a factor in determining dangerous particles), are usually given by count. Neither method tells the whole story, but in both cases it may be possible to secure the information necessary for the purpose.

The maximum silica dust concentration considered permissible in the air breathed by a workman at any point in the normal breathing zone has not been definitely established. There is considerable difference of opinion regarding the range of particles that are counted when using the Public Health Service technique and light field illumination. Bloomfield of the United States Public Health Service and Brown of the United States Bureau of Mines contend that they count particles from one micron and upward, or even 0.7 micron and upward. The Industrial Commission of Wisconsin and its Advisory Committee, composed of both employers and scientists, however, agreed in 1932 on a tentative figure of 15 million countable particles under 10 microns in longest dimension with free silica content of 35 per cent in a cubic foot of air as determined by United States Public Health Service technique. Variations in free silica content will make proportional inverse changes in this standard. In the case of practically pure silica, the permissible dust count should probably never exceed 5,000,000 countable particles. By countable particles is meant those particles between 0.5 to 10 microns in the longest dimension. Particles of this size are the ones that are believed to cause the greatest damage and form no visible cloud. Dust particles smaller than 0.5 microns in the longest dimension are not ordinarily countable. Dust particles larger than 10 microns in longest dimension do not ordinarily reach parts of the lung where they can produce injury of a respiratory nature. Most industrial dusts have but few particles above two or three microns in size. They are usually about 90 to 95 per cent. below two or three microns and 50 per cent. below about 0.5 to 0.7 microns. An exception to this would be a dust sample taken close to the point of generation of dust and before the larger particles had time to settle out of the air.

In South Africa the figure is 1 milligram per cubic meter (or 300 particles per cubic centimeter. or approximately 8.5 million per cubic foot.) Dr. Lanza found in 1917 in the Joplin, Missouri district that with good engineering practice, a figure of 1 milligram per 100 liters of air could be attained. This value attributed to Lanza appears too high in comparison with the South African standards. As there bone ash.

III - INSULATING OPERATIONS

Insulation plays an important part in the processing of petroleum products. The two types of insulating material most frequently used are "Sponge Felt" (asbestos with ground sponge to give dead air space and thus increase the effectiveness of the insulation) and a mixture of 85% magnesia and 15% asbestos. Rock wool is used to a considerably lesser degree. In the ordinary commercial form, Rock Wool, as used at our refineries, does not present a dust hazard. It is also used for house insulation, and is available in small nodule form which can be blown into place. "85% magnesia" is a mixture of magnesia and granulated asbestos and pressed into blocks of various sizes and shapes (usually 16" x 18" x 1-1/2"). The most dust comes from dismantling old insulation and grinding scrap material for use as a plaster or "ganister". The average service of men engaged in insulating operations is about fifteen years. Most of these men have been transferred from the Common Labor Department. They work nine out of fourteen eight-hour shifts, in gangs of from two to six men, and are actually exposed to dust for less than sixty per cent. of their working time. Goggles are sometimes provided, and occasionally MSA "Comfo" Respirators, but this equipment is not used as much as it should be. Generally speaking, about 85% of their work is with sponge felt and 15% with 85% magnesia insulation. At one of the larger southern refineries about 300,000 square feet of sponge felt and 50,000 square feet of 85% magnesia are handled a year.

A - <u>What Physiological Reactions are Provoked by Insulating Materials?</u> According to Dr. Leroy U. Gardner (Journ. Indust. Hyg. Mar. 1937, Vol. 19, No. 3, P. 121) asbestos dust with its fibrous particles does not seem to be readily handled by the protective mechanism of the lungs. Quoting from his article:

> "They are not removed to the lymphoid tissue but remain in contact with the delicate walls of the air spaces. They become surrounded by an iron-containing coating that fractures and gives rise to the peculiar structures known as 'asbestosis bodies'. The fibers are irritating, perhaps because of their form, and they excite a fibrosis which begins about the terminal bronchioles and spreads to form diffuse patches in the parenchyma. Often the distribution is sub-pleural. In the presence of infection, the reaction to asbestos dust is much more severe than that caused by the dust alone."

There is nothing in the pertinent literature, nor does the Bureau of Mines know of any evidence, which would demonstrate magnesite (a natural magnesium carbonate) to be harmful. It would fall in the class of "nuisance dusts" such as gypsum. While many of the so-called "nuisance dusts" have never been found to be harmful, it is the opinion of most investigators in the field of industrial hygiene that no worker should be exposed to any dust in a concentration exceeding 75 or 100 millions of particles per cubic foot of air.

B - <u>What are the Principal Insulating Operations and How Much Dust is Produced During Such Operations?</u> There is, of course, a wide variation in the amount of insulation work and the amount of dust produced. A few examples, however, will give a good general idea:

> INSULATING 12" STEAM LINES: 6" x 18" x 1-1/2" blocks of 85% magnesia are tied on the steam line with 14-gauge galvanized wire and covered with roofing paper to make it waterproof. Often times this work is performed on scaffolds twelve to fifteen feet above the ground, with men lying on their backs under the line part of the time.

"In practice it is the dust of quicklime and slaked lime, given off in the course of manufacture and manipulation, which gives rise to the well known lesions. This very fine dust is deposited readily on the mucous membranes and skin. When inhaled it may penetrate as far as the respiratory tract."

Although lime has a tendency to irritate the mucous membranes of the respiratory tract, it is not considered particularly hazardous when breathed in small quantities at intermittent intervals. However, complications may result when a large amount of the dust is breathed more or less regularly. Therefore, it is desirable to wear an approved respirator such as the MSA "Comfo" or the Willson "Dust-tite".

B - METALLIC ZINC DUST: Metallic zinc dust (90% through 300 mesh) is an important constituent in Pipe Thread Coating Compound. About 1500 pounds of this material is used per batch, and about fifty batches are made per month. The zinc dust comes in 400 pound wooden kegs or 500 pound steel drums. According to a chemical analysis, this zinc dust is 99.20% metallic zinc and 0.80% zinc oxide (ZnO). The particle size distribution of a typical sample as determined by a standard screen analysis is:

All through 120 mesh screen

3.76%	retained	on	200	mesh
2.04%	"	"	250	"
22.24%	"	"	325	"

The zinc dust is dumped from the keg or drum onto a metal sheet in front of the kettle and shoveled into the kettle by two or three men (with an average service of about three months) from the General Labor Department. This is a very dusty operation. One sample taken during the shoveling of zinc dust had as high as 68,760,960 particles per cubic foot of air the average concentration being 28,331,328 particles, less than ten microns, per cubic foot. The workmen are exposed to this dust about thirty minutes per batch or approximately 2-1/2 hours per month. They wear dust respirators. About 95% of these dust particles are dark grey, opaque, angular in appearance under the Konimeter microscope, and about five microns or less in size; 5% appear slightly angular, crystalline, ten microns or less in size. The crystalline material is probably zinc oxide.

What Physiological Effect is Produced by Zinc Dust? Although zinc oxide (ZnO) produces definite physiological effects, metallic zinc dust does not seem to affect the person breathing it other than that caused by the inhalation of any inert dust. Nevertheless some investigators are of the opinion that zinc is not entirely inert and harmless. Certainly it is not as harmful as lead or arsenic, but the United States Public Health Service has certain limitations on the amount of zinc that is permitted in drinking water. According to Nuck, E. Remy, and F. Holtzmann (Jour. Indust. Hyg., Vol. 12, 1930, page 171 Ab.) Zinc dust can cause lung trouble after being inhaled in large quantities. Zinc dust is also very definitely explosive.

C - ASBESTOS "FLOAT": Float asbestos is used in the manufacture of tractor lubricants. It comes in 150 pound cloth bags by railroad, about 2000 bags to a car. From 200 to 3000 pounds are used per batch and from two to fifteen batches are made per month. The bags of asbestos float are dumped into the mixing kettle by three men with an average service of twelve years. These laborers are exposed to dust about forty minutes per batch. Dust concentration as high as 8,269,440 particles, ten microns or less in size, per cubic foot are produced during the dumping of asbestos float, the average being 3,058,560 particles per cubic foot. About 98% of these particles are slightly angular, round, transparent in appearance under the Konimeter microscope. and two microns or less in size; 2% are round, semi-opaque, plate like, five microns or over in size.

Recent investigations have indicated that the inhalation of asbestos particles ten microns or less in size is even more hazardous than was originally believed, and that in order to prevent harmful effects concentrations should be kept below five million particles (10 microns or less) per cubic foot. The physiological effects have already been discussed under "ASBESTOSIS" so need not be given any further consideration. Men handling asbestos float should be required to wear approved respirators.

D - GROUND MICA: Ground mica (80 mesh) is used in the manufacture of axle grease. It comes in 100 pound burlap bags. About fifty pounds of ground mica is used per batch and an average of five batches are made per month. The period of exposure will not exceed ten minutes a batch. Handling ground mica produces an average of 2,577,120 particles ten microns or less in size, per cubic foot. About 60% of these particles are transparent irregularly shaped scale like in appearance under the Konimeter microscope, and five microns or less in size; about 40% are over ten microns in size. The transparent plates have small lines or fissures and appear to contain small air bubbles.

Although ground mica has never been considered a hazardous dust, some recent studies made among the workers in North Carolina indicate that continued exposure to large quantities of ground mica over a period of years will produce a fibrosis. However, there is very little probability of any trouble where concentrations are kept below 10,000,000 particles per cubic foot of air and where the exposure to mica dust is such a small percentage of the employee's working time.

E - SULPHUR: Sulphur flour is used for sulphurizing cutting oils and in the preparation of special lubricants for hypoid gears. Crude sulphur is used in the manufacture of sulphuric acid and in the treatment of gasoline and naphtha for removal of impurities such as the mercaptans.

Sulphur Flour: Sulphur flour comes in paper-lined wooden barrels, 100-pound cloth bags, or 150-pound burlap bags. About 2500 pounds of this sulphur is dumped into the melting kettle by two men with an average service of twelve years, once a day. Their exposure to the dust which results from handling and dumping the bags, an average of 1,540,608 particles, ten microns or less, per cubic foot, is about fifteen minutes per man per shift on an average. No goggles or respirators are worn. About 90% of the dust particles in samples taken during the dumping of the sulphur flour were slightly angular crystalline in appearance under the Konimeter microscope, and five microns or less in size; 10% were semi-opaque, rounded, and over five microns in size. The larger particles appear to contain small air bubbles. There were also a number of very small specks.

About 370 pounds of flour sulphur is used per batch in the preparation of hypoid gear lubricant. Two batches are made per week on an average. The exposure to the sulphur dust is only about two hours per week on an average. Since the sulphur is dumped into drums of oil being agitated by a rapidly revolving propeller type mixer more dust is produced than where the bags are simply dumped into a kettle. Samples taken during this operation had as high as 6,910,080 particles, ten microns or less in size, per cubic foot. The average was 3,783,552 particles per cubic foot. The dust particles had the same characteristics as those given in the preceding paragraph.

Crude Sulphur: Crude sulphur comes in box cars holding about 90,000 pounds, usually from Freeport, Texas. Towers are filled with this sulphur by four mixing operation is 1,003,337 particles, less than ten microns, per cubic foot of air. These particles are all slightly angular, crystalline in appearance under the Konimeter microscope and about five microns in size. Many are transparent, glass like. There are a number of small black specks.

H - TALC or "SOAPSTONE": Pulverized talc or "soapstone" is used as a filler in the manufacture of "hot neck" greases used in the steel mills. According to R. B. Ladoo (U.S. Bureau of Mines Bul. No. 213, 1919) ordinary talc or soapstone is Steatite (hydrous magnesium silicate - $H_2Mg_3(SiO_3)_4$). In the form of powder, the talc is greyish white. Associate Chemist Frederick Goldman of the U.S. Bureau of Mines, who made a chemical analysis of samples of talc as marketed, reports:

SiO_2..............	46.04	per cent
CaO................	4.39	" "
MgO...............	26.20	" "
Combined Oxides.....	15.64	" "

Grease makers usually consider the composition of "soapstone" which they use as approximately 90% magnesium silicate and 10% calcium carbonate. It comes in 90-pound paper bags, 700 bags to a box car. About 7200 pounds are used per batch and one batch is made a day on an average. The "soapstone" is dumped into the mixing kettle by two men with an average service of ten years. This dumping which requires about an hour per batch is a rather dusty operation. One sample taken at face level just after a bag had been dumped had as high as 22,995,840 particles, ten microns or less in size, per cubic foot of air. The average dust produced was 13,064,960 dust particles per cubic foot. About 98% of these dust particles were transparent, crystalline, irregularly shaped plates and rods, in appearance under the Konimeter microscope. Most of these particles (about 98%) were five microns or less in size, the remainder being ten microns or over; about 2% were scale-like, semi-opaque, five microns or less in size.

Physiological Effects Produced By Talc Dusts. About two years ago Dr. W. C. Dreessen, Passed Assistant Surgeon, and J. M. Dalla Valle, Assistant Sanitary Engineer, United States Public Health Service, made a study to ascertain whether there is a connection between talc dust exposure and the relatively high tuberculosis death rate in Murray County, Georgia, where two talc mills and mines are located. They found (Reprint No. 1669 from the Public Health Reports Vol. 50, No. 5, Feb. 1, 1935, pages 131-143):

> "Physical and roentgenologic examinations were made of 66 men and women who were exposed or had been exposed to talc dust. In the higher dust groups comprising 33 men, 8 were found to have Pneumoconiosis I and 8 to have Pneumoconiosis II or III. Six of the thirteen examined were diagnosed as having Pneumoconiosis I. No advanced stages of the disease were found in this group. In the group exposed to low concentrations of dust, no Pneumoconiosis was found."

The final conclusion of this study was that although Georgia talc appears to be "more injurious than tremolite talc" the high tuberculosis mortality rate in the County "could not be attributed to the talc industry".

Investigators have suggested, however, that for more or less continuous exposures concentrations of talc or "soapstone" dust should not exceed 15,000,000 particles, ten microns or less in size, per cubic foot of air.

I - GRAPHITE: Powdered graphite (80% to 85% graphitic carbon and 15% probably magnesium silicate) is used in the manufacture of spring and pressure lubricants. It

PART III - MEASURES FOR REDUCTION OF THE DUST HAZARD

HOW CAN THE DUST HAZARD BE REDUCED? - The quantity of dust inhaled may be minimized by the employment of these four methods outlined by Dr. M. Kummel in "Medical Record":-

"1. Suppression of Dust Near It's Origin, by the use of exhaust draught, dust traps or water. The water has the advantage of a fly-paper effect on the silica particles, but the humidity created tends to favor infection by prolonging the life of pathogenic organisms outside the body and facilitating their entrance into the body.

"2. Admixture of Adulterant Dust with the silica which may assist in the expulsion of silica from the lungs, retard the process of the disease or prevent the development of tuberculosis. However, the introduction of an additional foreign body into the lungs is of doubtful value fraught with potential danger and should be regarded very cautiously and conservatively.

"3. Proper Ventilation, in connection with other methods.

"4. Masks should be an ideal preventive measure but, unfortunately, most of the masks stopping the dust also stop the respiration, thus necessitating their frequent removal. They should be of an approved type, properly maintained, strictly supervised and their use rigidly enforced."

We do not believe that the use of water would have any outstanding effects on raising the humidity in most of the dust producing operations in the Petroleum Industry, any more than, for example, sprinkling one's lawn would have. We believe it remains to be proved beyond doubt that the humidification of air actually favors bacteriological growth to the extent that the incidence of disease from pathogenic organisms is raised significantly. There has been much discussion on this subject, but little has been proven. Theoretically, it may be admitted that these organisms live longer in a moist atmosphere than in a dry atmosphere, but it is rather hazardous reasoning to conclude that for the reasons stated, the use of wet methods in dust control causes an increase in disease.

Dr. Kummel's statement that most masks (we presume he means respirators) that stop dust also stop respirations, is a little strong. There are available today respirators that adequately remove dust without creating a resistance to breathing in excess of 15 to 30 millimeters of water column, and the tendency of progressive manufacturers of such devices is to further lower the resistance. Men during the war actually did fighting while wearing respiratory protective devices that had as much as 50 to 75 millimeters resistance. The resistance figures given for respirators are measured at a rate of air flow of about three cubic feet a minute which is equivalent to the amount of air breathed by a person doing hard physical work.

Dust Respirators and Air Masks - Respirators and masks of various types have been used since the days of the alchemists and are mentioned by Agricola, Ramazzini and others. Control of the dust hazard by means of respiratory protective equipment is effective, provided:

(1) the protective equipment is efficient, and

(2) it is worn continuously.

Efficient equipment is available, but for continuous use, day after day, this method more air than those with tight fitting facepieces.

There is some difference of opinion among users of respirators as to whether or not adjustments should be provided whereby the wearer can vary the flow of air to meet variations in his requirements. It was the opinion of the National Silicosis Conference Committee that definite recommendations for all situations cannot be made, but for many situations, and particularly where tight-fitting facepieces are used, an adjustable flow is desirable and may even be necessary; also, most workmen can learn to adjust the air properly. On the other hand fixed-flow procedures require a minimum amount of instruction and supervision and are the most conducive to safety under all conditions.

While Hose Masks and Air-Line Respirators have many definite advantages the area of travel of the wearer is limited to the length of the hose, and movements are handicapped to some extent by the hose. Manifestly, the air for the hose and the mask should be fresh and pure, but unfortunately this is not always so.

<u>Abrasive Blasting Respirator</u> - Abrasive blasting respirators consist essentially of a hood, with windows, that fits loosely over the head and shoulders and designed to withstand and protect the wearer's head, neck and shoulders from abrasion by the rebounding of particles of sand or grit; and a supply of fresh air, at least six cubic feet per minute, blown into the hood. Only equipment which has met the United States Bureau of Mines test requirements and which is approved by the Medical and Safety Departments should be used.

(c) <u>Acceptance and Use of Personal Respiratory Protection by Workmen</u> - As stated in a paper by G. M. Kintz and H. C. Fowler of the United States Bureau of Mines (I.C.6915 No.v1936) presented at the International Petroleum Exposition and Congress, Tulsa, Oklahoma, May 21 1936, selecting respiratory protective equipment is simple compared with getting men to wear it after it is supplied. Generally workmen will wear masks readily in places where they have seen others asphyxiated, or in some similar trouble, but they are likely to resist wearing protective equipment where the dust cannot be seen or where the fumes and mist have no objectionable odor. There are three main reasons for such resistance:

First, inbred objection to any new idea;

Second, the feeling that the individual is a superman and can "take it" without protection; and,

Third, the inconvenience of wearing the equipment.

In a survey conducted among the employees of the Colgate-Palmolive-Peet Company by Mr. F. H. Wallner of that Company's Insurance Department, it was found that the men didn't like the disfiguring appearance of a "muzzle" over their faces. This survey also disclosed that some workers objected to the respirator because they thought it made breathing difficult when the real trouble was that they were not breathing correctly. Breathing through a respirator should be done deeply and slowly and after the proper habit has been acquired much discomfort may be eliminated. Quoting Mr. Wallner:

> "Foremen should appreciate that the position of the straps that hold the respirator in place has much to do with comfort. They should learn whether the straps should be worn over the head or around the neck. Some types have two straps, one to be worn around the neck, the other around the head."

Probably the most effective plan in getting respirators worn is first to "sell" the supervising personnel who in turn should "sell" the worker by education, possibly accompanied by strict and fair supervision and discipline. ~~Employees~~ Employees exposed to dust hazards requiring the wearing of respirators should be convinced that it is essential to sacrifice some comfort and dignity to avoid serious cases of disability and suffering. Every worker should have his own respirator. It requires time and effort to adjust this protective device so it contacts the face snugly with a minimum of head-band tension. It cannot be expected that the average workman will readjust a different respirator each day. Also, the psychological effect of using a respirator worn previously by another workman is not unimportant. Although he may not say anything about it, it is naturally revolting to most men's principles of bodily sanitation to have to clamp over his face a device that has been soaked with sweat and dirt of another man's face and into which one or more men have breathed day after day! It is too much like using the other fellow's tooth brush. The best practice is to mark every respirator so each workman can identify his own.

(d) Use, Maintenance and Care of Respirators - Personal respiratory protective devices must be maintained in a condition substantially the same as when received from the manufacturer. Depending on the density of the dust replaceable filters should be changed frequently to prevent their becoming clogged and usually it is desirable to use a respirator without a facelet. However, if they are considered necessary, the facelets should be changed often to avoid skin irritation. A clean facelt gives the respirator a clean appearance and removes one objection to wearing it.

The Colgate-Palmolive-Peet Company found that the habit of some workers of removing their respirators at intervals caused skin irritation. Everytime they did this, dust settled on the surfaces that lay next to the worker's face and irritating particles were transferred to the skin when the device was replaced. It is, therefore, best to have the employee wear his respirator constantly while under exposure. In some cases, ointments or petroleum jelly has helped to overcome the irritating effect of points that contact the skin.

Where a considerable number of respirators are used, it is good practice to have a "Respirator Room" with an attendant who issues the respirators and cleans, sterilizes and otherwise keeps them in good condition. Respirators may be cleansed by washing and brushing them with an antiseptic soap and warm water. They should be checked for damaged or improperly functioning parts such as rubber valve seats and head-bands. If defective, these should be replaced by new parts.

WHAT MEDICAL CONTROL SHOULD BE EXERCISED IN THE SELECTION AND SUPERVISION OF MEN WORKING ON DUSTY JOBS? - It is essential that adequate medical control be exercised. Such control should include the examination, prior to initial working on dusty jobs of the worker to insure that he is a suitable physical subject. This examination should preferably include X-ray examination of the lungs which permits closer control with subsequent X-ray tests as well as being a protection to the employer in the event of any later legal action.

A worker, to be classed as physically suitable, should be in addition, determined to be a nose-breather rather than a mouth-breather and the natural filtering capacity of the hose should be found to be satisfactory. G. Lehmann (J. Ind. Hyg. 17,37 - 1935) indicates that the "Silicotic susceptibility of workers with poor nasal filtration is much greater than that of men with good nasal filters". He advises that jobs with a silicosis hazard be held only by men with good nasal filters" and that mouth breathers are an especially bad risk. He suggests that the "dust retaining capacity of the nose be used as an index of the individual's qualification for working in a silicosis producing atmosphere". It is possible that Sternstein's technique for measuring nasal resistance ("Industrial Dusts - p. 65) could be developed into a simple procedure for selecting men best adapted to dust exposure.

According to Drinker and Hatch ("Industrial Dust" p. 32) it is wise to select for dusty jobs men who are past the age of 40 and not young men just taking up a trade.

All workers engaged in harmful dusty operations should be periodically thoroughly re-examined, including X-ray tests. Particular emphasis should be placed on any indication of shortness of breath and chest pains

Regulations should be enforced concerning the time limitation of work of any employees involved in a dust producing operation. Such Company regulations concerning sandblasting calling for a fixed six-month maximum period on such work, after which a minimum six-month period away from dust producing work should be followed more closely.

For protection from a legal angle, the worker should be given a final thorough examination including X-ray before being permanently transferred to some other type of work, laid off or discharged.

CONCLUSION

There is still a tremendous amount to be learned about pneumoconiosis and dust-producing operations. One thing, however, is certain -there is a very definite tendency to require compensation for industrial or occupational diseases. If these compensation costs are to be kept to a minimum and the health and safety of workman are to be promoted it will be necessary to make further studies and to promptly adopt adequate precautionary measures. Many of these are now in effect, the others should be put in force as soon as possible. After years of study and direct contact with the Dust Problem, Mr. Dan Harrington, Chief, Health and Safety Branch, United States Bureau of Mines, has come to this conclusion (Eng. & Min. Jour. March 1937 pps. 119-21) with which we are heartily in accord

> "In the maze of uncertainties connected with almost all phases of the causation and diagnosis of dust disease, about the only really well-determined fact available is that breathing large quantities of dust (or possibly of certain dust) over extended periods is likely under some conditions to be harmful to health and that subsequent alleviation or cure is difficult or impossible. Therefore, it would seem to be logical to try to prevent dust formation thus preventing it from harming workers through respiration or otherwise. Here is a real job for the engineer, and little or no help can be expected in these vital functions from any agency except the engineers and operating officials.
>
> "The most harmful of the ordinary dusts to breath is probably silica dust, but, on the other hand, not even free silica, supposedly the most detrimental of the silica dusts, is harmful unless it is breathed, in considerable quantities and over extended periods. No human being ever lived any considerable time on this earth of ours without breathing silica dust (free silica dust), yet by no means all of the people of the world have or have had silicosis. In other words, the quantity of dust taken into the respiratory organs is a controlling factor in dust respiratory harmfulness.
>
> "One common-sense answer is that any atmosphere in which dust is visible to the naked eye is certainly too dusty to be breathed with safety by human beings, and the wise, farsighted, human employer will immediately start to decrease the dust content in any atmosphere where dust is visible. After he has eliminated visible dust, there may

still remain enough very small invisible dust to cause harm to the health of those who breath it, but in any event if he has exerted sufficient well-directed effort to remove the visible dust it is certain that much of the smaller invisible, and probably most harmful dust has also been removed.

"Manifestly, if dust is kept out of the air breathed by workers, the latter cannot succumb to dust disease of a respiratory character."

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