# DUST PRODUCING OPERATIONS

IN THE

PRODUCTION OF PETROLEUM PRODUCTS
AND ASSOCIATED ACTIVITIES

A MEDICO-SAFETY SURVEY
BY
Roy S. Bonsib, M.A., E.M.
*CHIEF SAFETY INSPECTOR*
*STANDARD OIL COMPANY (N. J.)*

FOREWORD BY
Willard J. Denno, M.D.
*GENERAL MEDICAL DIRECTOR*
*STANDARD OIL COMPANY (N. J.)*

STANDARD OIL COMPANY (N. J.)
30 ROCKEFELLER PLAZA,
NEW YORK, N. Y.

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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.

Willard J. Denno

Willard J. Denno, M. D.
General Medical Director
Standard Oil Company (N. J.)

# MEDICO - SAFETY MEMORANDUM

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

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STANDARD OIL COMPANY
(Incorporated in New Jersey)
30 Rockefeller Plaza
New York, N. Y.

# 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 recognized 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. Heretofore difficulty has been encountered in determining actual dust concentrations and sizes of the particles, but recently developed instruments such as the Zeiss Konimeter 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 concentrations 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 argument".

# 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.

While the type of pulmonary lesion depends on the particular dust inhaled, the underlying pathological principle is the same in all forms of the disease, namely, an ultimate fibrosis and replacement of the elastic lung ~~tissue~~ by a hard unyielding fibrous tissue. All occupations that expose men to large amounts of dust may give rise to pneumoconiosis but not necessarily to silicosis. It is now generally agreed that in order to produce the latter, (silicosis) inhaled silica dust must reach the lungs in a chemically uncombined condition, in very fine particles not more than ten microns (10/25,000 inch) in diameter and in sufficient amount and over a sufficiently long period of time. In relatively recent literature it appears that the proponents of the idea that only "free silica" is harmful are beginning to have some doubts and to have the thought that possibly some silicates may under some conditions be harmful. Generally speaking, the necessary length of exposure to produce silicosis is in direct proportion to the size of the dust particles and inverse proportion to the dust concentration and the amount of free silica in the dust. Silicosis is characterized anatomically by a generalized fibrosis of the lungs and clinically by shortness of breath, decreased chest expansion and a progressively lessened capacity for work which is out of proportion to the objective physical findings. The effect of exposure to dust such as silica is cumulative, the rapidity of development of the disease depending upon the time and amount of inhalation. Silicosis may develop to the point of causing symptoms only after several years exposure to silicious dust, but it may be progressive in some cases even after exposure has ceased and may cause symptoms or become disabling long after the workman has left the environment that caused the condition. Some may improve or at least remain stationary in the absence of infection. Watkins-Pitchford (J.Ind.Hyg.9,109 - 1927) tells of Welsh miners who passed the physical examination for enlistment in the British Army, fought through the World War, then came back to England, and died of silicosis. Unfortunately, it is not stated whether these persons died from silicosis complicated with tuberculosis. Britton and Head (J.Am.Med.Assoc.96, 1928 - 1931) give more detailed descriptions of similar latent cases in the United States.

Silicosis in General - It is generally agreed that silicosis may be defined as

"A chronic disease due to the breathing of air containing silica ($SiO_2$), characterized anatomically by generalized fibrotic changes and miliary nodules in both lungs, and clinically by shortness of breath, decreased chest expansion, lessened capacity for work, absence of fever, increased susceptibility to tuberculosis (some of all of which may be present), and by characteristic roentgenological findings."

In other words, silicosis is a disease of the lungs in which the normal lung tissue is replaced by scar tissue due to breathing air containing silica dust. Unfortunately there is no known cure for silicosis - but SILICOSIS and nearly all other forms of dust diseases CAN BE PREVENTED.

Recognizing the wide interest and even hysteria among apprehensive employers against whom claims had been filed by alarmed workers, and the necessity of thoughtful consideration of the silicosis problem, the Secretary of Labor on April 14, 1936 called the First National Silicosis Conference attended by more than 300 persons representing workers, employers, State and Federal Agencies, Insurance companies, and other interested groups. Four Committees were organized to study specific phases of the silicosis problem; and assemble the essential facts about silicosis in a series of reports; also to present specific suggestions for silicosis prevention and straighten out other difficulties that silicosis has created. Reports made by these Committees were formally adopted at a second conference held February 2nd and 3rd 1937 in Washington, from which we quote:

"While a few persons may still be of the opinion that such workers" - (Workers having silicosis) "are 'through' and doomed to an early death, every study conducted thus far confirms the fact that the ~~great ma~~jority of these men will not necessarily progress from bad to worse. Perhaps it may be wise to transfer some workers to other employment, but many may be continued at their regular occupations if known methods are applied to control the dust and if special care is employed to prevent the development of tuberculosis, pneumonia and other lung complications".

"Contrary to popular belief, silicosis is slow to develop. Usually it takes seven years or more of exposure to silica dust for a worker to contract the disease. It is said that a few cases have been known to develop in as short a period as 1-1/2 years, but these were under extreme and unusual conditions. On the other hand, many workers have labored under ordinary exposures to silica for more than 30 years without demonstrating any trouble whatever that could be diagnosed as silicosis".

For the convenient diagnosis of silicosis or of silicosis complicated by tuberculosis, the pulmonary changes are classified in three stages by Drinker & Hatch ("Industrial Dust" - 1936). In the first stage, the disease produces no diability. The victim can work just as well as ever. In the second stage, his respiration is affected; he is bothered by dyspnea or labored breathing. In the third stage dyspnea becomes severe and he is likely to contract pulmonary tuberculosis, generally with fatal results. Whether he contracts tuberculosis or not, the advanced silicotic is far below normal and is very susceptible to all respiratory diseases.

These three stages of silicosis can be distinguished by X-ray. A comparison of the X-ray plates of a silicotic with those of a normal person of like age and physique shows, in the first stage, distinctive shadows, evenly distributed in both lungs. These may be missed or misinterpreted by any but an expert; but the changes in the second and third stages are obvious even to a layman. It is, of course, essential that the X-ray plates be properly made. Dr. Pancost and Dr. Pendergrass of the University of Pennsylvania have given extensive study to the influence of X-ray technique on the diagnosis of silicosis. Pendergrass is of the opinion that shadows and appearances of fibrosis can be actually produced by the technique employed. Under other conditions, existing fibrosis can be entirely missed by use of improper technique.

<u>Silicates</u> as a class are by no means harmless. It was pointed out by Dr. R. R. Sayers (U.S. Public Health Bulletin 221) that Miners' Consumption was rather common in the Broken Hill district of Australia where the rock contains considerable sillimanite ($Al_2 SiO_5$), fibrous silicate, and a rather low percentage of quartz (12.23%). The studies of Badham (Rept. Dir. Gen. Pub. Health, New South Wales) give considerable support to W. R. Jones' (J. Hyg. 15, 307-<u>1933</u>) contention that silicates, particularly the fibrous varieties, may well be <u>the</u> cause of pulmonary disability. Badham in 1927 coined the word SILICATOSIS to cover disability from the inhalation of silicates. Other silicates such as Talc ($H_2 Mg (SiO_3))_4$; Shale; Kaolin ($H_4 Al_2 Si_2 O_9$); Feldspar; Cryolite, ($Na_3 AlF_6$); and pure Mica give much less specific changes than quartz. A moderate fibrosis may appear after exposure to numerous materials but this fibrosis is usually not disabling. According to Dr. Lanza, "Silicatosis" is not a recognized term in this country and disability from the inhalation of silicates has not been proven.

Dr. Cary P. McCord (Ind. Med. July 1933, pps. 4-12) states that all silicates taken into the lungs, of particle size capable of passing the cellular membranes, are likely to induce some fibrosis in excess of normal but the progress of such silicatosis is not nearly so rapid as for silicosis. Tuberculosis rates are high in silicate using industries. Antecedent tuberculosis, quiescent, may flare up as a result 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 are 1,000 liters in a cubic meter, it would indicate that Lanza's estimation represents something of the order of 80 million particles per cubic foot. With good engineering practice, lower concentrations than this can be obtained. In fact the experience in South Africa and also the present experience in this country indicates that it can readily be kept below one-tenth of this value by using ordinary good practices. The United States Public Health Service in its recent study in the anthracite region of Pennsylvania, found that 50 million particles per cubic foot with 5 per cent. quartz in the coarse dust and 10 million particles per cubic foot with 35 per cent. quartz were apparently satisfactory and often were attained. The figure of 10-20 million particles per cubic foot for granite dust with 35 per cent. quartz content is often quoted from the Vermont granite studies of the United States Public Health Service. From a consideration of general experience, Cummings suggests 5 million particles per cubic foot as a threshold for dusts high in quartz. This figure is based upon a combination of South Africa, Australian and American experience but lacks entirely any published data in its support.

According to studies quoted by Philip Drinker and Theodore Hatch in their book "Industrial Dusts" 10 to 20 million particles per cubic foot by the impinger sampling method, light field counting is a reasonable figure for cement and limestone. Recent work by Dreessen confirms the universally accepted opinion that dusts high in calcite and low in quartz do not produce disabling fibrosis. The threshold figure of 0.15 milligram per cubic meter is given for lead dust, presumably litharge and white lead, or other soluble lead salts.

It should be noted that many of the data were not determined as the Medical requirement, but as being attainable in good practice and apparently satisfactory from a safety standpoint. It should be further noted that the accepted figures are only relative due to the indefinite powers of resistance of an individual which are an unknown quantity. One individual might resist a proportion of 200 particles per cubic centimeter, while another would react unfavorably to 50 particles. The worker's physical condition prior to the exposure is of great importance, since a young, healthy individual usually can stand a higher concentration or longer exposure before the first stage of silicosis is developed. However, far greater influence than physical condition might be the ability of the nose and respiratory passages to arrest dust.

In their report to the National Silicosis Conference the Committee on Prevention of Silicosis through Medical Control pointed out that since standards of safe atmospheric dust concentration, based on medical findings have been established for only a few industrial dusts, and in view of the fact that considerable study and investigation will be required to establish standards for other industrial dusts, some tentative standard would be useful. It was also stated that this arbitrary standard should be based upon what is believed to be within the limits of good engineering practice provided, it will largely control the silicosis hazard for most industrial exposures. They, therefore, suggest that

"The maximum permissible concentration of silica in the air breathed might be expressed by the following formula. (Determination of dust concentration according to technique described by United States Public Health service in Reprint No. 1520 from Public Health Reports, March 18, 1932):

Multiply the percentage of free silica by the total particle dust count. If the result is under 5 million, the condition may be considered permissible. If the result is over 5 million, the condition may be considered too high. For example,

10% free silica with an average total dust concentration of 30 million particles per cubic foot would give .10 times

30 million, which equals 3 million (good practice); 30%, with average total dust concentration of 50 million, would equal .3 times 50, or 15 million 9 (unsatisfactory).

This formula is not applicable to any dust containing less than 5% free silica."

Theodore Hatch in his article "Some Fundamental Data on Mechanical Dust Traps" (Tech. Pub. No. 637-A, 60, Amer. Inst. Min. & Met. Engrs., Aug., 1935) gives these

<u>Safe Dust Concentrations, Impinger Samples;</u>

(Light Field, Low Power Counts.)

| Kind of Dust | Maximum Permissible Concentration |
|---|---|
| Containing no Silica. . . . . . . . . . . . . . . | 50 millions per cubic foot |
| Containing any small amount of silica, free combined. . . . . . . . . . . . . | 30 " " " " |
| Containing 20 to 40 per cent. Free Silica . . . . . . . . . . . . . . . | 10 " " " " |
| Greater than 40 per cent. Free Silica . . . . . . . . . . . . . . . | 5 " " " " (Preferably as much less as possible) |

Dr. R. R. Sayers, Medical Officer in Charge, Industrial Hygiene and Sanitation, U.S. Public Health Service in answer to a question as to permissible dustiness writes:

"During recent years, it has been customary to recommend threshold or permissible dust limits ranging from five to ten million particles per cubic foot as determined by Public Health Service technique, especially with dust in which the percentage of free silica is above five per cent. There is no basis for the application of this criterion to all dusts, but it is generally considered a safe practice and one which can be attained in most industries by exhaust ventilation, wetting, or other methods of dust control."

As pointed out by Drinker and Hatch ("Industrial Dust" - <u>1936</u>) it is unfortunately impossible to evaluate dust exposures with the arithmetical nicety that we should have liked yet it is commonly claimed - by laymen - that prolonged exposure to low concentrations is just as serious as short exposures to heavy concentrations. This claim is contrary to a fundamental law of physiology. In discussing the subject Clark and Drinker ("Industrial Medicine" - <u>1935</u>) remark that ".....a sub-threshold stimulus (dust inhalation) for a long time produces no reaction whereas a relatively brief super-threshold stimulus may cause a reaction". If workers are exposed to sudden heavy concentrations, the threshold values suggested previously would be correspondingly lowered. However, most threshold values are weighed -- an average of the ranges.

V - HOW MAY THE CONCENTRATION AND CHARACTER OF INDUSTRIAL DUSTS BE DETERMINED? The properties of a dust which determine its harmfulness have been shown to be its composition, concentration (the quantity suspended in the industrial atmosphere), and its particle size. The methods used for the determination of the concentration and character of industrial dusts vary from a routine dust count for the purpose of evaluating the efficiency of dust control methods to a detailed study of both the concentration and the character of the dust in connection with medical and engineering surveys.

The Impinger Apparatus developed at the United States Bureau of Mines, Pittsburgh Experiment Station by George Smith and Leonard Greenburg, (Described in Reprint No. 1528 from the Public Health Reports Vol. 47, No. 12, March 18, 1932 pp. 654-675) has been employed for more than 13 years as a standard instrument for dust studies. In this apparatus samples of air are drawn into an impinger tube and flask where the dust particles are thrown or impinged on a prepared wetted glass collecting plate. The rate of air flow is fixed at one cubic foot per minute while the duration of the sampling period is dependent upon the dust concentration. The air passes through an orifice in the bottom of the impinger tube and strikes glass collecting plate which is submerged in 3 cm. depth of distilled water or some other fluid with satisfactory wetting properties. (If water is used as the fluid in the impinger, silica particles are dissolved--hence not available for counting -- unless the laboratory (counting) work is done within a few hours of taking the sample.) This affords the means for accurately determining the quantity and size of the particles. The liquid is then thoroughly shaken to obtain a uniform distribution of the particles; filtered to remove those over 40 microns in size and again agitated. Samples of approximately 1 cc. are taken by means of a pipette and placed in Sedgwick-Rafter counting cells. The use of a suitable microscope equipped with a Whipple micrometer disc to aid in counting. will permit the determination of the number of particles in one quarter of the microscopic field. From this figure, the number of particles of dust in 1 cu. ft. can be calculated. One special advantage of this apparatus is the fact that analysis of the sample can be determined by counting, by weighing or by chemical analysis. The impinger method is neither simple nor extremely complex; however, reliable results can be obtained only by well trained, competent and experienced investigators. However, owing to the wide use of the impinger in previous investigations that have been correlated with the pathological findings, an impinger should be used for any investigation which is to include pathological findings or where the results are to be introduced as evidence in court. Some state codes on dust control recognize the impinger method. The United States Bureau of Mines has practically completed the development of a "Midget" impinger which has most of the good characteristics of the impinger but lacks most of its drawbacks. This midget impinger will soon be available and will greatly simplify both sampling and counting.

Other devices are also available for sampling of dust over a continuous period, namely, the electric precipitator, the paper thimble, the electrostatic precipitator, and the hot wire thermal precipitator. The English are working on a dust sampling instrument which precipitates the dust from the air by thermal means ("Physical Methods for the Estimation of the Dust Hazards in Industry", by H. L. Green and H. H. Watson, Privy Council, Medical Research Council, Special Series No. 199, His Majesty's Stationery Office, London, (1935)). The U.S. Bureau of Mines has been using an electric precipitator similar to those described by Drinker ("Alternating Current Precipitator for Sanitary Air Analysis; I - An Inexpensive Precipitator Unit" by P. Drinker, Jour. Ind. Hyg., Vol. 14, 1932, p. 364) for collecting samples of the test suspensions used in testing mechanical filter respirators for permissibility.

A number of instruments are available for making dust determinations for control purposes. Among these is the Konimeter which calls for but little skill in sampling. It is light, simple and quick to handle, needs no power for operation and requires only a microscope for counting the particles. The Zeiss Konimeter consists of a microscope which gives a magnification of 200X, an air pump, a dust filter to remove very coarse dust particles, a sample disc and a micrometer ruled in square millimeters. The air pump drives a measured quantity of air against the sample disc which is covered with a sticky substance (glycerine jelly). This sample forms a dust spot which can be examined under the microscope for a general idea of the nature of the dust and the relative quantities present, or for an actual measure, a "dust count", which shows how many dust particles are present in one cubic centimeter or in one litre of the air samples examined. The Konimeter has been used very widely in

South Africa (Final Report of the Miners' Phthisis Prevention Committee, Johannesburg, 1919, p.10) and also in Canada. The U.S. Bureau of Mines has also used it in some of its dust studies. In discussing the value of the Konimeter in their recent book "Industrial Dust" (McGraw-Hill Book Co., New York and London - 1936) Philip Drinker and Theodore Hatch of the Harvard School of Public Health write:

> "It is the most compact and simple sampling device. Space is provided for thirty samples on a single disc and no auxiliary source of power is required for its operation. Grab samples can be collected with speed and the fluctuations in dustiness and the development of dust floods can be revealed in a way that is impossible with more cumbersome apparatus. South African experience involving the collection of thousands of samples has shown that the figure of merit given by the Konimeter is directly related to the amount of phthisis - producing dust in the air. It is a valuable routine sampling instrument but because of its low and selective efficiency, the counts reported are probably considerably below the true level and they are not easily compared with data obtained in England, for example, with the Owens apparatus, or in the United States with the impinger."

Experience has shown that contrary to Drinker's statement, the Konimeter if properly used, will give results that agree very well with those obtained by the use of the Impinger. The U.S. Bureau of Mines Experiment Station at Pittsburgh in making some comparative studies with the Konimeter and the Impinger found that an average of five Konimeter determinations was within about two per cent. of one impinger determination. The reason for taking an average of individual results obtained by the Konimeter, for comparison with those of the Impinger, is due to the fact that the Konimeter takes an instantaneous grab sample of small volumes and owing to the hetrogeneous nature of dust in air grab samples do not represent the average conditions. The Impinger takes a continuous sample of rather large volumes and is thereby representative of the average. For these reasons, if it is desired to compare Konimeter results with Impinger results it is necessary to take several Konimeter samples during the course of the Impinger sample, in order to obtain average conditions. We have no correlating information of the Konimeter with the 20 to 30 micron porcelain filter against the standard impinger method.

A Zeiss Konimeter, using a 20 to 30 micron porcelain filter was used in making actual dust counts in our various dust producing operations. The particle size and size classification was estimated rather than accurately measured and computed. Only particles ten microns or less in size were counted since it is generally agreed that dust particles larger than ten microns in size are not particularly pathogenic.

Other methods in common use are the Owens jet dust sampler ("Jet Dust Counting Apparatus" by J.S. Owens, Jour. Ind. Hyg., Vol. 14, 1932, P. 522), which has recently been manufactured in this country and the photographic dust counter, developed by Ficklen and Ott. The Owens jet dust counter is used in this country to collect samples for particle size distribution determinations. It is used principally in Australia for determination of number concentration of atmospheric dust of industrial hygienic importance.

The latest device for determining dust concentrations is the Bausch & Lomb Dust Counter which was placed on the market a few months ago. This instrument consists of a dark-field microscope magnifying 200X, and an impinging apparatus mounted on a common base. The base is a hollow chamber with the bottom hinged to provide easy access to the dark field condenser and a circular glass specimen slide. By means of a hand pump, which is part of the impinging device, a sample of air is drawn through a moistening chamber which has at its lower end a narrow slit. The dust is deposited through this slit on to the circular specimen slide in the form of a ribbon. The slide can be rotated until the sample comes into proper position for viewing with the microscope, or a maximum of twelve samples can be collected on the slide and then viewed. The slides are quickly removable and replaceable. This dust counter is not designed for accurate dust determination but rather as an inexpensive device for roughly checking dust conditions. It has not been available long enough for a thorough test in actual practice.

The principal objection to instruments like the Bausch & Lomb Dust Counter and the Owens jet dust sampler for determining number concentration is that their dust collecting efficiency decreases with an increase in the atmospheric dust concentration and the fact that they take grab samples.

Since the major portion of dust present in industrial atmospheres is small enough to gain entrance to the lungs, very little attention need be given to determinations of the exact sizes of particles.

# PART II - DUST PRODUCING OPERATIONS STUDIED

WHAT ARE THE PRINCIPAL DUST PRODUCING OPERATIONS? - In order to determine to what extent if any, workers in the production of petroleum products and associated activities are exposed to the hazard of breathing dust, a survey of all dust producing operations was made at the various plants concerned. These operations, listed in order of their apparent degree of dustiness, are:

## I - SAND - BLASTING

Due to the large amount of finely divided silica dust produced by the impact of the grains of sand on the surface of the object being cleaned, sand-blasting is the most dangerous silicosis hazard encountered in our survey. Sand-blasting is used rather extensively at oil refineries for cleaning inside soaking drums, bubble towers, tar separators, run-down pans and storage tanks for metal inspection and to permit the application of gunite lining as a means of preventing corrosion. Header boxes or other similar parts, tubes in cracking coil fire boxes and return bends are sand-blasted to permit a detailed and thorough examination for cracks and defects. Sand-blasting is also employed in the removal of corrosion from under floating roof tanks; for removing roughness or rust from steel shapes or rods; for cleaning bell caps, bubble plates, trays, and pipe prior to putting them back in service; also on the ends of tubes preparatory to placing them for rolling; and for cleaning castings which are too large or fragile to withstand being tumbled. It has been used, to a limited extent for cleaning buildings and rendering window glass opaque.

The cracking coil tubes, pipe, bell caps, trays, header-boxes and similar objects are usually sandblasted out-doors in the open air or in a more or less open shed, both locations being as far removed as feasible from any shops, process units or other working places. Coarse river sand is discharged through a one-half to three-quarter inch nozzle with compressed air under a pressure of 30 to 90 pounds per square inch. The men at the nozzles stand to the windward side of their work and wear a "Healthguard" (Chicago Eye Shield Company) mask, a Sly Sand Blast Helmet or a Fresh Air Hose Mask covered with a canvas hood. The men at the Sand Blast Machines wear "Dust Safe" goggles and a M.S.A."Comfo" Respirator. The Mine Safety Appliances Company now has a sand-blast hood that is meeting with considerable approval by industry and also by the United States Navy Department. A blower is available for supplying air to these hoods that cleans the air. This same blower can be used in connection with air-line respirators.

When sand-blasting is done inside of drums having more than one opening, such as soaking drums, an air siphon is placed in the lower manhole which draws out the dust and allows a continuous circulation of fresh air through the drum. In drums where the siphon cannot be used, the air circulation is poor and the men work in shifts ranging from 30 minutes to an hour, depending on the size of the drum and the amount of air circulation inside. They also wear an approved sand-blast helmet.

These sand-blasting jobs are not continuous routine operations but are performed when necessary by men selected from the Common Labor gangs or the Mason's Department. The work is rotated so that in most cases it occupies less than twenty per cent. of the worker's time and there is an interval of 15 to 20 days between sand-blasting jobs. Consequently, on the average, no one man is exposed to more than a combined total of 400 hours during the course of a year. In discussing rotation of men on sand-blasting jobs. Dr. Gehrmann, Medical Director of the du Pont Company wrote:

"It must be borne in mind that silicosis is a cumulative disease and, therefore, the rotation of men in this type of work cannot be considered as entirely preventive. Assuming that a man works in an atmosphere of silica dust for several months, during whichtime he is bound to absorb a certain amount of the dust which produces permanent damage in his lungs; he is then removed and the possibilities are that the damage which is already done will be sufficient to continue on and progress to the point where in later years he will develop symptoms.

"Therefore, if we take to rotating men in this type of work we are facing the possibility of, in later years, developing a large number of cases of a moderate silicosis with some permanent disability. The only safe expedient which can be used is complete prevention and this can only be done by eliminating the dust."

During our survey we found that men engaged in sand-blasting, that is handling the nozzle or attending the sand-blast machine, were more or less properly protected while actually doing the work but often times they removed their protective equipment before getting completely away from the working area.

A large amount of very small particles is produced by sand-blasting. In an analysis of dust samples collected both outdoors and indoors during sand-blasting, the following distribution (Public Health Bulletin No. 217 - p.52) on a size frequency basis was found:

| Size Group in Microns | Per Cent of Total |
|---|---|
| 0.00 - 0.49 | 1.4 |
| 0.50 - 0.99 | 19.7 |
| 1.00 - 1.49 | 34.7 |
| 1.50 - 1.99 | 20.3 |
| 2.00 - 2.49 | 12.6 |
| 2.50 - 2.99 | 5.2 |
| 3.00 - 3.49 | 2.8 |
| 3.50 - 3.99 | 1.6 |
| 4.00 - 4.49 | 1.1 |
| 4.50 - 4.99 | 0.2 |
| 5.00 - 5.49 | 0.2 |
| 5.50 - 5.99 | 0.2 |

While it has been estimated that free silica dust particles, 1 micron in diameter, require 8 hours to fall 6 ft. in still air; particles 5 microns in diameter require less than 1 hour to fall the same distance. Considering this fact, it is apparent that the dust hazard from a particular operation may, even though carried out for short periods, be acute throughout the working day. In view of the fact that the condition of still air is rarely, if ever achieved, and that dangerous particles exist in sizes below one micron, it is evident that a hazard exists.

Fortunately most of the outside sand-blasting is done in more or less isolated locations which makes it rather improbable that there will be any unsafe silica dust exposure to other workmen. However, should it become necessary for any work to be done in the vicinity of sand-blasting operations either on process units or the sand-blast sheds or yards, it should be remembered that there may be silica dust in the air even though it can not be seen. Dust counts as high as 5,344,160 particles ten microns or less per cubic foot were found in samples taken about 50 feet "downwind" (wind blowing about 15 to 20 miles per hour) while sand-blasting cracking coil tubes; about 95% of these dust particles appeared angular crystalline under the Konimeter microscope and were about five microns or less in size. Samples taken about 100 feet "downwind" from sand-blasting operation had counts as high as 1,812,480 particles per cubic foot.

Dust counts as high as 13,933,440 and as low as 453,120 particles per cubic foot were found in samples taken during the filling of the Sand Blast Machine feed hoppers. The high counts were found when sand was shovelled ~~into a~~ small circular screen and shaken by hand, the lower counts, when the sand was simply shovelled into the hopper. The average dust produced by filling or charging the Sand-Blasting Machines was 4,950,316 particles, ten microns or less, per cubic foot.

Dust counts as high as 4,964,320 particles, ten microns or less, were found in samples taken inside a Sand-Blasting Room while cleaning castings. The average dust in this room during sand-blasting was 3,873,625 particles per cubic foot. About 80% of these particles were angular crystalline three microns or less in size and about 20% appeared rounded, quartz-like crystals about ten microns in size. There were a few rust-like scales over ten microns in size and a very large number of minute dark metallic particles too small to be counted accurately. The dustiness of this operation could be greatly reduced by the use of steel abrasives exclusively.

All of the samples for dust counts referred to above were taken at face level in the vicinity of workmen.

6,000,000 dust particles per cubic foot is the tentative maximum allowable limit of dust particles containing free silica of a size less than 10 microns recommended for sand-blasting.

## II - FILTERING OPERATIONS

The process of filtering is extensively used in the refining of petroleum products to improve the color stability and to remove impurities from motor lubricants and paraffine waxes. The three materials most commonly used for this purpose are Filter Clay or Fullers Earth, Contact Clay and Bone Black. Considerable dust is produced by the handling, charging and reconditioning of these materials.

### A - FILTER CLAY OR FULLERS EARTH:

What is Filter Clay or Fullers Earth? Filter clay cannot be identified from chemical composition but consists of silica, alumina, iron and alkaline earths in varying percentages. The distinguishing properties are lack of plasticity and the power to remove color from oils. There are numerous deposits of this clay and other filtering earths in the United States; the oldest and among the most extensive are those found close to the Florida-Georgia line. One of these, at Attapulgus, Georgia, supplies a major portion of the clay used by the affiliated Standard Oil Company (New Jersey) organizations. At the mine this material contains on an average approximately 32% silica and 45% moisture. The average composition after being processed and prepared for shipment is approximately:

| | | |
|---|---|---|
| $SiO_2$ | 67.46 | per cent |
| $Al_2O_3$ | 10.08 | " " |
| $Fe_2O_3$ | 2.49 | " " |
| MgO | 4.09 | " " |
| Combined Moisture | 5.61 | " " |
| Free Moisture | 6.28 | " " |

The comparatively low dust counts found even in places where there was cleaning and sweeping is no doubt due to the fact that this filter clay is of a rather coarse nature and without appreciable amount of fines.

There appears to be a wide variation in the composition and free silica content of filter clays used in European refineries. "Terrana" a German Filter clay used in Poland shows:

| | |
|---|---|
| Loss in calcination.............. | 6.05 per cent |
| Free Silica ($SiO_2$)............... | 83.27 " " |
| $Al_2O_3$ and $Fe_2O_3$................. | 8.27 " " |

The filter clay used in Roumania is reported as having 60.4 per cent. free silica or 75.3% total silicates. "Granosil" clay used in Belgium contains a total percentage of 73-1/2 per cent. of silicates expressed as $SiO_2$. The percentage of free silica was not determined.

<u>How is Filter Clay Mined and Prepared?</u> - The deposit varies from 2 to 12 feet in thickness, probably averaging about 7 feet. There is an overburden of about 35 feet which is removed by an electrically operated drag line or a steam shovel. The clay is loaded into small cars, transported to the wet clay shed where it is dumped on to the drying floor and dried for three days. It is then picked up by orange peel buckets, loaded into portable distributors and delivered to belt conveyors which discharge the earth into roller crushers where it is reduced to sizes up to a maximum of two inches. From these crushers the clay goes to secondary crushers where it is reduced to a maximum of one inch. Since the clay is more or less damp very little dust is produced. The clay is then transferred to tandem oil-fired rotary dryers, 50 to 60 feet long and six to seven feet in diameter. In the 20 minutes required for the clay to pass through the dryers the volatile and moisture content is reduced 40 to 50 per cent. to a maximum of 15 per cent. The average dust ten microns or less in size in samples taken at various points around the dryers and conveyors was 1,564,969 particles per cubic foot. This rather low dust count is the result of the installation of hoods with ducts to exhaust fans placed over the discharge points to the conveyors or elevators. About 85% of these dust particles were angular crystalline in appearance under the Konimeter microscope and about five microns or less in size; about 15% were over ten microns in size. The larger particles had rough edges and appeared to contain several small air bubbles. The clay is removed from the dryers to hot rock cooling tanks, then to a vibrating screen. The oversize is next pulverized in a roller mill and the product conveyed to a sifter. An exhaust system for the mills and elevators has been installed. This process may be repeated until the desired size material has been obtained and graded to standard mesh sizes, the better known of which are 15-30, 30-60, 60-90, and the 200 mesh. The 60-90 grade is probably the most commonly used in the petroleum industry when decoloring by percolation, and the 200 when contacting. However, the 30-60 is preferred by most of our refining units in the United States. The size selected is apparently determined largely by the type of reburning equipment.

Screen tests are made hourly to insure that the sizes are within the specifications. Here are two typical screen analyses:

<u>30 - 60 GRADE FILTER CLAY</u>

| Mesh | Per Cent. |
|---|---|
| Over 30 | 9.7 |
| 30 - 40 | 47.5 |
| 40 - 60 | 40.3 |
| 60 - 82 | 1.5 |
| Thru 82 | 1.0 |
| Total | 100.0 |

FINES (100 - up) GRADE FILTER CLAY

| Mesh | Per Cent. |
|---|---|
| Over 97 | 0.6 |
| 97 - 157 | 22.7 |
| 157 - 200 | 8.0 |
| Thru 200 | 68.7 |
| Total | 100.0 |

There is very little dust produced by the sifting operation. All of the connections are designed to be dust tight but there is some leakage. Samples of air taken at various points around the sifters while in operation had an average of 2,208,960 dust particles less than ten microns per cubic foot. About 85% of these dust particles were slightly angular crystalline in appearance and five microns or less in size; about 15% were slightly rounded semi-opaque ten microns or over in size. The larger particles had small cracks or fissures and several small air bubbles.

Men spend about two hours a day cleaning, repairing or replacing silk screens in the sifters. Samples taken during this operation contained an average of 2,039,040 dust particles less than ten microns per cubic foot. About 97% of these dust particles were angular crystalline in appearance and five microns or less in size; about 3% were opaque over five microns in size.

After being sifted and graded the clay is ready for shipment. The 30-60 mesh grade is placed in burlap bags holding 128 pounds and loaded into railroad box cars; about 400 bags to a car on an average. Dust counts of samples taken during the filling of the bags with the 30-60 mesh grade show that there are from 7,589,760 to 9,968,640 dust particles less than ten microns per cubic foot which indicates that all men engaged in bagging and handling bags in this area should wear approved respirators such as the "M.S.A. Comfo". About 80% of the dust particles in samples taken during the filling and handling of the bags appear slightly angular crystalline under the microscope and are five microns or less in size; 20% are rounded crystalline, ten microns or over in size.

Bulk Loading of railroad box cars with the 30-60 mesh grade produces clouds of dust, but a major portion of this dust is apparently larger than 30 microns in size as samples taken during this bulk loading had an average of only 6,853,440 particles, ten microns or less in size per cubic foot.

The Fines (100-up) grade is put into 128-pound cotton bags. Dust counts in samples taken during this operation showed that there were from 4,644,480 to 14,216,640 dust particles less than ten microns per cubic foot in the air being breathed by the fillers, weighers, sewers and truckers. About 80% of these particles were rounded, semi-opaque crystalline in appearance under the Konimeter microscope and five microns or less in size; 20% were semi-opaque crystalline from about seven to fifteen microns in size. There were also a large number of very small particles about one micron or less in size.

<u>How is Filter Clay Used?</u> - Upon arrival at the refinery, the bags of clay are removed from the box cars by a crew of men usually from the General Labor Department; the job being rotated so that the same men do not do this particular operation more than perhaps twelve hours twice a year on an average. Goggles and "M.S.A. Comfo" respirators are generally provided. The clay is either trucked or dragged to an elevator or conveyor hopper and dumped and the bags are piled for storage. At points where the clay is received in bulk, it is unloaded by a large wooden scoop pulled by a motor driven drag-line. Unloading, handling, and dumping the clay is one of the

dustiest parts of the filtering operation. The amount of dust produced is of course dependent on how the work is done, the ventilation provided, and the care used by the men doing the job. Here are some average dust counts of particles less than ten microns in samples taken during the unloading of bags of 30-60 mesh Attapulgus clay

| | Particles Per Cubic Foot |
|---|---|
| Unloading and dumping bags (128 lbs.) into Hopper at a Southern Refinery | 5,403,456 |
| Dumping clay from Bags into Elevator Hopper at a Northern Refinery | 2,237,280 |
| Handling bags from Storage and Dumping into Elevator Hopper at another Northern Refinery | 755,150 |
| Inside Box Car During Unloading | 1,110,144 |
| Outside " " " " | 372,924 |
| In Filter House Passageway being used to Truck Clay to Elevator hopper | 339,840 |
| Average Dust Produced while sweeping up inside car after unloading | 651,360 |

Apparently unloading clay in the bulk is less dusty than handling and dumping of the clay in bags. Samples taken during the unloading of bulk clay gave these average counts of dust under ten microns in size:

| | |
|---|---|
| Inside car during unloading | 962,880 particles per cubic foot |
| Outside " " " | 623,040 " " " " |

There is of course more dust produced in the vicinity of bulk unloading than is produced when handling and dumping clay in bags.

After dumping, the new clay is taken by elevators and conveyors to storage bins which hold about 20 tons each. This is also a dusty operation due to the failure to cover the storage bins or to place hoods over the junction points of elevators and belt conveyors. Samples taken during the filling of storage bins with new clay had these average dust counts of particles less than 10 microns in size:

| | |
|---|---|
| Dust over Bins around elevators and conveyors during filling at a Northern Refinery | 1,910,432 |
| " " " & Conveyors while filling at another Northern Refinery | 4,275,842 |
| " " " & Conveyors while filling at a Southern Refinery | 4,531,200 |
| " Face Level on Walkway over Storage Bins Northern Refinery while Filling Bin | 2,307,776 |

Dust Counts as high as 8,609,280 particles per cubic foot were found in samples taken near the discharge of one belt conveyor into the top of a storage bin. About 90% of these dust particles appeared angular crystalline under the Konimeter microscope and were five microns or less in size; about 10% were black, opaque, many scale-like in appearance and ten microns or over in size.

"BURNING" CLAY - From the storage bins the clay is conducted by chutes and/or conveyors and elevators to gas or oil fired Wedge Burners or Rotary Burners or Kilns in which it is "burned" or roasted, and then discharged into rotary coolers where it is cooled. Where all openings. chutes and elevator outlets as well as the ends of rotary coolers are properly enclosed and an exhaust duct is placed over the burner, very little dust (an average of only 604,160 particles, ten microns or less in size per cubic foot) is produced and no respiratory protection is necessary. Three types of burners or kilns are used to recondition filter clay. Average dust counts of samples taken during the operation of these burners give a comparison of the amount of dust (particles ten microns or less per cubic foot) produced by each:

| Type of Furnace | Feeding | About Furnace | Coolers | Total General Average |
|---|---|---|---|---|
| Herman-Frasch Oil or Gas Fired | 2,624,320 | 3,700,480 | 2,732,880 | 2,990,542 |
| Wedge Gas Fired | 5,399,680 | 1,522,459 | 2,108,590 | 2,395,971 |
| Rotary " " | 2,067,360 | 1,070,046 | 3,115,200 | 1,818,206 |

The present practice of using a compressed air hose to clean up the clay on the various floors of the Furnace House at one of the Refineries is particularly objectionable due to the excessive dust (12,687,360 particles ten microns or less per cubic foot) which is stirred up.

About 90% of the dust particles in samples taken during the burning of filter clay were angular transparent crystalline in appearance and five microns or less in size; 5% were round opaque, ten microns or over and 5% were rounded semi-opaque, ten microns or over in size.

Exposure to dust produced by burning or reconditioning clay is rather limited. Usually there is one fireman for each shift of eight hours, three shifts per 24 hours and a porter for the day shift only. Since one of the porter's main jobs is to "clean-up" he is exposed more continuously to dust than are the firemen.

CHARGING FILTERS - The cooled, burned clay (30-60 grade) is conveyed to the filters by means of elevators and belt conveyors and charged through chutes from the conveyor belt tripper at a rate of from one and a quarter to eight tons per hour. These vessels hold from seven to fifty tons each. The amount of dust produced during the charging operation depends upon the grade of clay being handled, the rate of charging, the position of the clay on the conveyor belt, the condition of the conveyor belt, tripper and charging chute; also whether the top manhole of the filter is left open during the filling. A general average of 54 dust counts made of samples taken during the charging of filters at all of our plants using 30-60 mesh Attapulgus Filter Clay was 3,717,884 particles ten microns or less in size per cubic foot. The amount of dust produced by the charging operation varies considerably at the various plants as is shown by these averages:

| Refinery | Charging Rate | Particles per cubic foot |
|---|---|---|
| Baton Rouge | 8 tons per hour | 4,271,413 |
| Bayway | 1-1/4 " " " | 2,435,520 |
| Bayonne | 3-1/2 " " " | 2,242,944 |
| Eagle Works | 6 " " " | 1,042,976 |

It is the general belief that the more times a clay has been used and reconditioned, the less dust is produced during its handling. Our study does not confirm this belief as applicable to dust produced while charging filters. Averages of dust counts in samples taken during this operation were:

| | | |
|---|---|---|
| # 1 Clay | 2,242,944 | particles per cubic foot |
| # 3 " | 4,604,832 | " " " " |
| # 10 " | 3,896,832 | " " " " |

According to an analysis of particle size made by the Bayonne Laboratory of a sample of Raw (30-60 grade Attapulgus Clay) No. 1, No. 3, and No. 8 Wedge clays, the following is the size classification or distribution:

| | Raw Clay | #1 Clay | #3 Clay | #8 Clay |
|---|---|---|---|---|
| Coarser than 100 mesh | 98.5% | 99.4% | 98.7% | 98.3% |

| Diameter of Particles: Millimeters | Diameter of Particles: Microns | Raw Clay Per Cent | #3 Clay Per Cent | #8 Clay Per Cent |
|---|---|---|---|---|
| .149 to .074 | 149 to 74 | 0.14355 | 1.00750 | 0.54159 |
| .074 " .044 | 74 " 44 | 0.55095 | 0.17186 | 0.08449 |
| .044 " .035 | 44 " 35 | 0.29760 | 0.05369 | 0.04585 |
| .035 " .025 | 35 " 25 | 0.21555 | 0.03887 | 0.01603 |
| .025 " .015 | 25 " 15 | 0.17550 | 0.01729 | 0.00847 |
| .015 " .005 | 15 " 5 | 0.11640 | 0.01027 | 0.00336 |
| .005 " .001 | 5 " 1 | 0.00045 | 0.00052 | 0.00021 |

About 85% of the dust particles in samples taken during the charging of #3 clay were slightly angular in appearance and five microns or less in size; 15% were rounded semi-opaque, ten microns or over in size. About 75% of the particles in samples taken during the charging of #10 clay were slightly angular crystalline, five microns or less in size; about 20% were over ten microns in size and were semi-opaque about 5% were round semi-opaque between five and ten microns in size. All of the larger particles appear to contain small bubbles. There are numerous small black specks about one-quarter micron in size.

Charging of filters is usually done by one man per shift for each filter house. There are three shifts a day. These men have an average service of about 20 years and work eight hours a shift, nine shifts out of fourteen.

Ventilation is provided in the newer filter houses by eighteen-inch roof ventilators extending about twelve inches above the roof and also by windows which occupy about 80% of the wall space in front of the top of the filters.

DUMPING FILTERS - After the filters are charged with clay they are plated up and the oil is allowed to percolate through the clay for several hours, the length of time depending upon the nature of the oil run and the "yield" of the clay. The oil is all drained off and the clay is then washed with naphtha or "Varsol" and steamed to remove all trace of the naphtha. After this the filter is dumped on to a canvas belt conveyor and the clay returned to the kiln for burning or reconditioning. Filter clay is used as many as fourteen times before it is finally discarded. In order to determine what effect the reconditioning of filter clay had on its free silica content samples were analyzed by the New York State Department of Labor, Division of Industrial Hygiene with this result:

| Times Burned | % Free Silica |
|---|---|
| Raw Clay | 6.30 |
| Once | 8.50 |
| Three | 9.20 |
| Eight | 9.30 |

Considerable steam is usually given off during the dumping which probably explains the smaller dust count (a general average of only 2,518,781 particles ten microns or less in size per cubic foot) than would be expected. The dustiest part of the filter dumping operation is sweeping up the floor under the filters after dumping is completed. Samples taken during this sweeping or cleaning up had as high as 16,538,880 particles per cubic foot, although the general average of samples taken during dumping at the various refineries was 2,514,816 particles per cubic foot. About 95% of these dust particles are slightly angular crystalline in appearance under the Konimeter microscope and are above five microns or less in size; about 5% are rounded semi-opaque over five microns in size. Occasionally the clay doesn't "flow" when the filter is opened and must be started "flowing" by means of an iron bar. This action causes some dust (2,888,640 particles per cubic foot) but not as much as pounding the bottom and lower sides with a sledge (4,248,000 particles per cubic foot) as is sometimes done. After the clay has run out, the inside of the filter is swept out with a broom which produces a little dust (an average of 792,960 particles per cubic foot). The filter is then plated up and is ready for recharging.

The work of dumping filters is done by one man per shift, for each filter house. These men have an average service of about ten years and work eight hours a shift, nine shifts out of fourteen. They are exposed to dust less than 60 per cent. of their working time.

Spent clay is used to a limited extent for packing around valves and fire hydrants to prevent freezing; also for certain other small absorbing job such as on the warehouse floors of some of the larger bulk sales plants where lubricating oils are transferred from barrels or drums to smaller containers, or loaded into five gallon cans from bulk. Most of the spent clay is disposed of, however, by dumping it on nearby Company property and, to a lesser extent on railroad property near river banks.

Composition of Filter House Air Borne Dust: Samples of dust from Attapulgus Clay, which had settled on the tops of elevator housings and on girders over the storage bins in filter houses, were submitted to the United States Bureau of Mines Experiment Station for petrographic examination. Ordinarily positive results are not obtained in petrographic tests for the identification of minerals in atmospheric dust. However, the samples submitted were coarse enough to give results in most cases. In studying the results of the petrographic examinations it should be borne in mind that the samples submitted were settled dust, and that they are not representative of the composition of the dust that would be breathed generally owing to the differential settling rates and the ease with which the various mineral constituents can be crushed to a powder.

"Montmorillonite" ((Mg, Ca) $O.Al_2O_3.5SiO_2.nH_2O$ -- n=5 to 8) is the mineral that is characteristic of many types of fullers earth. Not all of the less important minerals found were fully identified.

Clay dust from top shell of elevator - Top #2, Herman-Frasch Furnace.

Quartz - 10% Montmorillonite - 80%
Calcite, Microcline and Unidentified - 10%

Dust from accumulation on girder over clay storage bins - #4 Filter House.

Quartz - 10% Montmorillonite - 70%
Possibly other clay minerals present, opaque - 20%

Dust from accumulation on girder over clay storage bins - #1 Filter House.

Quartz - Over 1% Montmorillonite - 55%
Opaque - 40% Unidentified - 5%

<u>Control of Filter Clay Dust:</u> Dust in a filter plants results principally from the operation of the clay handling machinery. The condition is aggravated by the present practice at some refineries by using an air hose ~~to blow~~ accumulated dust and spilled clay from equipment, walls and floors. Handling a fine light dust producing material, such as filter clay, in a system which includes open belt conveyors is inherently a dusty operation. (12,687,360 particles, ten microns or less in size, per cubic foot). It is difficult to prevent some dust from being generated at unloading points where the clay falls into chutes or bins, but it can and should be controlled by means of hoods, enclosures, and adequate exhaust systems with effective dust collectors.

There will always be an irreducible minimum of spillage and dust settlement wherever dusty material is handled in systems such as exist in most refinery filter houses. This is an economic waste and increases the difficulty of the dust control problem. Unless the present practice of cleaning dust spillage by blowing with compressed air is changed, the necessary periodic cleaning will continue to be a very dusty and unhealthful operation even though all precautions have been taken to prevent the escape of dust from clay handling equipment. A modern industrial vacuum cleaning system would do the job efficiently, without creating any dust.

The principal source of dust in filter buildings is the belt conveyor which is usually located at the top of the building. Gusts of wind from the monitor blow the clay and dust from the belt. A certain amount of dust is also generated by clay falling into the tripper chute (6,060,480 particles per cubic foot) and discharging from the tripper chute into the chute leading to the various filters (7,306,560 particles per cubic foot). This could be considerably reduced by inserting canvas or sheet iron connections between the ends of the tripper chutes and the chutes to the filters, and by using a properly designed belt tripper on the conveyer belt.

Bins for the storage of filter clay should be closed with steel decks having the smallest possible openings in the form of chutes to receive clay from the conveyers. If care were taken not to overflow the bins, the dust and spillage could be greatly reduced.

For complete control of dust, an exhaust system equipped with dust collector, fan, ducts and hoods should be installed to remove dust from the points of origin, such as, all unloading points (except movable trippers) of each belt conveyer in the building, new clay bins and burned clay bins. One estimate which has been prepared for such an installation calls for an exhaust system with a capacity of approximately 15,000 cubic feet of dust laden air per minute, and is based on maintaining an inward flow of air at openings into hoods and bins at a recommended velocity of 200 feet or more per minute. In considering dust collectors, it should be borne in mind that the cyclone type will not remove the fine dust particles (ten microns or less in size) which are most injurious to health, and that the cloth bag type filter has been proven to be more successful in removing these fine particles.

Under existing conditions at most plants it is almost impossible to keep the plants clean, regardless of how carefully the equipment is operated. However, the installation of a vacuum system and adequate dust collectors should encourage operators to exercise more care in the operation of equipment and thus cut down the amount of dust and spillage.

B - CONTACT CLAY:

Most contact clays, particularly in the United States, are acid treated "Bentonite". Bentonite is a non-refractory clay, a double silicate of iron and aluminum, derived from the shale of the Fort Benton formation in the upper Missouri valley.

There appears to be a wide variation in the composition and free silica content of American and European contact or activated clays. "Filtrol" an extensively used American contact clay is reported to contain about 57% free silica (silica which is insoluble in concentrated hydrochloric acid). "Milwhite", another extensively used American contact clay, contains 65% free silica. The contact clays listed are those most extensively used in Europe:

| | Insoluble in Concentrated HCL | Insoluble in Concentrated HCL and 5% $NA_2$ $CO_3$ |
|---|---|---|
| "Ivry" Clay (French)........ | 75.0%............. | 64.6% |
| "Terrana Extra" (German).... | 64.4%............. | 27.2% |
| "Clarit" (Italian).......... | 49.5%............. | 50.6% |

"Tonsil AC", another French contact clay, has 61.75% free silica.

The main constituents of "Petrisil", a German contact clay, are:

| | |
|---|---|
| Total Silica................ | 51.57% |
| Lime (CaO).................. | 0.63% |
| Aluminum and Iron Oxides.... | 18.83% |
| Loss on ignition (Water).... | 23.62% |

The balance probably consists of potassium and sodium oxides.

The following is the result of a petrographic examination of "Petrisil" which was made at the United States Bureau of Mines experiment station:

| | |
|---|---|
| Quartz...................... | 5% |
| Montmorillonite............. | 90% |
| Unidentified Minerals....... | 5% |

The use of contact clay for improving the color of lubricating oils is a recent development.

At present the price of contact clay is so low that it is used only once and then discarded.

Although there are many contact clays on the market, a large percentage of that used by the Standard group is known as "Filtrol", consequently this was included in our dust studies.

<u>What is "Filtrol" and How is it Produced?</u> "Filtrol" is a pulverized acid treated Bentonite, used as a decolorizer, absorbent and deodorizer in the refining and preparation of both organic and inorganic oils. It comes from "open cut" mines in Mississippi and California, and occurs in beds about two and one-half feet thick under an over-burden of some eighteen to twenty-five feet. There has been some doubt as to its origin, but it is now believed to have been volcanic dust transported by the air and deposited under the waters of either a lake or a sea. Raw Bentonite is mined and loaded onto trucks with steam shovels, and then taken to the preparation plant. A tractor scoop lifts the raw material from the storage shed floor and places it in a hopper out of which it is fed into an elevator by means of a steel pan feeder. The elevator discharges into a crusher which breaks the material down sufficiently to enable it to pass through a screen (three meshes to an inch) onto a belt conveyer which takes it to a pre-mixer where it is mixed with water to form a "slurry". This slurry is passed into large wooden tanks and treated with dilute sulphuric acid

agitated with air and steam. It is then dumped into thickeners, washed, and delivered to an Oliver filter. From there it goes in turn to a pug mill, drying tower, cage and imp mill, and classifier. The finished product is placed in a bin where it is put into fifty pound Bates Valve paper bags by means of a Bates Bag Packer. It is shipped in railroad box cars, each having a capacity of from 1600 to 2000 bags. The three grades of "Filtrol" in greatest demand are:

| GRADE (Per cent. thru 200 mesh) | Per cent. of Total Production | Coarser Than 200 Mesh | 200 - 325 Mesh | Finer Than 325 Mesh |
|---|---|---|---|---|
| 85 - 88 | 80 | 14.0% | 16.0% | 70.0% |
| 75 - 88 | 15 | 23.0% | 24.0% | 53.0% |
| 90 - 93 | 5 | 8.0% | 23.0% | 69.0% |

The only real dust producing operations in the production of Filtrol are the filling, stacking and handling of the fifty pound bags. Samples of dust taken during these operations revealed the following:

| Operation | Particles per cu ft. |
|---|---|
| Average dust filling bags with 85-88 grade | 10,416,096 |
| " " packing room while filling bags | 9,572,180 |
| " " produced in handling of filled bags | 5,845,248 |

An exhaust system has been installed to reduce and control the dust produced during the packing of Filtrol. This consists of a metal hood above the filling tubes in front of the machine, with a basin below. A seven-inch duct leads from the basin and a six-inch duct to a canopy in back of the packer, both connecting with a ten-inch main duct which runs to a Sturtevant Fan (1750 R.P.M.) designed to handle 1,620 cubic feet of air per minute against four-inch water static pressure. A cyclone dust collector removes the larger particles from the air before delivering it to a tubular cloth dust collector.

About sixty per cent. of the dust particles of samples taken during the filling operation are slightly angular crystalline in appearance under the Konimeter microscope, and are about two microns or less in size; approximately twenty per cent. appear to be rounded crystalline, glass-like, but with rather smooth edges, and over ten microns in size. There are a large number of very small gray particles (about twenty per cent.) too minute and too numerous to count accurately.

<u>What is the Chemical Composition of "Filtrol"?</u> Below is the result of an analysis by a commercial chemical laboratory in Los Angeles, California, of a sample of Filtrol from the Jackson (Mississippi) plant:

| | Per Cent. |
|---|---|
| Silica ($SiO_2$) | 56.90 |
| Alumina ($Al_2O_3$) | 13.97 |
| Ferric Oxide ($Fe_2O_3$) | 1.44 |
| Titanium Oxide ($TiO_2$) | 0.10 |
| Calcium Oxide ($CaO$) | 2.82 |
| Magnesium Oxide ($MgO$) | 3.55 |
| Manganese Dioxide ($MnO_2$) | - |
| Carbon Dioxide ($CO_2$) | - |
| Potassium Oxide ($K_2O$) | 0.03 |

| | Per Cent. |
|---|---|
| Sodium Oxide ($Na_2O$)........................ | ~~0.04~~ |
| Chlorine (Cl)........................... | - |
| Phosphoric Anhydride ($P_2O_5$)............. | - |
| Sulphuric Anhydride ($SO_3$).............. | 0.63 |
| Total ignition loss..................... | 20.00 |
| Free Moisture........................... | 12.23 |

"It is customary to separately report materials such as Silica ($SiO_2$) and Alumina ($Al_2O_3$) in ultimate analysis although the elements are known to be in combination with one another. It is difficult to get an analysis of free Silica and since the quantity contained in Filtrol would be very small, we have not attempted to have this particular analysis made."

The following is the result of an analysi of "Super-Filtrol" which was made in France:

| | Per Cent. |
|---|---|
| Moisture at 120 degrees C .............. | 16.5 |
| Loss on ignition....................... | 33.5 |
| Insoluble in concentrated HCL.......... (Total Silica and unattacked crystals) | 55.0 |
| Insoluble in HCL and in a 5% $Na_2CO_3$ solution. (Silex, quartz and unattacked crystals) | 15.0 |

A microscopic examination shows a few particles with "acute angles".

An examination made by the United States Bureau of Mines Experiment Station in Pittsburgh, Pennsylvania showed that Filtrol contains more than 1% quartz, 95% Montmorillonite ((Mg, Ca) $O.Al_2O_3$-$5SiO_2$-$nH_2O$--n=5 to 8) and 5% unidentified minerals. A similar examination of Attapulgus Fines (200 mesh) showed 5% quartz and 95% Montmorillonite.

<u>How is Contact Clay Used?</u> The clay is mixed with oil, agitated and heated, and either allowed to settle or run through a filter press. It is then discarded. The clay is either dumped directly into the oil or placed in a hopper from which it flows into inductors or mixing chambers where it is mixed with the oil and then pumped to a filter tank. The only dusty operations are the unloading of the material and dumping it into the hoppers or mixing chambers. The higher dust counts with the contact clay as compared to filter clay is probably due to the fact that it is a finer material, or at least disintegrates more easily than the filter clays studied.

Samples taken during the dumping of Filtrol and Attapulgus Fines into a reaction chamber gave the following dust counts.

| Operation | Particles per cu. ft. |
|---|---|
| Average dust produced while dumping 50 pound bags of "Filtrol"........................ | 6,768,480 |
| Average dust produced while dumping 100 pound bags of "Attapulgus Fines"................ | 9,260,640 |

Under the Konimeter Microscope the particles were rounded in appearance. The "Attapulgus Fines" appeared more crystalline and angular, and had a greater proportion of particles five microns or less in size than did the "Filtrol". The counts indicate that more dust results from dumping Attapulgus Fines than from dumping Filtrol activated clay.

Dumping fifty pound bags of "Milwhite" (90% through 200 mesh), a Texas contact clay, into the feed hoppers to the inductors or mixing chambers is an exceedingly dusty operation. Samples taken during this operation had as high as 14,046,720 particles ten microns or less in size per cubic foot. Samples taken in the middle of the room just after thirty bags had been dumped into the hopper had 55,847,040 particles per cubic foot. Under the Konimeter Microscope, about 90% of these particles appeared slightly crystalline, and were five microns or less in size; 10% were round, semi-opaque, ten to twenty microns in size. There were also a few scale like particles.

Fourteen men with an average service credit of six years are involved in this operation. Three men are exposed to the dust during six hours of each eight hour shift for nine of the fourteen shifts during the 85% of the time the filtering plant is in operation. They wear M. S. A. "Comfo" respirators.

After extensive study and investigation the local management has made arrangements to receive the clay in tank cars similar to those manufactured by the General American Tank Car Company. These cars are self-unloading and will discharge into an enclosed hopper. The clay will then be transported to storage bins by means of a screw conveyor completely enclosed in ten-inch tubing. It will be withdrawn from the bottom of the bins, passing through weighing scales, into the inductors where it will be mixed with the oil. This will provide a completely closed system and should eliminate all air contamination.

C - BONE BLACK OR CHARRED BONE:

Refined wax is filtered through bone black or charred bone to improve its color. This material is obtained from various meat packing firms in finely woven coffee bags that hold about 150 pounds each. An open belt conveyer and elevator carry the bone directly from the reactivating furnace to the covered filter charging hopper. Metal chutes lead directly from this hopper into filters which hold about 3,000 pounds of bone black. Upon completion of filtration the bone is washed with "Varsol", steamed for about 24 hours, washed with hot water, steamed for two hours more, and then dumped upon belt conveyers which carry it to the reactivating furnace which is gas fired. The bone goes through the furnace at a temperature of about 1100 degrees Fahrenheit and at the rate of about 250 pounds per hour. Bone black can be used over and over again. Three men one on each shift, with an average service credit of fifteen years, are engaged in this operation. Their period of exposure to dust is about one hour per shift. The greatest amount of dust produced results from the open conveyers, particularly in dumping the material from the furnace onto the conveyer belt. Samples taken during this operation had as high as 11,044,800 particles of ten microns or less in size per cubic foot. Considerable dust (14,273,280 particles per cubic foot) also arises from the open hatch of the filter charging hopper during filling. An eight-inch motor driven exhaust fan has been installed to suck back the dust from where the elevator buckets dump the reactivated bone into the chute to the charging hopper. The dust loss from this filtering operation is estimated to be about 1500 pounds per month.

Under the Konimeter Microscope about 65% of the dust particles of samples taken during the reactivation of bone black appear to be black, opaque, scot-like, and are five microns or less in size; 5% are rounded, semi-opaque, ten microns, or more in size. The angular crystalline and light grey particles which constitute about 30% are probably 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.

Considerable dust (as high as 18,124,800 particles of less than ten microns per cubic foot) results from tapping the blocks into place. Samples taken during the entire operation had an average concentration of 6,881,760 particles per cubic foot. About 90% of these dust particles were slightly angular, crystalline in appearance and above five microns or less in size (as seen under the Konimeter Microscope); 5% were rounded opaque, ten microns or more in size; and 5% were opaque scale-like, five microns or more in size. Samples taken while applying asbestos sponge felt to a 12" steam line had a dust concentration as high as 23,788,800 particles of ten microns or less in size per cubic foot. The average was 12,574,080 particles per cubic foot. These dust concentrations are considered too high for working without adequate protection.

INSULATING A 750-POUND CRACKING COIL ACCUMULATOR: 6" x 36" blocks of Johns-Manville "Fire Felt" are first applied and plastered with extra AA Rubberoid Asbestos Cement and waterproofed with Johns-Manville "Insulkote". The dustiness of handling these materials has been considerably reduced since the manufacturers began shipping the "Fire Felt" in cardboard cartons containing thirteen or twenty blocks, and the plaster in hundred-pound paper bags. Samples taken during this operation had an average dust concentration of 4,502,880 particles, ten microns or less in size per cubic foot. About 75% of these dust particles were slightly angular in appearance, five microns or less in size; 10% were scale-like; opaque; and 15% were rod-like and fibrous.

INSULATING TREATING PLANT ACID SUCTION LINE: Sections of "Sponge Felt Pipe Cover" are cut to fit pipe lengths with an ordinary carpenter's hand saw. This operation produces on an average 821,280 particles of dust, ten microns or less in size, per cubic foot. Under the Konimeter Microscope all of these particles are slightly angular, crystalline in appearance, and five microns or less in size. The blocks or sections of the pipe cover are held in place by wrapping #16 gauge galvanized wire about each one.

INSULATING CRACKING COIL HOT OIL LINES: All hot oil lines at cracking coils are insulated with 2" asbestos tubing (85% magnesia and 15% asbestos) held in place by fine copper wire. Sections of the tubing are cut to fit particular areas by means of an ordinary carpenter's hand saw. This produces 7,788,000 particles of dust, ten microns or less in size, per cubic foot. Under the microscope, 90% of these dust particles appeared to be rounded crystalline and about three microns or less in size. Each section of tubing is pounded into place with the open hand so that it fits snugly against the pipe, and then wired into position. The dust produced from both of these operations averages about 3,379,520 particles per cubic foot. Under the microscope, approximately 80% or 90% of the dust particles appear crystalline, more or less angular, and five microns or less in size; the remaining 10% or more are rounded in appearance, and over ten microns in size.

DISMANTLING OR REMOVING OLD INSULATION: As a general rule, the dismantling or removal of old insulation is a more dusty operation than the application of new insulation. The old insulation is chopped or cut with a hatchet or small hand-axe, and pried loose and pulled off with the hands. This produces dust concentrations as high as 5,890,560 particles, ten microns or less in size, per cubic foot. In dismantling an old cracking coil 4" tar line, the average dust concentration was 2,322,240 particles per cubic foot. In appearance these particles were clear crystalline, rather rounded, ~~and five~~ microns or less in size. No fibres were observed in any of the dust samples from dismantling operations. After a few weeks or months service, insulation on hot lines dries out and appears to disintegrate. This is probably due to the fact that such insulation is usually covered with a weather-proof material which prevents absorption of moisture from the air.

CRUSHING SCRAP ASBESTOS: Scrap asbestos insulation, usually the 85% magnesia type, is crushed in a belt-driven Williams crusher to pass through a screen with one-inch holes or slots, and is then mixed with new asbestos to make insulating plaster. This operation, which is a very dusty one, is performed by two men, with an average service credit of about twelve years. Goggles and MSA. "Comfo" or Willson Dust Respirators are worn. Considerable dust is produced in breaking up the scrap insulation by hand prior to crushing (10,195,200 particles, ten microns or less, per cubic foot), and also when feeding the crusher which is done by shovelling the broken-up pieces into the hopper and poking them down with a short wooden stick (14,839,680 particles per cubic foot). Dust counts as high as 27,527,040 particles per cubic foot were found in samples taken from over the hopper. These dust concentrations are dangerously high. About 95% of these particles are sharply angular, crystalline in appearance and five microns or less in size; 5% are opaque scale-like, six microns or more in size. Crushing scrap asbestos is not a steady routine operation, the exposure varying from eight hours a month to about twelve hours a week.

CRUSHING OLD CORK INSULATION: This operation is performed approximately twice a year and takes about twenty or thirty minutes. The insulation is crushed on a belt-driven Williams crusher, by the same men who crush the scrap asbestos. This crushed cork is used for insulating lines in the cold settling plant. The average amount of dust produced is 20,016,178 particles, ten microns or less in size per cubic foot. About 80% of the particles are slightly angular, crystalline, in appearance, and five microns or less in size; 20% are round, semi-opaque, ten microns or more. There are also a large number of very small black or dark grey specks.

## IV - GUNITING OPERATION

What is Gunite and How is it Applied? - Gunite is a mixture of approximately one part (one 94 pound bag) of Portland Cement and two parts (twelve scoop shovels) of clean sharp sand. The sand and cement are mixed dry, shoveled into the hopper of a Gunite machine, using water under about 40-pounds per square inch pressure and compressed air at thirty to ninety pounds per square inch. It is applied under pressure, as a semi-fluid, against the surface to be protected (usually process equipment, such as, cracking coil soaking drums and storage tanks). In practically every case where guniting is done, it follows immediately, after the sand blasting job used to clean the surace. In most cases, the work is performed by the same crew. The individual holding the gunite nozzle is provided with the same protection as is the operator of the sand blast nozzle, and the men tending the gunite machines are provided with respirators and are required to use them while actually handling the sand and cement. This involves mixing the materials and charging them into the machines (the two dustiest parts of a guniting job). Samples taken during these operations showed the following dust counts of particles ten microns or less in size:

| Operation | Particles per cu. ft. |
|---|---|
| Screening sand prior to mixing with cement.. | 2,493,160 |
| Mixing batch.............................. | 1,699,200 |
| Shoveling mix into hopper................. | 6,485,280 |

About 40% of the dust particles in samples taken while mixing the batch and filling the hopper were crystalline, quartz-like in appearance, and about five microns in size. The remainder were dark grey in color and below one micron in size. The dust particles in air coming out of the bottom manhole of a soaking drum being gunited averaged 528,640 particles per cubic foot, and were slightly angular, crystalline in appearance and four microns or less in size.

A gunite crew consists of six men. The average service credit of the men in the Crews studied was eight years. Two "nozzle-men" who "spell" each other every two or three hours apply the gunite. There is one man at the gunite machine, and three men screen the sand and mix it with cement. Only about 25% of their working time, or nine hours per week per man, is devoted to guniting.

Removal of Gunite Lining: Pneumatic chisels are used to remove gunite lining. Samples taken from inside a cracking coil tar separator during this operation had as high as 16,595,520 particles of dust, ten microns or less in size, per cubic foot, and an average of 10,804,080 particles per cubic foot. About 75% of these particles were rounded, angular, more or less opaque, in appearance, one micron or less in size, and 25% were angular, quartz-like, about ten microns or less in size. A chemical analysis of the gunite lining showed that it contained 68.2% free silica. Four men from the Plant Labor Department, with an average service of seven years, spend about twenty hours per week removing gunite linings from process equipment. An air syphon provides ventilation, and the men are required to use the goggles and respirators which are furnished them.

## V - WELDING AND CUTTING OPERATIONS

Welding has never been considered a dust-producing operation. However, our studies and those of others indicate that the use of the modern coated electrodes or rods produces a large amount of dust in addition to the fumes which are evolved. An electric arc is used for most of the welding around refineries. There are a number of welding jobs, however, for which oxy-acetylene is used. Oxy-acetylene is also used for practically all burning or cutting.

### A - WELDING OPERATIONS:

1. ELECTRIC ARC WELDING: Electric arc welding is used on all types of construction and repair work. The average service of the electric welders is about two years and most of them came from the Labor Department, having been developed into welders at the individual plants. They are exposed to particulate matter generated by the welding operation on an average of six hours per shift, nine shifts out of fourteen. This particulate matter is ordinarily referred to as "fumes or smokes". The particles when found have a much smaller size range than that of dust, such as silica. With some operations there may also be some dust present, but the product formed from volatilizing the metal and rod coatings is commonly termed a "fume". All welders are provided with approved hand shield or helmets equipped with #10 Noviweld lens. Welding in shops is done in canvas or wooden booths. A steam or air syphon is installed when any arc welding is done inside of closed vessels such as drums or towers.

What are Coated Electrodes? Coated electrodes are metal welding rods covered with a composition which prevents oxidation and permits the formation of stronger and more uniform welds.

What Do These Electrodes Contain and What Products Result From Their Use? In general, the coatings used in modern coated welding electrodes are patented or trade secrets, with special virtues attributed to each. Obviously, it is inadvisable to put into these coatings materials which might produce products harmful to man. Nevertheless, chemical analyses of both the coatings and their products indicate that the continual use of some of these rods might possibly lead to complications.

Most of the arc welding at our affiliated plants is done with #5 Fleetweld coated electrodes which come in two sizes (5/32" and 3/16") and with General Electric W-20 5/32" coated rods. Other rods sometimes used are #4 Stainweld $Ka_2S$ alloy welding rod, 5/32" Stainweld A rods for stainless steel, and Murex Nickel Steel coated rods. Among the constituents of some of these electrodes coatings are:

| Coated Electrode Brand | Per Cent. $SiO_2$ | Fluorine | Calcium Fluoride |
|---|---|---|---|
| "Fleetweld", Lincoln Electric Co. | 30.28 | - | - |
| "Murex", American Metal & Thermite Co. | 28.05 | - | - |
| "USS Cr-Ni 18-8", Amer. Steel & Wire Co. | 37.20 | - | 14.50 |
| "Stainweld", Lincoln Electric Co. | 12.101 | 21.20 | 43.50 |
| "Rezistal K-A-25", Crucible Steel Co. | 24.03 | 13.40 | present |

All of the above coatings also contain Iron Oxide ($Fe_2O_3$) Manganese Oxide, either $Mn_2O_3$ or MnO or both, and Aluminum Oxide ($Al_2O_3$), in varying percentages.

The composition of the fluxes or coatings used in G & E types W-20, W-22 and W-23 is not available, but it is known that they contain amounts of free silicates and free silica. According to determinations made by the General Electric Company, the maximum concentration of free silica on any of their electrodes under a particular set of conditions is 1,575,000 particles per cubic foot of air with W-20, 778,000 with W-22, and 1,093,000 with W-23 under other conditions the concentrations might be higher or lower than those given. The maximum permissible concentration as listed by the Metropolitan Life Insurance Company is 7,000,000 particles per cubic foot of air.

Coatings also contain cotton fiber, cellulose, or other organic pulp which creates fumes, but since we are only concerned with dust in this study all fume producing materials will receive no further consideration.

Welding corrosion-resisting steel with coated corrosion-resisting steel electrodes forms a slag, among the major constituents of which are:

| | "Stainweld" | USS CR-Ni 18-8 | "Rezistal" |
|---|---|---|---|
| Fluorine (F) | 11.4% | 6.6% | 14.9% |
| Silica ($SiO_2$) | 25.1% | 38.5% | 13.3% |
| Iron, Chromium and Manganese Oxides | 22.3% | 24.2% | 15.2% |
| Calcium Oxide (CaO) | 50.7% | 28.0% | 26.7% |

The major constituents of dusts separated from atmosphere by gravity and collected from the bottoms of welding chambers after welding corrosion-resisting steel plates with coated corrosion-resisting steel welding rods are:

| | "Stainweld" | USS CR-Ni 18-8 | "Rezistal" |
|---|---|---|---|
| Silica (SiO )........................ | 11.0%......... | 19.6% ........ | 10.0% |
| Calcium Fluoride (CaF )............. | 40.5%......... | 11.4%........ | 23.4% |
| Oxides of Iron, Aluminum and Nickel. | 30.2%......... | 52.1% ........ | 36.6% |

The following is an interesting comparison between the compositions of dust formed when using bare mild steel electrodes and when using coated electrodes for welding galvanized steel:

| Brand | Bare Electrodes | | Coated Electrodes | |
|---|---|---|---|---|
| | % ZnO | % $Fe_2O_3$ | % ZnO | % $Fe_2O_3$ |
| "Fleetweld" | 79.2 | 20.0 | 67.5 | 31.9 |
| "Wilson" | 62.6 | 60.5 | 78.8 | 21.5 |
| "Murex" | 60.5 | 40.0 | 72.0 | 28.0 |

Investigations have shown that there may be as much as a five per cent. variation in composition of dust produced by the same make and kind of electrode when used under constant conditions but by different operators.

Ferric oxide ($Fe_2O_3$) which emanates from all welding arcs, regardless of the type of coating, is disagreeable but not harmful. Concentrations of iron oxide of about ten milligrams per cubic meter are said to be entirely non-injurious to the respiratory organs.

Breathing the dense clouds of fumes of zinc oxide, formed when the zinc of the galvanized coating is boiled off by the heat of the welding arc, causes what is commonly known as "fume fever". This is evidenced by nausea followed by chills and unpleasant fever. The fume fever does no lasting harm except after prolonged exposure, and the effects are not cumulative. Ordinary ventilation. which is necessary in any welding operation, is considered adequate to prevent fume fever.

What Is The Amount And What Are The Characteristics of Dust Produced By The Various Electric Arc Welding Operations? There is a wide variation in the amount and character of dust produced by different types of rods on different materials under different operating conditions.

FUME, OR DUST PRODUCED BY ARC WELDING

| Material Being Welded | Electrode Used | Size of Electrode | Particles Per cu. ft. | Characteristics of Dust Particles. (Sizes and Percentages Estimated) |
|---|---|---|---|---|
| Rivets inside Cross Coil Drum. | G-E W-20 Coated | 5/32" | 20,050,560 | About 98% angular crystalline, 5 microns or less in size; 2% rounded semi-opaque, 10 microns or more in size. |
| Mild Steel Blanks Inside Booth. | G-E W-20 Coated | 5/32" | 14,839,680 | About 80% round black or reddish brown specks, 1 microns or less in size; 20% slightly angular crystalline, 10 microns or less but mostly about 5 microns and large number reddish brown specks too small and numerous to count. |

FUME OR DUST PRODUCED BY ARC WELDING (Continued)

| Material Being Welded | Electrode Used | Size of Electrode | Particles Per cu. ft. | Characteristics of Dust Particles. (Sizes and Percentages Estimated) |
|---|---|---|---|---|
| 1/4" Boiler Plate Inside Booth. | #5 Fleet-weld Coated | 5/32" | 11,441,280 | About 80% angular crystalline, 3 microns or less in size; 10% round semi-opaque, 10 microns or more in size; 10% opaque scale like, 10 microns or less in size. Countless number of minute particles, reddish brown smudge. |
| 1-1/4" Mild Steel Expansion Joint Inside Booth. | #5 Fleet-weld Coated | 3/16" | 19,861,793 | About 95% angular crystalline, 3 microns or less in size; 5% rounded semi-opaque, 10 microns or less. Countless number of particles reddish brown smudge. |
| 1/2" Rolled Steel (55,000# per sq. in. Tensile strength) Inside 6+Foot Dia. drum near head of closed end. | #5 Fleet-weld Coated | 3/16" | 2,265,600 | All particles 5 microns or less in size; about 10% angular semi-opaque. |
| Welding Flange on 4" Steel Line Pipe, Inside Booth. | Murex Coated | 3/32" | 2,756,480 | All particles 2 microns or less in size; slightly angular, glass-like; dark grey smudge. |
| 5/8" Boiler Plate Inside Booth. | #5 Fleet-weld Coated | 5/32" | 490,880 | About 75% round, metallic opaque, 5 microns in size; 25% semi-opaque, crystalline. Countless number of minute particles |
| Welding Rivets in Courtney Edge Inside Cracking Coil Soaking Drum. | #5 Fleet-weld Coated | 5/32" | 6,456,960 | About 90% sharply angular crystalline, about 1 micron or less in size; 10% rounded semi-opaque, 5 microns or more. Countless number of minute particles. |

FUME OR DUST PRODUCED BY ARC WELDING (Continued)

| Material Being Welded | Electrode Used | Size of Electrode | Particles Per cu. ft. | Characteristics of Dust Particles. (Sizes and Percentages Estimated) |
|---|---|---|---|---|
| 18-8 Stainless Steel Band at Top of Soaking Drum Manhead | Stainweld A Coated | 5/32" | 849,600 | About 60% slightly angular semi-opaque, 5 microns or less in size; 20% rounded, over 10 microns; 20% very glass-like, 10 microns or less. |
| 1/2" Boiler Plate to 6" Pipe Inside Booth. | G-E W20 Coated | 3/16" | 23,222,400 | About 80% semi-opaque, reddish brown rounded, crystalline, 5 microns or less; 20% round globules of metal 5 microns or more in size. Countless number of small particles. |
| 1/2" Boiler Plate to 6" Pipe Inside Booth. | Roebling Iron Rod | 5/32" | 26,592,480 | About 90% black opaque, 1 micron or less in size; 5% rounded metallic globular, 5 microns or less; 5% slightly angular, semi-opaque, crystalline, 3 microns or less. Countless number reddish brown particles. |
| Back Welding a Flange on 6" Standard Pipe in Outside Welding Shop. | Fleetweld #7 Coated | 5/32" | 362,496 | About 95% black opaque metallic, 2 microns or less; 5% angular crystalline, 5 microns or less. Countless number of reddish brown particles. |
| Back Welding a Flange on 6" Standard Pipe Inside Booth. | Fleetweld #7 Coated | 5/32" | 1,000,640 | About 95% black opaque metallic, 2 microns or less; 5% angular crystalline, 5 microns or less. Countless number of black particles. |
| Welding Rivets Inside Cracking Coil Vaporizer (Mild Steel Aluminum Coated). | Fleetweld #7 Coated | 5/32" | 6,253,056 | About 95% angular crystalline, 5 microns or less, mostly around 2 microns; 5% semi-opaque, round, 5 microns. Countless number of black particles. |

## FUME OR DUST PRODUCED BY ARC WELDING (Continued)

| Material Being Welded | Electrode Used | Size of Electrode | Particles Per cu. ft. | Characteristics of Dust Particles. (Sizes and Percentages Estimated) |
|---|---|---|---|---|
| Welding 2" Ring on 1" Mild Steel Boiler Plate Inside Booth. | Fleetweld #7 Coated | 3/16" | 27,662,976 | All particles less than 2 microns. 70% round, opaque; 30% slightly angular, crystalline. Countless number of black particles, reddish brown smudge. |
| Mild Steel Scrap Plates Inside Booth. | Stainweld A Coated | 5/32" | 2,605,440 | All particles black opaque, 2 microns or less in size. |
| $Ka_2S$ Steel Inside Booth. | Stainweld A Coated | 5/32" | 12,460,800 | About 80% angular opaque, 2 microns or less; 20% slightly angular crystalline, 5 microns or less. Countless number black particles, brownish grey smudge. |

The U.S. Navy recently conducted some extensive tests with coated electrodes, and found that the quantity of dust or fumes developed while welding on galvanized steel plate was greater than when bare steel plates were used and the dust remained in suspension for far longer periods of time. It was also found that the average size of the dust particles was 0.27 microns and that there were 130,000 particles under four microns diameter per cubic centimeter. Quoting the Navy report:

"It is apparent that considerable quantities of dust are found in any arc welding operation. The dust formed when operating on plain mild steel or corrosion resisting steel is largely derived from the flux coating on the electrodes, as is shown by the composition of these dusts".

__What Physiological Effect on Welders is Produced by The Use of Coated Electrodes.__ According to a study made by Doctors A.T. Doig and A.P.G. McLaughlin on lungs of Electric Arc Welders (Lancet - V.20; 771 - 775 (April 4, 1936)), definite pulmonary lesions which gave rise to striking X-ray changes in the appearance of the lungs were found in welders which had breathed the dust or fume from coated electrodes. Quoting Doctors Doig and McLaughlin:

"The electrodes or welding rods which contain a core of metal and an outer covering are consumed gradually by the heat generated (about 1500°C.) during the welding operation. The metal in the core of the rod becomes molten and, assisted by the flux contained in the covering, spreads over the surface of the metal which is being welded. The fume is therefore made up of the volatilized constituents of the coverings of the rods together with fine particles of oxidized metal, usually in the form of iron oxides. In addition the fumes probably contain gases such as nitrogen peroxide and ozone which are formed by the action of an electric spark on the air. The composition of the coverings of the electrodes or welding rods becomes, in the circumstances, a matter of some importance. Many substances, all of which we do not propose to enumerate, are used. The basis of the majority of the coverings is sodium silicate which acts as a flux. Again, the coverings of a certain type of electrode contain asbestos. The rods are sometimes dipped in a mixture containing powdered asbestos and sodium silicate, or asbestos yarn is wound round the rod and fixed by sodium silicate. In some cases the asbestos completely covers the rods, and in others it is merely a cord which is wound spirally about the rod.

"The composition of the fumes arising from electric welding electrodes has not yet been fully investigated. Mr. L.C. McNair, H.M. Engineering Inspector of Factories, has however had partial analysis made of the fumes evolved from an asbestos-covered electrode and some asbestos fibres were found. When the particulate matter of the fumes was collected in an Owen's dust-counter, it was seen that a large proportion consisted of iron oxide particles, with an occasional asbestos fibre.

"The X-ray appearances in the well-marked cases differ from the usual picture of asbestosis. In none of the positive cases and in only one of the suspicious cases was there any blurring of the diaphragmatic shadow, and in no case was the heart outlined blurred. The line of the interlobar septum (a feature present in a number of films of cases of asbestosis) is seen in only one positive case. The opacities in the films are not accentuated at the bases of the lungs, but on the contrary the upper lung fields appear to be the earliest, and in established cases, most markedly affected. Before asbestosis can be eliminated from the differential diagnosis it must be remembered that the asbestos fibres are being subjected to intense heat and are not in the same physical state as the fibres which are inhaled by workers in an asbestos factory. It is possible that a typical picture of asbestosis might be produced by the inhalation of altered asbestos. Merewether says that - 'the radiographic appearances of the developed or advanced states of asbestosis are distinctive, although they are not specific. While, as is the case with silicosis, certain radiographic appearances may be looked upon as typical of the disease, frequently modifications of and departure from the typical picture occur'. The X-ray appearances in our cases most closely resemble those of a fine silicosis, but the clinical features show two important differences. In the first place, the electric welders whom we examined are all in good health and are fit to work. The only symptoms observed were slight cough and morning expectoration, and in the first case a small haemoptysis occurred. This man has not been away from work even for a day since he was first seen in June, 1933, and his health at the present time is good. None of the men suffers from dyspnaea. Secondly none of them has concomitant pulmonary tuberculosis.

"Miliary tuberculosis can be ruled out of the differential diagnosis for clinical reasons, and to some extent on the radiological appearances. None of the cases shows the dyspnaea, cyanosis, and tachycardia of acute or subacute miliary tuberculosis. Chronic or healed miliary tuberculosis is rare and it is difficult to imagine that a condition of such rarity would be found in 6 out of one group of 16 men. In the X-ray films of the welders' chests the fine opacities are irregular in size and shape, whereas in miliary tuberculosis of the lung the shadows are more uniform.

"A further possible explanation of the X-ray appearances in this series of cases is that the inhalation of small quantities of nitrous fumes together with the superadded effect of fine iron oxide dust might set up small areas of chronic inflammatory change, congestion, or fibrosis in the lungs. Again, the iron oxide particles might be opaque to the X-rays and produce the picture without the associated presence of fibrosis and congestion."

2. OXY-ACETYLENE WELDING: Oxy-acetylene welding is more or less confined to small repair jobs or to certain emergency operations where arc welding is not available or practical. Exposure of men doing welding is more or less irregular. They usually wear American Optical Company or Willson Welding Goggles with #4 Noviweld lens. The amount of dust produced by oxy-acetylene welding is considerably less than that caused by the use of coated electrodes in arc welding, and varies considerably with the style tip and welding rod being used as well as the material welded, as is shown by the following table:

DUST PRODUCED BY OXY-ACETYLENE WELDING

| Material Being Welded | Welding Rod | Tip Used | Particles Per Cu. Ft. | Characteristics of Dust Particles (Sizes and Percentages Estimated) |
|---|---|---|---|---|
| Galvanized Metal Hood Welding Shop. | Norway 5/32" | Airco #4 | 396,480 | About 70% slightly angular, semi-opaque, greyish, 5 microns or less; 20% rounded semi-opaque, greyish crystalline, 10 microns or more; 10% amorphous, scale-like; 10 microns or more in size. |
| 1/4" x 2" Bar Iron, Welding Shop. | Oxweld copperized steel 3/16" | Airco #8 | 509,760 | About 80% black opaque, 1 micron or less in size; about 20% rounded, crystalline; 5 microns or less in size. |
| 1/2" Boiler Plate, Soft Steel, Welding Shop. | Oxweld copperized steel 1/8" | Oxweld #6 | 1,019,520 | About 80% round, semi-opaque, 5 microns or less in size; 10% angular crystalline. Countless number of small black particles. |
| 1/8" Galvanized Sheet Iron, Welding Shop. | Oxweld copperized steel, 1/8" | Oxweld #6 | 1,359,360 | About 80% rounded, semi-opaque, dark grey, 1 micron or less in size; 10% slightly angular crystalline, 3 microns or less; 10% sharply angular crystalline, 5 microns or less; countless number of small dark grey particles. |
| Welding Teeth on Band Saw. | Simmons Saw Welding Rod. 3/64" | Aeroplane #2 | 1,472,640 | About 98% round black opaque, about 1 micron or less in size; 2% slightly angular, crystalline, 3 microns or less in size. |

B - BURNING OR CUTTING OPERATIONS:

1. WITH OXY-ACETYLENE: The oxy-acetylene torch is used both in the construction

and the demolition of process equipment and works structures. It also plays an important part in emergency and rescue work. Goggles with shade #5 Noviweld lens are provided and their use is required. At the larger plants men with an average service credit of six years spend about ~~three~~-fourths of their working time on cutting or burning operations (about half their time is given to "burning steel" for new construction). The amount of dust produced is usually greater than that caused by oxy-acetylene welding.

DUST PRODUCED BY OXY-ACETYLENE BURNING

| Material Being Burned | Tip Used | Particles per cu. ft. | Characteristics of Dust Particles (Sizes and Percentages Estimated) |
|---|---|---|---|
| Burning 6" Flues (1-1/2" thick) Out of Shell Still. | Oxweld #2 | 1,869,120 | About 75% round black, 2 microns or less in size; 20% slightly angular, crystalline, 2 microns or less; 5% opaque, scale-like, various sizes. |
| 1/2" Boiler Plate (soft steel) | Oxweld #4 | 2,718,720 | About 90% semi-opaque, black, 2 microns or less 10% round, dark grey, over 5 microns in size. |

2. WITH NATURAL GAS: A large part of the burning or cutting at one of the larger southern refineries is done with oxygen and natural gas (60 pounds per square inch pressure). A special torch with a 1/16" x 5/16" tip made in the refinery shops is used. Two men with an average service of thirteen years spend a major portion of their working time on this natural gas. They wear goggles with #5 shade Noviweld lens. Samples taken while burning holes in 3" standard pipe in the yard outside of welding shop with oxygen and natural gas had a concentration of 471,811 particles, ten microns or less in size, per cubic foot. About 75% of these particles were slightly angular crystalline in appearance under the Konimeter microscope, and were five microns or less in size; 25% were rough scale-like, opaque, ten microns or less in size. There were also many minute particles.

- HEALTH HAZARDS PRODUCED BY WELDING AND BURNING OPERATIONS: Although our study was confined to the fumes or dust produced by Welding and Cutting operation the possibility of lead poisoning from welding or cutting iron plates that have been previously coated with red lead should be pointed out. Lead poisoning from this source is rather common, especially in cutting up old scrap, bridges, tanks, and other iron structures that have through many years of use received protective coatings of red lead. The action of the flame volatilizes this lead material and creates a smoke that is poisonous. The same hazard exists in cutting out rivets in new structures.

It should also be pointed out that some of the welding rods contain manganese which is very poisonous when taken into the body. There is an apparent hazard from volatilizing this material, or rather changing it to the oxide of manganese, and breathing the fumes produced. There are further dangers from carbon monoxide and oxygen deficiency owing to the use of gas-cutting or welding flames inside small tanks or similar confined spaces.

It is becoming more and more recognized that persons engaged in cutting and welding operations, either by arc or flame, should have respiratory protection, in all work where there is a possibility of the workmen breathing fumes and dusts created.

## VI - GRINDING OPERATIONS

Power grinders are perhaps the most universally used ~~of the~~ small power-driven tools. The usual power grinder, commonly known as the emery wheel, consists of a cast metal stand and two abrasive wheels mounted on a through shaft which is either belt or motor driven. There are also several grinding wheels, such as are found on machine tool equipment where grinding takes the place of lathe and planer work. All grinding operations produce dust to a greater or lesser degree, depending on the composition and construction of the wheel, the material being ground and the ventilation or exhaust hoods provided.

<u>What is the Composition of Grinding Wheels?</u> Grinding wheels are made of either bauxite which is mined, or silicon carbide which is made by heating a mixture of quartz sand, coke and common salt in an electric furnace. The bauxite or silicon carbide are crushed to the desired grain size, mixed with an adhesive substance called a bond, and formed into wheels, discs, cones or cylinders. There are many wheels in which the binder is shellac, rubber, bakelite and other organic compounds. Bauxite wheels are known in the shop as "Alundum" and "Aloxite", while silicon carbide wheels are known as "Crystolon" and "Carborundum". Alundum wheels should be used on material of low tensile strengths such as cast iron, brass, aluminum, copper and marble.

<u>Is Abrasive Dust Harmful?</u> According to Dr. W. Irving Clark in a paper read at a meeting of Government Officials in Industry (Boston - May 21, 1931) the artificial abrasives, aluminum oxide and silicon carbide do not contain free silica and their dust cannot produce silicosis. The dust, like any other inorganic dust, can, however, if breathed for a long period of time in large quantities, produce an X-ray picture similar to that of early silicosis. This picture changes very slightly as years of exposure increase, and at no time are the nodules, characteristic of silicosis, evident. Unlike silicosis, there is no progress in the process after exposure ceases and there appears to be no marked physical disability. Although there is no silicosis, the X-rays do show signs of pneumoconiosis.

Carborundum dust, chemically, is silicon carbide. According to Miller and Sayers (U.S. Pub. Health Rep. Vol. 49 #3 of Jan. 19, 1934) carborundum dust when injected into the peritoneal cavity of guinea pigs produced no reaction and was termed "inert". Dusts such as quartz and flint - silicosis producing dusts - produced a proliferative reaction.

Leroy U. Gardner (U.S. Pub. Health Rep. Vol. 50 #21 of May 24, 1935) reports that carborundum produces practically no reaction when inhaled by guinea pigs in high concentrations over a period of time. Quoting from Dr. Gardner's article, the part pertaining to carborundum dust:

> "The dust which does reach the tracheobronchial lymph nodes apparently lacks the proper physiochemical properties to stimulate any but a very slight proliferation of connective tissue. In the lungs, there is practically no fibrosis."

The Journal of the American Medical Association (Notes and Queries 103, 1472, 1934) makes this statement regarding the health hazard of breathing dust from artificial abrasives:

> "Only silica ($SiO_2$) is capable of inducing silicosis, but any other mineral dust under conditions of prolonged and gross exposure may cause some increase in pulmonary fibrosis. If the relative potential harm of silica is rated as 100, these other non-toxic mineral dusts may be rated

only on the order of 5 or 10."

Despite this comparatively low rating of harmfulness of these dusts it is generally considered advisable to use dust hoods and exhausts wherever practical as there is clinical evidence that workers exposed to heavy concentrations of dust of any kind are more liable to develop diseases affecting the nose, throat and chest during the winter months than those not exposed to dust. Dr. Clark believes that an effort should be made to keep the dust count below twenty million particles of less than ten microns per cubic foot of air.

1. <u>What are the More Frequently Used Types of Grinders, the Quantity and Character of the Dust They Produce?</u> The grinders most commonly found in the refineries and associated activities are:

A - TANDEM FLOOR TOOL GRINDERS: Tandem floor tool grinders, the most frequently used type, are in most cases motor-driven and operate at a speed of from 1450 to 1850 RPM. The type of wheel or grinding media selected depends upon the material to be ground. Generally speaking, the wheels found in most of the machine shops and wood working shops around our refineries used:

1-1/2" x 10" Norton Alundum (Grade P, Grit 46) wheels for sharpening tools and for general service grinding.

1-1/2" to 3" x 14" Carborundum wheels for miscellaneous grinding.

3" x 16" Carborundum (Grit 30, Grade K) wheels for grinding lathe and other machine tools.

Sometimes two different wheels are used on tandem tool grinders; for example, a 2" x 14" grain 24, grade Q Norton Alundum vitrified wheel on one side and a 2" x 14" grain 44, grade M Alundum wheel on the other side.

The amount of dust produced by the operation of tandem tool grinders depends primarily upon the composition of the wheel and the hardness and character of the object being ground. Theoretically, the operating speed and the pressure should also be determining factors, but these were not studied. The following are average dust counts of particles ten microns or less per cubic foot in samples taken in the breathing zone of the person using the grinder during the grinding of various objects on various wheels of tandem floor grinders:

| Operation | Particles per cubic foot |
|---|---|
| Grinding Cast Iron on 2" x 12" Aloxite (46M Grit) Wheel......... | 11,648,960 |
| " a Steel Sleeve on a 1/2" x 10" Carborundum Wheel....... | 8,127,840 |
| " " Hard Steel Chisel on a 5/8" x 8-1/2" Alundum Wheel... | 7,476,480 |
| " " " " " " " 1/2" x 10" Carborundum Wheel.. | 1,670,880 |
| " " " " " " " 3/4" x 10" " " .. | 906,240 |
| " " Pneumatic Tool Steel Chisel on a 3-1/2" x 14" Norton Alundum (3836 - 0.5B) Wheel.......................... | 1,869,120 |
| " " Chisel Bar on the same wheel (3836 - 0.5B Alumdum)... | 4,134,720 |
| " " Tool Steel Chisel on a 1" x 10" Carborundum (Grain 46M) Wheel.......................................... | 2,594,112 |
| " Tool Steel on a 2" x 14" Alundum (24 grain, grade Q) Wheel | 396,480 |
| " " " " " " " (44 " " M) " | 1,019.520 |
| " a Lathe Tool on a 1/2" x 12" " (Grade P) Wheel....... | 339,840 |
| " " " " " " " " ( " R) " ....... | 1,331,040 |

| Operation (Continued) | Particles per cubic foot |
|---|---|
| Grinding a Lathe Tool on a 3" x 16" Carborundum (grit 30, grade K) Wheel....... | 362,496 |
| " Mild Steel on a 1-1/2" x 10" Alundum Wheel............. | 6,655,200 |
| " Steel Dies on a 3" x 14" Carborundum Wheel............. | 56,640 |
| " Squaring Shear Blades on a 1-1/2" x 16" Carborundum Wheel. | 2,577,120 |

Dust Produced By Operation of Tandem Floor Grinders. As would be expected, there is a wide variation in the appearance of the dust particles under the Konimeter microscope. These examples however. will give an idea of the characteristics of the dust produced during the operation of Tandem Floor Grinders:

| Material Being Ground | Size of Wheel | Type of Wheel | Characteristics of Dust Particles. (Sizes and Percentages Estimated) |
|---|---|---|---|
| 1" x 3" Mild Steel Bar | 1-1/2" x 10" | Alundum (Grit 46, Grade P) | About 70% angular crystalline, 5 microns or less in size; 30% metallic shreds; 10% white opaque, slightly angular, over 10 microns; many small black specks. |
| Tool Steel | 2" x 14" | Alundum vitrified (Grit 44, Grade M) | About 90% angular crystalline, 2 microns or less in size; 10% opaque, 1 micron or less in size. |
| Tool Steel (Same material as above) | 2" x 14" | Alundum vitrified (Grit 24, Grade Q) | About 60% round, semi-opaque, 10 microns or less in size; 40% angular opaque, 5 microns or less in size. |
| Lathe Tool | 3" x 16" | Carborundum (Grit 30 Grade K) | About 75% round, crystalline, 5 microns in size; 25% slightly angular. |
| Chisel Bar | 2-1/2 x 14" | Alundum (3836-0.5B) | About 70% slightly angular, 3 microns in size; 30% black, opaque, metallic. |
| Pneumatic Hand Tool Steel Chisel | 2-1/2" x 14" | Alundum (3836-0.5B) | About 98% round, black. opaque, one micron or less in size. |
| Lathe Tool | 1-1/2" x 12" | Alundum (Grade P) | About 50% angular crystalline, 2 microns or less in size; 50% round, black, metallic, 1 micron or less in size. |
| Lathe Tocl (Same as above) | 1-1/2" x 12" | Alundum (Grade R) | About 75% angular crystalline, 2 microns or less in size; 25% round, black, metallic, 1 micron or less in size. |

DUST PRODUCED BY TANDEM FLOOR GRINDERS (Concluded)

| Material Being Ground | Size of Wheel | Type of Wheel | Characteristics of Dust Particles. (Sizes and Percentages Estimated) |
|---|---|---|---|
| Cast Iron | 2" x 12" | Aloxite (Grit 46, Grade M) | About 85% sharply angular, crystalline, 5 microns or less; 10% rounded angular crystalline, over 10 microns; 5% opaque scale-like metallic, 10 microns or less; large number of black metallic specks. |

Where "hard" wheels are used for grinding soft cast steel, about 98% of the dust particles are metallic and less than one-half micron in size.

With the exception of a very small number of men who devote about 95% of their working time to actual grinding, there is a very wide variation in the number of men exposed and the length of such exposure to dust produced by the operation of tandem floor tool grinders. In only one case was a respirator worn. Goggles have been provided and their use required in most cases.

B - TANDEM BENCH GRINDERS: These grinders are small in size and are used for sharpening small tools and light grinding. They are all motor driven and operate at about 3400 R.P.M. Different grade wheels are used, usually 1-1/8" x 8" Carborundum (Grain #80) on one side, and on the other a 1" x 8" Carborundum (Grain #90). The amount of dust produced by the operation of tandem bench grinders varies with the material being ground and the composition of the wheel, but these average dust counts are fairly representative:

| Operation | Particles per cu. ft. |
|---|---|
| Grinding Cold Chisel on 1-1/8" Grain #80 Carborundum Wheel.... | 5,909,440 |
| " " " " 1" x 8" " #90 " " .... | 8,401,600 |
| " 1/2" Boiler Plate on 1" x 8" #90 " " .... | 12,460,800 |
| " Hard Steel Chisel on 5/8" x 8-1/2" Alundum (Grain 46, Grade P)......................... | 7,476,480 |

Dust particles in samples taken during the operation of the tandem bench grinder have the following characteristics:

| Material Being Ground | Size of Wheel | Type of Wheel | Characteristics of Dust Particles. (Sizes and Percentages Estimated) |
|---|---|---|---|
| Medium Steel Cold Chisel | 1-1/2"x8" | Carborundum (#80 Grain) | About 75% slightly angular crystalline, 5 microns or less in size; 20% round opaque, metallic, one micron or less; 5% semi-opaque, over 10 microns and look like chips of glass. |
| Medium Steel Cold Chisel (Same tool as Above) | 1" x 8" | Carborundum (#90 Grain) | About 80% round opaque, 2 microns or less in size; 20% slightly angular crystalline, 5 microns or less in size. |

DUST PRODUCED BY TANDEM BENCH GRINDERS (Concluded)

| Material Being Ground | Size of Wheel | Type of Wheel | Characteristics of Dust Particles. (Sizes and Percentages Estimated) |
|---|---|---|---|
| 1/2" Soft Steel Boiler Plate (Taking off rough edges) | 1" x 8" | Carborundum (#90 Grain) | About 90% round, black, metallic, 2 microns or less in size; 10% slightly angular crystalline, 5 microns or less in size. |
| Hard Steel Chisel | 5/8" x 8-1/2" | Alundum (Grain 46, Grade P) | About 85% round, black opaque, 2 microns or less in size; 15% rounded crystalline, 10 microns or over. |

C - SINGLE FLOOR TOOL GRINDERS: There are only a few single floor grinders in use. They range in size from 1" x 10" motor-driven (1750 RPM) to 2-1/2" x 20" belt-driven (1250 RPM). The larger size is used for heavy grinding such as blanks and large tools; the smaller sizes for sharpening tools and miscellaneous grinding. The wheel on the large grinder is Carborundum (#9C Grain). For the smaller size class Grain 46, Grade M Carborundum wheels are used on the 1" x 10" and Grain 24, Grade Q Alundum wheels in the 1-1/2" x 14" size. Samples taken during the operation of Single Floor Grinders had dust counts as follows:

| Operation | Particles per cu. ft. |
|---|---|
| Grinding Tool Steel on 1-1/2" x 14" Alundum Wheel (Grain 24, Grade Q)................ | 679,680 |
| " Chisel on 1" x 10" Carborundum Wheel (Grain 46, Grade M)................ | 2,594,112 |
| " 1/2" x 4" Mild Steel Bar on 2-1/2 x 20" Carborundum Wheel (Grain 90)........ | 4,451,904 |

The hoods which almost completely enclose these wheels act as practical dust collectors.

Dust particles produced by the foregoing grinding had these characteristics when examined under the Konimeter microscope:

| Material Being Ground | Size of Wheel | Type of Wheel | Charecteristics of Dust Particles. (Sizes and Percentages Estimated) |
|---|---|---|---|
| Hard Steel Tool Bit | 1-1/2" x 14" | Alundum (Grain 24, Grade Q) | All particles were 2 microns or less in size. About 60% were angular crystalline; 40% were rounded opaque. |
| 1/4" x 2" Mild Steel Bar | 1" x 10" | Carborundum (Grain 46, Grade M) | About 98% were black opaque, 2 microns or less in size; 2% slightly angular, 5 microns or less in size. |
| 1/2"x4" Mild Steel Bar | 2-1/2"x20" | Carborundum (Grain 90) | About 85% were slightly angular crystalline, 5 microns or less in size; about 15% black semi-opaque, angular metallic, 2 microns or less in size. |

D - UNIVERSAL GRINDERS: As the name would indicate, universal grinders are used for a wide variety of purposes and therefore are in more continuous operation than are the other grinders, with the exception of the tandem floor tool grinders. There are two types or makes, the Brown & Sharpe Universal Grinder which has an operating speed of 3750 RPM. and the Grand Rapids Universal Grinder which operates at about 3850 RPM. The following abrasive wheels are used:

1/2" x 5" Norton Co. 3846 J 5B Alundum wheel for grinding hardened carbon tool steel.

1/2" x 7" Norton Co. 3846 I 8B Alundum wheel for grinding high speed tool steel.

2" x 3-1/2" Carborundum Co. grit 401-P-25, type 12 Aloxite wheel for grinding case hardened steel.

1/4" x 10" Carborundum Co. wheel used for cutting.

1" x 10" " " " " " sharpening tools, reamers, dies and drill bits.

Samples taken during the operation of the various Universal grinders had dust counts as follows:

| Operation | Particles per cu. ft. |
|---|---|
| Dressing 1/2" x 7" Alundum (3846 I 8B) Wheel with a "Diamond Point"........................................ | 1,397,120 |
| (Evidently the clouds of dust which come off during dressing have particled larger than 30 microns) | |
| Grinding High Speed Tool Steel on 1/2" x 7" Alundum Wheel (3846 I 8B)........................... | 1,846,464 |
| " Hardened Carbon Tool Steel on 1/2" x 5" Alundum Wheel .(3846 J 5B)........................... | 6,683,520 |
| " Case Hardened Steel on 2" x 3-1/2" Aloxite (Grit 401 - P - 25 Type 2)............. | 84,960 |
| Cutting off Tool Steel with 1/4" x 10" Carborundum Wheel.... | 1,416,000 |

Dust particles in samples taken during the operation of Universal grinders have these characteristics:

| Material Being Ground | Size of Wheel | Type of Wheel | Characteristics of Dust Particles (Sizes and Percentages Estimated) |
|---|---|---|---|
| Dressing Wheel With a "Diamond Point" | 1/2" x 7" | Alundum (3846 I 8B) | About 80% slightly angular crystalline. About 3 microns in size; 20% black opaque, round, about 1 micron or less in size. |
| High Speed Tool Steel (a Landis Pipe Chaser) | 1/2" x 7" | Alundum (3846 I 8B) | About 60% opaque angular, about 2 microns or less in size; 40% slightly angular, crystalline, 5 microns or over in size. |

Dust particles in samples taken during the operation of Universal grinders have these characteristics (Continued):

| Material Being Ground | Size of Wheel | Type of Wheel | Characteristics of Dust Particles. (Sizes and Percentages Estimated) |
|---|---|---|---|
| Hardened Carbonated Steel (Pipe Grip for Pipe Machine) | 1/2" x 5" | Alundum (3846 J 5B) | About 30% angular crystalline, about 2 microns or less in size; 70% round black opaque, less than 1 micron in size. Numerous black specks too small to count. Several large oblong black opaque particles about 20 microns wide and 35 or 40 microns long. |
| Case Hardened Steel (Plungers for Filling Machine) | 2" x 3-1/2" | Aloxite (Grit 401-P-25 Type 12) | All particles black opaque, 1 micron or less in size. |

E - SURFACE GRINDERS: Surface grinders are used almost exclusively on valves and dies. They are equipped with either 1/2" x 8" Norton Alundum (1946H) wheels or 1/2" x 4" to 6" Carborundum (Aloxite) wheels. No dust collectors are provided, the dust being thrown out into the atmosphere. Samples taken during the operation of surface grinders had the following dust concentration (10 microns or less):

| Operation | Particles per cu. ft. |
|---|---|
| Grinding Soft Cast Steel Valve on 1/2" x 6" Carborundum Aloxite Wheel........................ | 566,400 |
| " Tool Steel Die on 1/2" x 8" Alundum (1946H) Wheel.................................. | 1,019,520 |
| Dressing Surface of 1/2" x 8" Alundum Wheel with a "Diamond Point"................................ | 1,132,800 |

About 70% of the particles from grinding the steel die were metallic, 3 microns or less, whereas 98% of the particles from grinding the soft steel valve were metallic. Many of the particles were too small to identify or count accurately.

F - LANDIS TOOL GRINDERS: Landis tool grinders are usually equipped with two different types of wheels, one for side grinding and the other the ordinary type. 1-1/2" x 12" Carborundum Aloxite (Grit 40, Grade H, Bond 33) is used for general purpose grinding such as bull chisels, diamond points, cold chisels, flanges and scrappers. The Side Grinding Type is usually a 2-1/2" x 1-1/2" x 12" Grit 46A-P P678 Aloxite brand AA wheel used for grinding Landis dies. At one plant the wheels of the Landis tool grinder are enclosed by hoods at the rear of each of which is attached a two-inch pipe connected to a three-inch pipe which discharges into a sewer. Suction is induced by a stream of compressed air from a half-inch pipe inserted in the two-inch pipe just back of the hand. This arrangement acts as a syphon and pulls the dust away from the person using the grinder. Samples taken during the operation of Landis tool grinders had dust concentrations as follows:

| Operation | Particles per cu. ft. |
|---|---|
| Dressing 1-1/2" x 12" Aloxite Wheel (Grit 40, Grade H, Bond 33)................ | 226,560 |
| (Evidently particles in the cloud of dust thrown off by the 2-1/2" x 6" Metcalf Emery Wheel Dresser are larger than 30 microns in size) | |
| Grinding "Diamond Point" Chisel on 1-1/2" x 12" Aloxite Wheel (Grit 40, Grade H)........................................ | 2,067,360 |
| Grinding 2-1/2" x 6" Landis die on 2-1/2" x 1-1/2" x 12" Aloxite Wheel (Grit 46A-P P678)............................ | 755,203 |

Under the Konimeter microscope dust particles in samples taken while dressing the 1-1/2" x 12" Aloxite Wheel appeared slightly angular with a yellowish tinge and were five microns or less in size. About 75% of the particles from grinding the Landis die were round, opaque, and less than 1 micron in size; 25% were slightly angular crystalline, less than 2 microns. Particles from grinding the diamond point chisel were less quartz-like than those from grinding the die. This difference is, of course, due to difference in the composition of the two wheels. On an average, Landis tool grinders are used about twenty hours a week, usually by different men.

G - YANKEE DRILL GRINDER: Used for grinding all types of drill bits. Has a side grinding type 1" x 1-1/2" x 9" Carborundum Aloxite (Grit 30, Grade M, Bond 28) Wheel. Operating speed 1735 RPM. On an average a Yankee Drill Grinder runs about three hours a day and is used by four different men with an average service of twelve years.

Samples taken during the grinding of a 2-5/16" high speed drill had an average of 1,000,829 particles, ten microns or less, per cubic foot. About 70% of these dust particles are slightly crystalline in appearance, five microns or less in size; 30% were rounded, semi-opaque, over ten microns in size. There were also a few small metallic shreds. No exhaust or dust collector is used in this grinding.

H - AUTOMATIC CIRCULAR SAW SHARPENING MACHINE: There are a number of these grinders in use in the wood working operations - such as in the production of wooden barrels, boxes and crates - closely associated with the refining of petroleum products. Since they are automatic when once put in operation, there is very little dust hazard except where no exhaust or dust collectors have been installed and the dust produced is thrown into the filing room atmosphere. Automatic Circular Saw Sharpening Machines are equipped with 1/4" x 8" Norton Alundum Wheels (Grain 60, Grade N), 3/8" x 8" Norton Alundum (1946 M) wheels, or 1/2" x 6" Carborundum wheels. The average dust produced during operation of these machines is:

| Wheel | Particles per cu. ft. |
|---|---|
| 1/2" x 6" Carborundum.................................. | 1,923,280 |
| 1/4" x 12" " ........................................ | 3,568,320 |
| 3/8" x 8" Alundum (1946M)................................ | 2,095,680 |
| 1/4" x 8" " (Grain 60, Grade N)......................... | 1,461,312 |

About 98% of dust particles in samples taken while sharpening circular saws on the Carborundum wheels were black metallic in appearance, and one micron or less in size. About 75% of the particles from the Alundum wheels were rounded crystalline, 5 microns or under in size, and 25% round black metallic, about one micron or less in size. There were a number of small metallic shreds in the samples from the thicker (3/8" x 8") wheel.

I - AUTOMATIC BAND SAW GRINDER: After the Band Saw has been inserted and the machine adjusted, this grinder works automatically. The wheel ordinarily used is a 1/2" x 8" Grain 50, Grade N Norton Company Alundum. The wheel is refaced or dressed with a Metcalf Emery Wheel Dresser about twice a day. The average dust produced by this dressing operation is 2,284,480 particles less than ten microns per cubic foot. About 95% of these dust particles are sharply angular crystalline in appearance under the Konimeter microscope, and about five microns or less in size. The dust produced during the sharpening or grinding of the band saw blade is on an average only 877,920 particles per cubic foot. About 50% of these particles appear angular crystalline and about 50% round black opaque. All of them are about two microns or less in size.

J - AUTOMATIC BAND SAW LAP GRINDER: Used to grind ends of band saw preparatory to welding them together. The grinding wheel usually used is 5/8" x 10" Grain 46, Grade M, Norton Company Alundum. No dust collector is provided although a dust count as high as 16,142,400 particles, ten microns or less, was found in one sample taken in front of the wheel while it was in operation. The average dust produced by this lap grinder was 4,984,320 particles per cubic foot. About 80% of these dust particles were semi-opaque, slightly angular in appearance, and two microns or less in size; 20% were black opaque, about one micron or less in size.

K - PLANING KNIFE BLADE GRINDER: Uses a 1/2" x 8" Grain 46, Grade N, Norton Company Alundum wheel. Operating speed 3000 RPM. No hood or any other protection. Average dust produced while sharpening a Planer Knife Blade was 566,400 particles, ten microns or less per cubic foot. About 60% of these dust particles were slightly angular crystalline in appearance and about two microns or less in size; 40% were opaque of various sizes from about seven microns or less. There were a few small metallic shreds.

L - LINDERMAN CUTTER GRINDER: Sharpens cutters from the Linderman machine for tongueing and grooving. Grinder uses a 1/2" x 6" Norton Alundum (Grain 60, Grade N) cup wheel. Operating speed 3000 RPM. There is a hood guard over the top of the grinding wheel, but no exhaust or dust collector, although dust counts as high as 14,386,560 particles, ten microns or less, were found at the front of the grinder in operation, and 12,574,080 particles per cubic foot in the back. The average dust produced was 9,137,920 particles per cubic foot. About 70% of these dust particles are round semi-opaque in appearance under the Konimeter microscope, and three microns or less in size; 20% are round, globular like particles, seven microns or less in size; and 10% are metallic shreds about two microns wide and 20 to 30 microns long. There are many minute crystalline particles too small and too numerous to count accurately.

M - GANG SAW BLADE GRINDER: Uses a 5/8" x 10" Grain 50, Grade M, Norton Company Alundrum wheel, operating at 1800 RPM. A rather crude dust collector has been installed, but the average dust (8,760,320 particles per cubic foot) produced by this grinder in operation indicates that it is inadequate. About 90% of the dust particles in samples taken during the grinding of a Gang Saw Blade were semi-opaque in appearance and about two microns or less in size; 10% were black round, opaque, one micron or less in size. There were numerous minute black specks too small to count accurately.

N - EDGER SAW GRINDER: Uses a 3/8" x 8" Grain 60, Grade N, Norton Company Alundum wheel, operating at 1650 RPM. No hood or any other dust collector for this grinder. The low dust count, an average of only 453,120 particles, ten microns or less per cubic foot, indicates that there is very little real need for such equipment. The dust particles produced while grinding an Edger Saw Blade are angular crystalline, about two microns or less in size.

O - CIRCULAR SLAB CUT-OFF SAW GRINDER: Uses a 3/4" x 10" Grain N, Norton

Company Alundum wheel operating at 1650 RPM. A rather ineffective dust collector has been installed, but the average high dust concentration (10,931,521 particles per cubic foot) shows that it is inadequate. About 80% of the dust particles in samples taken during the sharpening of a Circular Slab Cut-off Saw were opaque in appearance, two microns or less in size; 20% were slightly angular crystalline, five microns or less in size. There were also a large number of minute black opaque particles.

P - "HOG KNIFE" GRINDER: Uses a 1-1/2" x 24" Carborundum wheel operating at 300 RPM. This grinder is completely enclosed by a metal hood, but the dust is discharged onto the floor through an opening in the lower part of the hood. The average dust produced by the operation of this grinder is 1,869,120 particles per cubic foot. About 75% of these dust particles were angular crystalline in appearance under the Konimeter microscope and four microns or less in size; 25% were round, black opaque, two microns or less in size.

Q - CUTTER GRINDER: Uses a 3-1/2" x 2-1/2" x 1/2" Norton Alundum wheel (3846 K B 5). The amount of dust produced depends upon the material being ground as is shown by the following:

| | |
|---|---|
| Grinding a steel counter sink........... | 736,320 particles per cu. ft. |
| " " " reamer.................. | 1,019,520 " " " " |

The dust particles are about 98% opaque metallic in appearance and about one micron or less in size.

<u>What Precautions Should Be Adopted For Safeguarding Those Who Use Grinding Wheels?</u> Authorities generally agree (Jour. Indust. Hyg. Vol. VII No. 8 August 1925 p. 351) that workers who habitually use grinding wheels will run but slight risk of developing pneumoconiosis if they use certified abrasive rather than sandstone wheels for all grinding operations and if the machines upon which the artificial abrasive wheels are mounted are properly hooded and excessive dust removed by suction.

Control of Dust From Grinding, Polishing and Buffing Wheels. Exhaust systems for grinding, polishing and buffing wheels vary widely in design. In the case of grinding, the hoods used serve not only to provide means for capturing the dust but also act to protect the worker in case the wheel bursts. The chief difficulty to be overcome in grinding wheels, according to U. S. Public Health Bulletin No. 217, "The Determination and Control of Industrial Dust" (1935), is the outward sweep of air, a fan action, due to the revolving wheel. This effect is very marked with high speed and rough wheels and is so strong that in many instances it is sufficient to counteract the normal inward flow of air. The same effect exists with polishing and buffing wheels but to a less marked degree.

Practically all industrial States have codes regulating the construction and dust connections for grinding, polishing and buffing wheels. They also regulate the air required for wheels of various sizes in terms of static suction in the connecting ducts. These codes possess no uniformity. However, the requirements designated by State codes must be followed. In States where no codes have been adopted it is desirable to provide exhausts on all grinding wheels with a suction at the connection to the hood sufficient to produce a difference of level of at least two inches of water between the two sides of a U-shaped tube.

A number of the wheels have been provided with suction exhaust produced by a motor driven fan or a hood, with a two-inch pipe one end of which is immersed in a bucket of water. The dust is drawn in by the rapid revolution of the wheels (1750 RPM). This simple arrangement is particularly effective. Three samples taken near the discharge of a motor driven suction fan connected with the hood of 1-1/2" x 10"

Alundum (Grit 46. Grade P) wheel while a tool was being sharpened had an average of 2,076,989 particles per cubic foot which would have otherwise been thrown into the machine shop atmosphere.

As pointed out by Dr. W. Irving Clark in his paper "Dust Hazards and the Prevention of Injury from the Same" read at a meeting of Government Officials in Industry at Boston, Mass. on May 21, 1931, the most effective method of removing fine particles of dust is by suction applied as close as possible to the point where they are generated and the amount of this suction is great enough to overcome the dispersing action upon the dust of the work being done. The velocity at the air ducts of an efficient dust removing tube should be 1500 linear feet per minute. Quoting Dr. Clark:

> "No matter how well a workman is protected he should be kept under medical supervision and have a periodic examination of his heart and lungs. In addition, the X-ray should be employed freely in order to detect early signs of fibrosis in the lungs and to show any signs of early pulmonary tuberculosis. In my experience with workers exposed to inorganic dust, non-silicous in character, a yearly physical examination with an X-ray every second year after ten years exposure is sufficient but it must be remembered that this is the result of work in a factory where the character of the dust is relatively harmless and where excellent dust removing devices are installed on every machine where it is possible. Where free silica is present in large quantities the examinations should begin after two or three years exposure and an X-ray should be taken every year.

Dr. Clark also states that men who are asthmatic, who suffer from chronic bronchitis, or who have had pulmonary tuberculosis should not work at a dusty job.

## VII - HANDLING POWDERED OR PULVERIZED MATERIAL

A large amount of powdered or pulverized materials are used in the treatment of petroleum products and boiler water and in the manufacture of greases and insecticides. In most cases approved respiratory protection is provided and its use required when handling the materials. Exposure to dust is usually intermittent and of short duration. Among the powdered or pulverized materials used in the refining of petroleum products and associated activities are:

A - <u>LIME:</u> Lime is extensively used in the hydrated form and to a much lesser degree as lump quicklime.

1. <u>Hydrated Lime:</u> Used in the preparation of lime soap grease and the manufacture of pressure gun and cup grease; also in the treatment of boiler feedwater to "soften it". It comes in fifty pound paper bags by railroad, usually about 1,000 bags to a car. According to a chemical analysis of a typical sample, hydrated lime contains:

| | | |
|---|---|---|
| $Fe_2O_3Al_2O_3$........... | 0.30 | per cent. |
| CaO.................. | 73.64 | " " |
| MgO.................. | 0.93 | " " |
| Insoluble Silica Residue..... | 1.01 | " " |

(Remainder mostly Moisture and Volatile Matter)

From 150 to 350 pounds of lime are used per batch in the manufacture of greases.

The sacks of lime are usually opened and dumped into the mixing kettle. Considerable dust (as high as 34,890,240 particles less than ten microns per cubic foot in one sample) is produced by this operation. The average dust produced is 4,733,305 particles per cubic foot and the average exposure per batch is about five minutes. The number of batches made per week varies from one to twenty-five. No respirators are worn by men dumping hydrated lime at any of the points where it is used with the exception of Baton Rouge where the wearing of the MSA "Comfo" respirator is required. About 85% of the dust particles in samples taken while dumping lime in mixing kettles are slightly angular, slightly opaque, crystalline, in appearance under the Konimeter microscope, and five microns or less in size; 15% are rounded, semi-opaque, with a metallic greyish color, ten microns or over. There are also a countless number of very small particles.

Only a small quantity of Hydrated Lime is used in the treatment of boiler feedwater. About 70 pounds of lime is mixed per batch and about six batches are made every day (24 hours). The mixing is done by one man on each shift. Although the exposure is very short, the men at Ingleside Refinery wear Willson "Dust-tite" respirators while dumping lime. The average dust produced during this operation is only 657,024 particles, ten microns or less, per cubic foot. This low dust concentration is the result of a spray of water from a two inch pipe across the hatch of the mixing tank just below the opening while sacks are being dumped. Consequently, the material is wet almost as soon as the lime is introduced. About 95% of the dust particles in samples taken while the lime was being dumped into the mixing tank were semi-angular crystalline in appearance, and from five microns or less in size, and 5% were round opaque, two microns or less in size.

2. Lump Quicklime: Used to "soften" boiler feedwater. The lime used for this purpose is Oyster Shell Lump Quicklime (97% CaO). It comes in fifty pound paper-lined burlap bags, and eight bags are usually used per batch. One batch is made per shift. The dumping and mixing requires about ten minutes per batch, and the man doing this work is protected by rubber type goggles, but no respirator. The average dust produced by handling the bags of lump Oyster Shell Quicklime is 2,605,440 particles per cubic foot. The average dust produced while dumping the bags of lump Oyster Shell Quicklime into the mixing tank is 294,528 particles, less than ten microns, per cubic foot. The handling and dumping of this Oyster Shell Quicklime produces less dust than is produced by the hydrated lime usually used. About 95% of the dust particles in samples taken during the dumping of Oyster Shell Quicklime into the mixing kettle appear slightly angular, crystalline under the Konimeter microscope, and are five microns or less in size; 2% are round, semi-opaque, over ten microns in size; and 3% are black opaque scale-like, five microns or less in size.

What Physilogical Effect is Produced by Lime Dust? According to the International Labor Office (Occupation and Health, Vol. II, 1934) particles of lime mix with the sweat of workmen handling it and irritate the uncovered pores of the skin; lesions of the mucous membranes are also set up. We are told that:

> "The action of quicklime is due partly to its avidity for water (dehydration), to the heat given off in its reaction with water, and partly to the peculiar causticity of the alkaline oxides or alkaline earths. Quicklime exerts essentially a local action (on the skin and mucous membranes) irritating and caustic, which is naturally less marked in the case of slaked lime. Milk of lime is a feeble caustic acting only on the mucous membranes. The dilute lyes are only caustic to the skin after prolonged action and especially when they are warm.

> "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. Foltzmann (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 men with an average service of eight years. It requires about two hours to fill a tower with about 10,000 pounds of crude sulphur. Two towers are charged every week. Consequently, the men are exposed about four hours a week to the sulphur dust caused by breaking up the lumps (4,304,640 particles, ten microns or less, per cubic foot) and shoveling the crude sulphur into the tower elevator (an average of 3,357,640 particles per cubic foot). The amount of dust produced by this operation is somewhat reduced by the steam turned on inside the elevator shaft to prevent dust explosions. About 60% of the dust particles in samples taken while the tower was being filled were slightly angular crystalline in appearance under the Konimeter microscope and five microns or less in size; 35% were rounded, semi-opaque, ten microns or over in size; and 5% were opaque scale like, between five and twelve microns in size.

Sulphur dust particles are explosive but otherwise are not considered hazardous any more than any of the other "nuisance" dusts, although they will irritate the mucous membranes and the eyes after slight exposure. Consequently, it is advisable to wear rubber type goggles and approved respirators, such as the MSA Comfo type.

In an article by Aldo Cestari (Arch. Intern. Pharmacodynamie, 1933, vol. 46, pp. 300-314) it is stated:

> "Intratracheal injection of sulfur suspensions brings about excretion of hydrogen sulfide in a period of 50 hours. There are slight exudative and infiltrative reactions in the lungs. It is supposed that a substance similar to glutathione reduces the sulfur to hydrogen sulfide."

<u>F - LITHARGE:</u> Litharge is added to the Plumbite or "Doctor" Solution to assist in the removal of mercaptans, other sulphur compounds and unsaturated hydrocarbons from gasoline and naphtha. From one to five 600-pound drums of litharge are used in a batch, depending upon the stock to be treated and the condition of the "Doctor Solution". The litharge is removed from the drum a shovel at a time, and about fifteen minutes are required to dump one batch. A batch is made once a week on an average. The average service of the men involved in this operation is seven years. They wear MSA Comfo respirators with an approved lead filter and rubber type goggles. All of the work of adding litharge is done in the open air on a platform at the tops of the solution tanks.

The average dust produced during the dumping or shoveling of litharge into the solution tank is 3,077,480 particles, ten microns or less in size, per cubic foot, although there were as high as 9,288,960 particles per cubic foot during the operation. A rough estimation of this litharge concentration indicates the presence of from five to fifteen milligrams of lead per ten cubic meters - the amount that an average person doing moderate work would breathe in one day. This is in excess of 1.5 milligrams in ten cubic meters which is the maximum allowable limit set by the United States Public Health Service. About 80% of these dust particles were rounded, transparent, crystalline in appearance under the Konimeter microscope, and five microns or less in size; about 15% were over ten microns and appeared to contain small air bubbles; 5% were dark opaque scale-like, from five to ten microns in size.

<u>Necessary Precautionary Measures When Handling Litharge.</u> Litharge is a compound of lead, and consequently there is the possibility of lead poisoning unless a few simple precautions are observed to prevent the entrance of lead into the body by swallowing minute particles of the litharge dust, by inhaling the dust, or by absorption from the skin when handling the litharge. An effort should be made to cause as little dust as possible. Instructions issued by the Medical Department require that:

"1. No employee shall handle litharge until he has been examined and certified as physically qualified by the Company Doctor.

"2. Employees must be sent to the Company Doctor for physical examination at least every six months or at the first sign of ill health.

"3. Respirators - An approved type of lead dust respirator, properly adjusted, shall be worn when handling litharge. All respirators shall be thoroughly cleaned with soap and warm water.

"4. Clothing - Unionalls, caps or some head covering and gauntlet gloves shall be worn when handling litharge. Upon the completion of this operation the outer clothing must be removed and placed in a locker used for this purpose only. Unionalls should be washed at least once a week.

"5. Bathing and locker facilities - A conveniently located locker and was h room shall be designated for use of employees handling litharge. Separate lockers should be provided for street clothes, work clothes, and one for Unionalls worn when handling litharge. In plants where men are handling litharge throughout the shift, only two lockers need be provided. The floors of the locker rooms where the men change their dust covered Unionalls and the benches shall be thoroughly moistened before being cleaned.

"6. Personal cleanliness - General personal cleanliness is of first importance.

(a) Hands must be thoroughly washed on the completion of the litharge handling operation. Hands must also be thoroughly washed before eating or placing anything in the mouth. A special effort should be made to clean the finger nails so as to remove any litharge.

(b) Never eat until litharge covered clothing has been removed and the hands washed.

(c) Teeth should be brushed at least twice a day and the teeth and gums kept in good condition.

(d) The mouth should be rinsed thoroughly before eating.

(e) Never use tobacco in any form while working in and around litharge."

The responsibility for the careful observance of ALL of these instructions should be placed upon the foreman.

G - SODA ASH: Soda ash (58% $Na_2O$) is used to form a solution for neutralizing acid oil. Thirty 200-pound cloth bags of soda ash are dumped into a tank of water per batch by six men, with an average service of five years, from the General Labor Department; three batches a week. Men exposed to dust resulting from opening and dumping the bags of soda ash about five hours a week. Eight men spend about half a day a month unloading bags from railroad box cars. The men who do the unloading wear MSA Comfo respirators and are not the same men as those doing the mixing who do not wear any respirators or goggles. The average dust produced by the dumping and 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 comes in metal drums or 100-pound paper lined bags. About 3700 pounds of powdered graphite is used per batch and one batch is made per day on an average. The graphite is dumped into the mixing kettle by men with an average service of seven years. This operation requires about forty minutes per batch per man on an average. Three men are usually engaged in this dumping. They wear respirators while handling and dumping graphite, which is not a particularly dusty operation. The average dust produced is 1,803,080 particles, ten microns or less, per cubic foot of air. All of these dust particles are rounded or slightly angular, black opaque, amorphous, sooty or dark grey in appearance under the Konimeter microscope, and three microns or less in size.

J - SLATE FLOUR: Slate flour (300 mesh) gives rigidity to asphalt on "fast surfaces" such as steep roofs and pipe lines, and prevents its running off. It also produces desirable weathering properties. Mixtures as low as 10% slate flour and as high as 40% are used. An average of two tons of slate flour is used to each still which averages about 800 barrels of steam reduced asphalt. Since the slate flour is introduced by the use of closed pipe lines and centrifugal pumps, the only dust produced is that which results during the unloading of the sacks and dumping them into the hopper. The slate flour comes in 50-pound paper bags, 750 bags to a railroad box car. Four men with an average service of about a year, open the bags and dump the slate flour directly into a hopper from which it is siphoned by compressed air to a storage tank holding about 15 tons. About four carloads a month are received and an average of about 5-1/2 hours is required to unload each car. About one and three-quarter million pounds were dumped during the last quarter period. The men wear MSA Comfo respirators. A screen analysis of this slate flour showed that 99.7% passed through a 200 mesh screen and 96.8% through a 325 mesh screen. Due to the fineness of slate flour and its low bulk density (1.04) considerable dust, an average of 12,007,680 particles, ten microns or less in size, per cubic foot of air, and counts as high as 16,538,880 particles per cubic foot, are produced during dumping the sacks and filling the storage tank. About 98% of these dust particles are slightly angular, transparent, crystalline in appearance under the Konimeter microscope, and five microns or less in size; 2% are semi-opaque, slightly angular. There were a few plate like particles which appeared to contain small air bubbles, and a large number of small black particles.

A petrographic examination made of a slate flour sample at the United States Bureau of Mines Experiment Station in Pittsburgh, Pennsylvania showed that it contained more than 1% Quartz ($SiO_2$), 30% Sericite ($K_2O$-$3Al_2O_3$-6 $SiO_2$-$2H_2O$), 40% opaque and 30% five different unidentified constituents. A chemical analysis of slate granules and flour (Jour. Indust. Hyg. Vol. XV., No. 2, Mar. 1933, p. 67) reports these constituents:

| | | | |
|---|---|---|---|
| Silicon Dioxide | 59.27% | Magnesium Oxide | 2.21% |
| Titanium Dioxide | 0.99% | Potassium Oxide | 3.75% |
| Aluminum Oxide | 18.81% | Sodium Oxide | 1.88% |
| Ferric Oxide | 1.12% | Water below 110°C. | 0.32% |
| Ferrous Oxide | 6.58% | " above " | 3.98% |
| Managanous Oxide | 0.13% | Phosphoric Oxide | 0.11% |
| Calcium Oxide | 0.42% | Carbon Dioxide | 0.21% |
| Barium Oxide | 0.05% | Ferric Sulphide | 0.15% |

Specific Gravity - 2.795

"The silicon found, though expressed in the chemical analysis as silicon dioxide, is not differentiated chemically as to the forms present in the original minerals, whether free silica or silicate."

<u>Effect of Slate Flour on The Lungs</u> - In his paper "Effects of Certain Silicate Dusts in the Lungs" read before the Industrial Hygiene Section of the American Public Health Association at Washington, D.C. on October 27, 1932, Dr. Waldemar C. Dreessen of the United States Public Health Service, reporting the results of his studies of workers exposed to slate dust, wrote:

> "Of the 48 cases of pneumoconiosis observed, all were in the first stage except 5 cases. In general, the pneumoconiosis observed in the early or first stage cases resembled that induced by cement dust. The bronchial striations, however, were somewhat more prominent. There was always a moderate bilateral increase in the size and density of the hilar shadows with accentuations of bronchial striations which extended well out into each lung field. The linear striations seemed "softer" in appearance and lacked some of the sharpness of detail which is usually observed in the X-rays of individuals who have inhaled silica dust. This diffuse, fine generalized fibrosis was chiefly confined to the lower two-thirds of the lung fields.
>
> "In the second stage an increased prominence of the above mentioned characteristics was present with the appearance of flake like, dappled areas of increased density in both lung fields. In the third stage these dappled areas seemed to conglomerate, and in this manner gave way to massive, clouded areas of increased density."

Dr. Dreessen found that although the silicate dusts of slate "induce a fine diffuse, bilateral fibrosis of the lungs which is definitely demonstrable in the X-ray" workers exposed to slate dust do not begin to show definite first stage pneumoconiosis until after more than ten years' exposure. He did not find any evidence that the resultant pneumoconiosis had led to disability.

<u>K</u> - <u>GRINDING DERRIS ROOT:</u> Derris root is used in the manufacture of insecticides. It comes in 500-pound bales from the Dutch East Indies. In order to reduce dust, the bales are thoroughly wetted with white oil. The root is ground at the rate of 500 pounds an hour to pass through a 3/8"-screen. One man with three years' service is exposed to an average dust concentration of 1,604,800 particles, ten microns or less, per cubic foot of air. About 80% of these dust particles are rather round, crystalline in appearance under the Konimeter microscope, and about five microns in size; 20% are sharply angular, five microns or less in size. The particles appear to be more inorganic than organic in character. Evidently the lighter root dust particles are either larger than 30 microns and were, therefore, filtered out by the Konimeter filter or were carried out by the exhaust ventilation, thus leaving the dirt or soil which had adhered to the roots. The grinder is located in a small room well ventilated by means of a 30-inch motor-driven fan. This explains the low dust concentration in the samples taken during the grinding operation. The operator wears rubber gloves, cover-alls, and is provided with a fresh air hose type of mask while grinding.

<u>To What Extent is Derris Toxic?</u> According to recent studies by the United States Department of Agriculture (Indust. & Eng. Chem. Vol. 28, No. 7, July 1936, pps. 815-821) Derris is a possible health hazard to those engaged in milling, grinding, and diluting it (Derris) without the use of suitable protective measures. Pharmacological studies show that Derris and its water extracts affect the respiratory center which is initially stimulated and then, after fatal doses, completely depressed, with death resulting. Derris dust when applied to the armpits was also found to provoke a "mild evanescent irritation."

<u>L</u> - <u>GRINDING PYRETHRUM FLOWERS:</u> Pyrethrum flowers are an important source of one

of the essential ingredients of insecticides. They come from Japan in mat covered bales weighing about 450 pounds. On an average, about ten bales are ground per shift. Opening the bales of compressed flowers is the dustiest part of the operation, producing on an average 2,039,040 particles, ten microns or less, per cubic foot of air. About 85% of these particles are angular, crystalline in appearance under the Konimeter microscope, and three microns or less in size; about 15% are flat round particles and discs and shreds, ten microns or less. The crystalline - appearing dust probably originates from the soil which has blown on the flowers or plants. One man is exposed per shift for about four hours a day during a nine month period. He wears a Willson dust respirator. The grinder is enclosed in a metal housing connected by a fourteen-inch duct to a sixteen-inch motor driven exhaust fan.

Pyrethrum dust seems to irritate the skin of some individuals and not affect others in the least; as a matter of fact it causes an allergic type of reaction in some individuals to such an extent that it is inadvisable for such persons to work in pyrethrum dust.

M - MIXING AND PACKING "FLIT" POWDER: "Flit" powder is a mixture of pulverized derris root, pyrethrum flowers and other ingredients. It is mixed in a special room provided with exhaust ventilation by a man wearing a respirator. The dustiest part of this operation is sifting the pulverized derris and pyrethrum which produces an average of 8,722,560 particles, ten microns or less, per cubic foot of air. About 95% of these dust particles are angular, crystalline in appearance under the Konimeter microscope, and about three microns in size; about 5% are less crystalline and more opaque, five microns or less in size.

Filling Cans: Three-quarter and two and one-quarter ounce tin cans are filled by automatic machines. the filler ends of which are enclosed in a metal housing with a four-inch exhaust duct to a fourteen-inch motor-driven fan. That this exhaust arrangement is fairly effective is shown by an average dust concentration in samples taken at face level of the operator during the filling operation of 1,755,840 particles, ten microns or less, per cubic foot of air. The girl at the Sealer wears a bag-type dust respirator.

## VIII - CLEANING TUBES AND DRUMS CONTENTS

Cleaning tubes and drums of boilers and process equipment is a routine operation which produces considerable dust belonging more to the "nuisance" class than to the fibrosis causation group. Nevertheless, consideration should be given to keeping such dust down to a minimum of not more than 10,000,000 particles per cubic foot due to the number of men engaged in this work and their more or less continuous exposure

I. - CRACKING COIL SOAKING DRUMS: Cracking coil soaking drums "coke-up" about once a month, so that in many cases they are almost completely filled with the exception of an opening down through the center no greater than twelve inches in diameter. At most plants, this coke is removed by a special machine; at the others, men with an average service of ten years are regularly engaged in cleaning these drums by means of a concrete buster type of pneumatic chisel, starting at the top of the drum. One man works inside and two outside at the top manhole. The temperature inside the drum is about 90 degrees Fahrenheit. Each man works half an hour inside and is then relieved for about an hour. On an average, each man works about two and a half hours per shift, two shifts a week. A "boatswain" chair is used to get in and out of the drum. They wear "hardboiled" hats and life-belts. Excellent ventilation is provided by a steam or an air syphon placed in the bottom manhole of the drum, as a result of which samples taken at face level of men during the operation of the pneumatic chisel had an average of only 311,520 dust particles, ten microns or less, per cubic foot of air. About 60% of these particles were sharply angular, crystalline in appearance under the Konimeter microscope, and about five microns or less in size; 35% were round, semi-opaque, crystalline, about ten microns or over; and about 5% were small black particles. There were also a few black scale-like particles over ten microns in size. The major portion of this dust is probably coke or carbon and the scale-like particles are, no doubt, metal from the sides of the drum or from the chisel.

II. - CRACKING COIL TUBES: There are 183 tubes in a high pressure cracking coil unit. After running from twenty to twenty-five days, depending upon the character of the stock being run, the temperature and pressure, the petroleum coke which is deposited on the tubes must be removed. Liberty air-driven tube cleaners with cone and star cutters operated by men with an average service of six years are used for this purpose. The men work in gangs of six to eight and are exposed to dust about six hours every two shifts on an average. They wear neither goggles nor respirators although a dust sample taken immediately after reversing the cleaning machine while in a tube contained as high as 9,062,400 particles, ten microns or less in size, per cubic foot. About 30% of these dust particles are black, opaque in appearance under the Konimeter microscope, and two microns or less in size; 40% are angular, transparent, plate-like, ten microns or larger; and 30% are angular, transparent crystalline, five microns or less in size.

Samples taken on the Cleaning Platform while cleaning Cracking Coil Furnace tubes at a Northern refinery had an average of 113,280 particles per cubic foot. Ninety-eight per cent. of these dust particles were rounded crystalline in appearance under the microscope and five microns or less in size. Samples taken in the passageway back of the furnace while tubes were being cleaned had as high as 1,076,160 particles, ten microns or less in size, per cubic foot of air. This indicates that the men in the passageway, back of the furnace are exposed to more dust than those on the cleaning platform.

III. - WATER HEADERS AND BOILER TUBES: Tubes and headers are cleaned twice a year by means of air-driven turbines. It has been found that cleaning can be done more effectively if done dry rather than wet because the dust can be blown out. If water were used, the loosened material would soon form a paste which would be smeared back on the tubes by the action of the cleaning turbine. Regardless of the dust which is produced in concentrations as high as 30,359,040 particles, ten microns or less in size per cubic foot of air, workmen prefer working in dry drums rather than in wet ones. Eight men (two on each turbine) are engaged in this cleaning operation which requires about twelve days a year. Men with an average service of fifteen years are assigned to this job from the Labor Department. The temperature inside of the drums or headers is about 70 degrees Fahrenheit. In accordance with the usual practice, men operating the turbines, inside the drum or header, work about ten minutes and are relieved for ten minutes by their co-workers who assist in handling the air hose in and out of the drum manhole. Respirators have been provided in most cases but are not always worn. The average dust produced while cleaning water-headers and boiler tubes in samples taken from:

| | | |
|---|---|---|
| Lower Platform, Front Water Header................ | 18,306,048 | part. per cu. ft. |
| In #2 Drum While Cleaning Water Wall and Tubes.... | 5,664,000 | " " " |
| Inside Manhole Drum #3 While Being Cleaned........ | 28,320,000 | " " " |

About 40% of the dust particles in the samples taken on the lower front water-header platform, while header was being cleaned, were rounded, dark red in appearance under the Konimeter microscope, and about two microns in size; 50% were opaque, more or less angular, and about five microns in size; 10% were crystalline, slightly angular, and over ten microns in size. About 65% of the particles in the sample taken inside #2 drum during cleaning were black, opaque, angular, less than two microns in size; and about 15% were round, more or less opaque, over ten microns. The concentration of dust INSIDE the drum during cleaning appears to decrease with the distance from the manhole as is demonstrated by these counts in samples from Drum #2 (Riley Boiler):

| Location | Particles per cu. ft. |
|---|---|
| Inside Manhole | 19,257,600 |
| About 8 ft. Inside Drum | 4,078,080 |
| " 11 " " " | 2,265,600 |
| " 18 " " " | 1,585,920 |
| " 24 " " " | 1,132,800 |

The dust particles from inside the drum appear black, angular and were less than two microns in size. The dust from these cleaning operations are supposed to be largely the results of metal corrosion and sediment (largely Calcium Carbonate and Calcium Phosphate) deposited by the treated Boiler Feed Water. A petrographic examination of a sample of dust from the Front Water Wall Header was made by the United States Bureau of Mines Experiment Station at Pittsburgh, Pennsylvania, who reported:

| | |
|---|---|
| Quartz ($SiO_2$) | 1 per cent. |
| Opaque or Coated with Opaque Material | 90 " " |
| Unidentified Clay-like | 9 " " |

According to a chemical analysis of this same material made by a regular refinery chemist using the method of Adolph Knopf, U.S. Public Health Service, the dust contained:

| | |
|---|---|
| Free Silica | 0.70 per cent. |
| Combined Silica | 41.01 " " |

Although the analysis of the dust shows a low free silica content, the high dust concentrations found and the possibility that at times such concentrations may be higher than those found, demonstrate the desirability of wearing respirators regardless of the kind of dust encountered.

## IX - FOUNDRY OPERATIONS

During recent years considerable attention has been focused upon the health of foundry workers by the operation of the so-callod "Silicosis Racket" which has extracted large sums of money from the Foundry Industry. It is difficult to isolate this type of work which gives rise to a very general exposure to dust which may involve all workers employed in the foundry. In many cases the worker is in such close contact with the duty atmosphere as to cause serious exposure. Much progress has been made in reducing the dustiness of our foundry operations and plans are now being considered which will further safeguard our foundry workers. The following is a brief outline of foundry dust producing operations:

A. - POURING MOLTEN METAL INTO SAND MOULDS - About 19-1/2 tons of metal are poured per "heat". Thirty-five men with an average service of twelve years spend about one and a half hours pouring and six and a half hours moulding per day, five days a week. Goggles, asbestos leggings and congress-type shoes are worn by the men handling the molten metal. About 60% of the moulding sand, which is the principal source of dust, is free silica ($SiO_2$). During the pouring operation the foundry air appears to be full of dust and smoke, however, samples taken during this work averaged only 396,480 particles ten microns or less in size per cubic foot of air. Practically all of these dust particles appeared angular, crystalline under the Konimeter microscope and were about two microns or less in size.

A sample of dust from the top of the crane rail over the moulding floor was given a petrographic examination by the U.S. Bureau of Mines Experiment Station in Pittsburgh, Pennsylvania who reported 50% quartz ($SiO_2$); 15% Clay Mineral not completely identified. Kaolinite is $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$; 5% Calcite ($CaCO_3$) and 30% Opaque.

B. - "SHAKING OUT" CASTINGS - After pouring, the castings are allowed to cool, then the moulds are liberally sprinkled with water from a hose. The bands or clamps are removed and the flask is thrown over and broken open. The rough castings are pulled out, piled up and trucked to the Cleaning Room. "Shaking Out" is considered one of the serious occupational disease hazards encountered in industry and the dustiest operation in founderies but due to the thorough wetting and careful handling by the men, samples taken during the operation had an average of only 858,230 dust particles ten microns or less per cubic foot of air. The impinger method would no doubt reveal much higher counts. About 98% of the dust particles were slightly angular crystalline in appearance under the Konimeter microscope and were one micron or less in size. "Shaking Out" is rather hot work, the men perspire freely so that it would be difficult to enforce the wearing of goggles and respirators. Twelve men with an average service of eight years work on this job, eight hours per shift, five shifts per week.

After the castings have been removed the moulding sand is again wetted and thoroughly worked over with a motor-driven sand cutter which is a series of revolving blades, similar to those on a lawn mower, operated by an electric motor, mounted on a rubber-tired four-wheeled carriage which moves back and forth over the moulding floor. Moisture tests are made and when these tests indicate 4.6 to 5.6 moisture the sand is considered ready for the moulders. During the operation of this sand cutter, the operator is exposed to an average dust concentration of 1,529,280 particles ten microns or less per cubic foot. These particles were less than two microns and were slightly angular crystalline in appearance under the Konimeter microscope.

C. - CLEANING CASTINGS - Various methods are used to clean castings depending on their size and shape. All of these methods produce more or less dust some of which can be taken care of by exhaust ventilations, others cannot. The methods most commonly employed are:

(a) Preliminary Cleaning - Castings are brought from the moulding floor during the night and deposited in the Cleaning Room. The following morning the cores are knocked out, the sprues and gates are broken off and some scratch cleaning is done. This work produces considerable dust especially when the sand and old cores are shovelled through the grating into the car or bucket below (3,455,040 particles ten microns or less per cubic foot of air). Under the Konimeter microscope about 70% of the dust particles appear angular, crystalline, three microns or less in size; 20% were rounded crystalline, five microns in size and about 5% were scale-like semi-opaque with a reddish-brown tinge and over ten microns in size. Pulmosan Respirators have been provided but are not always worn by men doing this work. NO attempt has been made to control dust from preliminary cleaning although some study has been given to the provision of a special air-tight room with a grating floor and a hopper underneath with a screw conveyor at the bottom to convey the debris to the disposal car or bucket and thus eliminate the dust-producing shovelling and handling. Under this plan exhaust ducts with a series of outlets around the top of the hopper carry off the dust. Air is also introduced into the room about a man's breathing level and the amount of air taken out is greater than that introduced so that a negative pressure is maintained and a complete air change is made about every three minutes.

(b) Tumblast - The Tumblast is a machine which combines tumbling with air blasting. From 400 to 1500 pounds of castings are put into a drum which revolves about 10 RPM. They run from about 20 minutes to four hours, depending upon the type of castings and cleanliness required. While the castings are being tumbled they receive a blast of #20 Steel shot through three 5/16 inch nozzles under an air pressure of 85 pounds per square inch. This machine is operated by three men, with an average service of eight years, for a period of two and a half hours per man per day, five days a week. Pulmosan Dust respirators are provided but are not always worn. A ten-inch exhaust pipe has been installed at the top of the machine and a six-inch exhaust pipe over the screen. The suction on these exhaust pipes is said to be about 2-1/2 inches water. Samples taken during the operation of this machine averaged 1,200,760 dust particles, ten microns or less in size, per cubic foot which indicates that the dust control measures which have been provided are getting results although there is still room for improvement. About 98% of the dust particles appear quartz-like under the Konimeter microscope; about 60% are five microns or less in size and are angular crystalline in appearance; 40% are ten microns or over in size, and rather rounded in appearance. There are also a large number of minute black metallic specks entirely too small and numerous to count accurately.

(c) Sly Tumbling Mill - Cleans brass castings by a combination of tumbling and air-blasting with #3 Sand Blast Sand and 85 pounds per square inch air pressure. The Mill holds from 100 to 1500 pounds of castings and cleans five loads a day. Two men, with an average service of 15 years, operate this mill which runs about five hours a day. They wear Pulmosan Dust respirators and goggles when opening the machine. This Mill is hooded with an 8-inch exhaust pipe having a 2-inch water suction, also a 10-inch exhaust pipe over the sand screen at the rear of the machine. Samples of dust taken during the operation of the Sly Tumbling Mill had as high as 2,492,160 particles ten microns or less in size per cubic foot of air and an average of 1,393,344 particles per cubic foot. About 90% of these dust particles were rounded crystalline in appearance under the Konimeter microscope and two microns or less in size; 5% were black, opaque scale-like and 5% were rounded crystalline about five microns in size.

(d) Tumbling Barrels - 36" x 42" Whiting Tumbling Barrels remove sand from castings. They hold from 1200 to 1500 pounds of castings per load and revolve at 10 RPM. The castings are tumbled about two hours with about 700 pounds of one-inch unannealed cast malleable iron stars and jacks. An exhaust system with a 6-inch pipe through the trunnion having a suction of 1-1/4 inches water. This suction has been found inadequate to give the desired results consequently the suction is to be increased to 4-inches water. Samples taken during the operation of the Tumbling Barrels had an average of 1,348,032 dust particles ten microns or less in size per cubic foot of air. About 90% of these particles were angular crystalline in appearance under the Konimeter Microscope and three microns or less in size; about 10% were rounded semi-crystalline, ten microns in size. There were also a few triangular-shaped opaque metallic particles. Three men, with an average service of twelve years, operate these tumbling barrels eight hours a shift, five shifts a week. Pulmosan Dust Proof respirators and goggles have been provided but are not always worn.

The type of Tumbling Barrels being used has been condemned by a major company because it is impossible to ventilate it properly. The holes in the end liners clog up when the barrel starts revolving, thus preventing circulation of air through the barrel. This condition has been remedied, in a new design now on the market, by the use of two shells - an inner perforated and an outer solid shell. Both trunnions are hollow and are connected with the air chamber between the two shells. Air under pressure is introduced through one trunnion and exhausted through the other.

(e) Air-Blasting - Castings which cannot be tumbled due to their size and fragility are cleaned by air-blasting (85 pounds per square inch) with mixture of approximately half and half sand and #40 Steel Grit. Syracuse Core sand is used when a special finish is desired. There are three men, with an average service of three years, on this job who work 45 minutes of every hour, eight hours a shift, for one week out of three weeks. This work is done in a special tight air conditioned room while wearing a Sly Sand-blast Helmet supplied with outside fresh air provided by a special blower used for that purpose only. Samples taken inside the room while a casting was being air-blasted had an average of 3,738,240 ~~dust~~ particles ten microns or less per cubic foot of air. About 80% of these dust particles were sharply angular crystalline in appearance under the Konimeter microscope and three microns or less in size; 20% were rounded quartz-like crystals about ten microns in size. There were also a few rust-like scales and a large number of black metallic particles too minute and too numerous to be counted accurately. The silicosis hazard of this operation could be greatly reduced by the use of steel abrasives exclusively.

(f) Rough Snagging Wheels - These machines are used for removing projections such as sprues, parts and gates from castings. There are two types of these wheels: the DOUBLE END using either 19-1/2" x 3" Carborundum and Vitrified or 24" x 2-1/2" Redmanol (Bakelite bound) Wheels; and the HORIZONTAL DISC Grinder having a 50" diameter vitrified wheel. These wheels are used by seven men having an average service of nine hours per shift, five shifts per week. Each wheel is hooded and has a four-inch suction pipe. There is an eight-inch suction pipe on the Horizontal Grinder. Goggles and respirators are provided but the latter are not always worn with the exception of the men on the Horizontal Grinders. Vitrified wheels are run at a slower speed (1800 RPM) than the Bakelite Bound Wheels which operate at 3400 RPM. Samples taken during the operation of the Rough Shagging Wheels had the following dust concentrations.

Double End Snagging Wheels:

| | | | | | |
|---|---|---|---|---|---|
| Average Dust from Vitrified Wheels........... | 3,653,280 | particles | per | cubic | foot |
| " " " Carborundum " ........... | 3,322,820 | " | " | " | " |
| " " " Bakelite Bound Wheels...... | 2,662,080 | " | " | " | " |

Horizontal Disc Grinder:

Average Dust from 50" Vitrified Wheel....... 2,124,000 particles per cubic foot

The average dust produced by all the Rough Snagging Wheels was 2,322,820 particles, ten microns or less in size, per cubic foot of air.

About 80% of the dust particles from the vitrified wheels appeared black angular opaque under the Konimeter microscope and two microns or less in size; 20% angular crystalline about one micron or less. There were also a large number of black minute particles too small and numerous to count. The dust particles from the Horizontal (Vitrified) wheel were approximately 90% angular, crystalline and 10% black opaque. All of these particles were about two microns or less in size. About 60% of the dust particles from the Bakelite bound wheel were black angular two microns or less in size; 25% were angular crystalline, less than one micron in size and about 15% were rounded crystalline about five microns in size.

(g) Fine Snagging and Polishing Wheels - These wheels grind off small projections and remove rust from stock which has been in storage. There are three types: DOUBLE 4" x 14" POLISHING EMERY WHEELS - Wheels after being made up are dipped in glue and then rolled in Alundum Grinding Grain, sizes 60, 80 and 120 mesh. DOUBLE DISC GRINDERS - 36" discs covered with #46 Cast Iron Grain or Silicon Carbide (an electric furnace product) and WIRE SCRATCH BRUSHES - made up with four 12" sections. Exhaust hoods with a suction of from three to five inches water, have been installed on the Polishing Wheels and Disc Grinders. There is NO hood on the Wire Scratch Brushes. These wheels are used by four men with an average service of two years. They wear goggles and gloves but no respirators. Samples taken at face level during the operation of this equipment had the following average dust concentrations:

| | | |
|---|---|---|
| Dust Produced by 36" Disc Grinder........... | 1,416,000 | particles per cubic foot |
| " " " 12" Wire Scratch Brush...... | 736,320 | " " " " |
| " " " 4" x 14" Polishing Wheels.. | 481,440 | " " " " |

These comparatively low dust counts indicate that the dust control measures which have been provided are either effective or the dust particles produced are over 30 microns in size and were thus filtered out by the Konimeter filter. Under the microscope dust particles from the Polishing Wheels appeared all round crystalline and about one micron in size. About 40% of the dust particles produced by the Double Disc Grinder were sharply angular, opaque about three microns or less in size; 60% were less angular crystalline about one micron in size. The dust particles produced by the Wire Scratch Brush were all rounded, crystalline and about one micron in size. There were no metallic particles in any of the samples examined. Few exhaust hoods have been installed on Wire Scratch Brushes because it has been generally assumed that these brushes did not produce any dust. This assumption, however, is untrue as one sample from a wire brush at a Southern Refinery had as high as 6,683,520 particles ten microns or less per cubic foot of air.

(h) Cone Grinding Wheels - These wheels are operated with compressed air and are used to do miscellaneous grinding on castings by four men, with an average service of twelve years, about two hours a day on an average. The cones are 5-1/4" x 3-1/4" vitrified and produce an average dust of 1,869,120 particles ten microns or less per cubic foot of air. About 80% of these particles are sharp angular crystalline. In appearance under the Konimeter microscope they are five microns or less in size; 20% are round opaque but non-metallic in appearance and five microns or over in size. . There are no hoods over these wheels and the operators wear no respirators.

Average Dustiness of Cleaning Room Air - A series of five samples were taken between 9:30 and 9:40 A.M. to determine the average amount of dust in the air of the cleaning room while the various cleaning operations were in full blast. Another series of five samples were taken about 3:30 P.M. in the afternoon after the room had been given its regular clean-up. There was quite a difference in the amount of dust in the air during the morning (2,166,480 particles ten microns or less per cubic foot of air) and during the afternoon toward the close of the shift (338,272 particles per cubic foot). About 95% of the dust particles in the evening samples were angular crystalline in appearance and about two microns in size. There were a few large semi-opaque or scale-like particles about 20 microns in size. About 98% of the dust particles in the morning samples were angular crystalline two microns or less in size and about 2% were round, crystalline over five microns in size.

A sample of dust from top of one of the larger Exhaust Ducts in the center of the cleaning room was given a petrographic examination by the U.S. Bureau of Mines Experiment Station at Pittsburgh, Pennsylvania and found to contain 40% Quartz ($SiO_2$), 20% Clay Mineral not completely identified; 40% opaque.

D. - CORE MAKING - A large number of cores are made by the Demmler Air Operated Core Machine which uses a mixture of two-thirds sea sand, one-third river sand and one gallon core oil per 60 gallons sand. There are three sources of dust in the operation of this machine:

| | | |
|---|---|---|
| (1) Shovelling Sand to fill the Machine Hopper.. | 1,019,520 | particles per cubic foot |
| (2) Blowing out Core-boxes.................... | 736,320 | " " " " |
| (3) Blowing sand into the Core-Moulds.......... | 755,200 | " " " " |

About 98% of the dust particles from blowing out the core boxes are dark, opaque in appearance and about one micron in size. The dust particles from blowing sand into the core moulds are angular crystalline less than one micron in size.

Cores are "smoothed up" after being baked in the core oven by scratching off the rough edges with an old hacksaw blade. This operation produces an average of 906,240 dust particles ten microns or less in size per cubic foot of air. About 98% of these particles are angular, crystalline in appearance under the Konimeter microscope and are less than one micron in size.

E. - SEPARATION OF BRASS FOUNDRY SKIMMINGS - A Steinlein Separator, revolving about 25 RPM, separates brass from about 100 pounds of skimmings an hour. The separator has a 4-inch exhaust duct to a 12-inch fan which produces a suction of about four inches water. Samples taken during the operation of this machine had an average of 1,231,920 particles ten microns or less per cubic foot of air. About 95% of the dust particles in samples taken above the charging chute appeared opaque angular black in color under the Konimeter microscope and were less than one micron in size. About 80% of the dust particles in samples from the trunnion were more crystalline and rounded in appearance and less than one micron in size. This was also true of the samples taken in front of the machine where the slag drops down into a bucket. The dust particles in samples from the metal being discharged from the machine were about 50% metallic in appearance about 50% angular crystalline. Both crystalline and opaque particles were about two microns or less in size. Six men, with an average service of seven years, take turns operating this machine which runs about two hours per day on an average.

## X - MASON'S OPERATIONS

I. - TEARING OUT STILL FIRE BOXES - Two men with an average service of ten years. spend two days a month on an average tearing out slag-covered bottoms of cracking coil furnace fire boxes. Temperature inside fire box is about 85°F. The bottoms which are composed of fire brick are broken up with "Bull Point" Pneumatic chisels. Samples taken inside the fire box while this work was in progress had dust concentrations as high as 1,019,520 particles ten microns or less per cubic foot of air. These particles were glassy sharply crystalline in appearance under the Konimeter microscope. About 90% were five microns or less in size and 10% were over ten microns. The larger particles were semi-opaque. There were also a large number of round black opaque particles about one micron or less in size. After the bottoms had been broken up by the pneumatic chisels they are shovelled out through the firebox door and then reshovelled into trucks to be hauled away. This operation naturally produces more dust than the breaking up inside the fire box. Although no wind was blowing samples taken at face level during the shovelling and loading had dust concentrations as high as 2,435,520 particles ten microns or less per cubic foot of air and an average of 1,345,200. Goggles but no respirators were worn by the workmen.

II. - CHIPPING OR CUTTING CONCRETE - A large number of employees with an average service of three years, spend at least ten per cent. of their time dismantling or cutting concrete structures with pneumatic chisels in the removal of old foundations, concrete supports and blocks and in cutting holes in walls and floors. Samples taken during the cutting or chipping of concrete had as high as 6,910,080 particles ten microns or less in size per cubic foot and a general average of 1,591,051 particles per cubic foot. All of these dust particles are slightly angular crystalline in appearance under the Konimeter microscope. About 85% of the dust particles were five microns or less in size; 10% between five and ten microns and about 5% over ten microns in size. In many cases neither goggles or respirators were worn by the workmen. Regardless of the rather low dust counts found, men engaged in chipping or cutting concrete should wear concrete due to the high silica content in the usual aggregate used in concrete.

III. - CHIPPING MORTAR FROM BETWEEN BRICK - Chipping Mortar with pneumatic chisels from between bricks in walls of structures preparatory to weather-proofing is a particularly dusty operation. Samples taken during this work had dust concentrations as high as 20,956,800 particles ten microns or less per cubic foot of air and a general average of 13,848,480 particles per cubic foot. All of these particles were angular crystalline in appearance under the Konimeter ~~microscope~~ and about six microns or less in size. There were also a countless number of minute reddish-gray particles. This work was done by an outside contractor whose employees wore goggles but no dust respirators.

IV. - CRUSHING FIRE BRICK - Fire bricks are crushed in a belt-driven Williams or a Motor-driven Sturtevant Brick Crusher so that 80% will pass through a 3/8" or a 150-mesh screen - much of it is powdered during the crushing. This material is then mixed with fire clay, crushed asbestos and cement to make "Ganister" which is used in tube sheet linings, packings or as mortar in building fire boxes of furnaces. Samples taken during the crushing of fire brick had dust concentrations as high as 11,554,560 particles ten microns or less in size per cubic foot and a general average of 2,562,960 particles per cubic foot. Crushing new fire brick produces about six times as many dust particles (4,375,733 per cubic foot) as is produced when crushing old, used fire brick (736,320 particles per cubic foot). Under the konimeter microscope about 94% of the dust particles produced by crushing new fire brick appear angular crystalline, one micron or less in size; about 5% are opaque over ten microns and about 1% are dark opaque, scale-like about five microns in size. The dust particles from crushing old used fire brick are more rounded crystalline in appearance and are about five microns or less in size. An analysis of Alamo Fire-clay Brick, which is commonly used and was the new unused fire brick being crushed at the time our samples were taken, supplied by the manufacturers (Harbison-Walker Refractories Company) reports:

| | | | |
|---|---|---|---|
| Silica.................... | 51.8 | per | cent. |
| Alumina and Titania....... | 45.4 | " | " |
| Ferric Oxide.............. | 1.1 | " | " |
| Lime...................... | 0.5 | " | " |
| Magnesia.................. | 0.3 | " | " |
| Alkalies.................. | 1.1 | " | " |

Fire brick is crushed by two men assigned from the Labor Department, the average service of these men is about 14 years. Two to three tons are crushed per day. The total length of exposure per month depends upon the demand for crushed fire brick and will vary from a general average of fifteen hours per man per month to as much as twelve hours a week. Goggles and M.S.A.Comfo dust respirators are worn.

V. - SHAPING FIRE BRICK ON EMERY WHEEL - Fire brick are ground to a specified shape and size on a 2" x 24" Carborundum (Grit 16, Grade 1, Bond 6C) Wheel which revolves 900 RPM. This wheel is almost completely enclosed by a hood which has a 4-inch duct to a 24-inch motor-driven fan operating at 1750 RPM., but this exhaust is evidently inadequate as samples taken while rounding off the edges of a fire clay furnace block had a dust concentration as high as 4,078,080 particles ten microns or less in size per cubic foot of air. The general average was 2,001,658 particles per cubic foot. All of these dust particles were slightly angular and slightly opaque in appearance under the microscope and five microns or less in size. One man wearing goggles and a M.S.A. Comfo respirator, with about 15 years service, spends an average of about two days a month shaping fire brick and blocks on this wheel.

VI. - DISMANTLING MASONRY - Dismantling Masonry structures such as old boiler and still settings is a very dusty operation but was not included in this dust study as there was no work of this type in progress at any of the plants at the time of our survey.

# XI - WOODWORKING OPERATIONS

Woodworking operations, as performed in connection ~~with~~ the refining of petroleum products and associated activities, are used in the production of patterns, box shooks, containers, and construction or maintenance work. These woodworking operations produce more or less dust which is largely organic and although it may have some spores and have an allergic effect on some individuals, it is not considered harmful. Mr. D. Harrington of the U.S. Bureau of Mines advises that the U.S. Department of Labor in a recent bulletin indicate that workers breathing wood dust are far more definitely afflicted with tuberculosis than the general run of industrial workers. In large quantities, however, wood dust belongs in the "nuisance" class and may also be an explosion hazard

A. - BOX SHOOK MANUFACTURE - All pine lumber used in the manufacture of box shooks is "kiln-dried" and all gum lumber is "air-dried". Men work eight hours a shift, five shifts a week.

(a) Resawing - Band saws, twenty-five feet four inches in circumference, resaw four-quarter and five-quarter lumber into 3/8-inch and 1/2-inch shooks respectively. Samples taken during this resawing had an average dust concentration of 155,760 particles ten microns or less per cubic foot of air when sawing pine and 996,864 particles per cubic foot when sawing gum. These low counts indicate that the exhaust and dust collecting system which has been provided is functioning. This exhaust system includes hoods over each saw with 8-inch ducts to a belt driven fan with five-foot blades revolving 3500 RPM. About 60% of the dust particles in samples taken while resawing pine were crystalline, rather glass-like in appearance - probably resin - under the Konimeter microscope and over ten microns in size; 40% were round with rough edges gray and opaque, five microns or less in size. About 80% of the dust particles from cutting gum lumber were round crystalline semi-opaque in appearance, five microns or less in size; 20% were over five microns in size. Gum lumber is resawed only about four days a month.

(b) Ripsawing - Rip saws. 14 inches in diameter cut ends from four-quarter gum lumber. An exhaust system has been provided with a hood over each saw and four inch metal ducts to a belt-driven fan with six-foot blades revolving 3500 RPM. Samples taken during this operation had an average dust concentration of 169,920 particles ten microns or less per cubic foot of air. All of these particles were angular crystalline semi-opaque in appearance under the Konimeter microscope and about three microns in size.

(c) Cut-Off Sawing - Saw four-quarter lumber to make box ends. About 85% of the time gum lumber is sawed, and 15% pine lumber is sawed. Samples taken while sawing gum lumber had an average dust concentration of 877,920 particles ten microns or less per cubic foot of air. About 50% of these particles were round crystalline semi-opaque, gray in color and from five to ten microns in size; 50% were slightly angular crystalline in appearance under the Konimeter microscope and three microns or less in size. There were also several very small black specks. The low dust count indicates that either the particles were mostly over 30 microns in size and were thus filtered out by the porcelain filter or that the exhaust system was effective.

(d) Planing - Planers or double surfacers resurface the four-quarter and five quarter lumber to give it the proper finish. There is an exhaust hood over each machine with an eight-inch metal duct to a belt-driven fan with six-foot blades revolving 3500 RPM. Samples taken during the operation of planers or double surfacers had a general average dust concentration of 509,760 particles ten microns or less per cubic foot of air when planing pine lumber and 415,360 particles per cubic foot when planing gum lumber. Particles of dust produced while planing pine lumber were crystalline rather round in appearance under the Konimeter microscope, about 75% were five microns or less in size; 25% were larger than two microns and rather opaque. Dust particles from planing gum lumber were round opaque in appearance and one micron or less in size.

<u>Dustiness of Shook Factory Air</u> - A series of five samples were taken at five strategic points to determine the average dust concentration of the factory air. These samples gave an average concentration of only 141,600 dust particles ten microns or less per cubic foot of air which indicates that either the major portion of the dust is over 30 microns in size or that the ventilation system is proving effective. The latter is probably the more logical explanation although the excellent housekeeping is undoubtedly an important factor. About 98% of the dust particles in the factory air samples were slightly angular crystalline in appearance under the Konimeter microscope and about five microns or less in size; 2% were round, opaque dark gray in color and two microns or less in size.

B. - BELT SANDERS, SAND DISCS AND SPINDLES OR CYLINDERS - This equipment is used for "squaring up" and smoothing surfaces of wooden patterns, cleaning and finishing barrel-heading and staves and general mill work in the Carpenter Shops. Sanders are a notorious source of fine wood dusts. They are also contaminated with an appreciable amount of silica, if a sand-type of abrasive is used, consequently either hoods for the machines or respirators for the men engaged in operating these machines should be provided. We appreciate that it is rather difficult to properly hood a sander to prevent the fine dust being carried around by the abrasive member, particularly disc sanders. Our attention has been called to a case where a man engaged in the use of sanders suffered recurring respiratory illness and ultimately death from pneumonia. His attacks of illness seemed to correlate with extended use of the sanders.

(a) <u>Belt Sanders</u> - An 8" x 28-1/2 ft. Belt Sander (Lightning Adalox Cloth 1-1/2 - 40 X Grit Norton Abrasives) runs on an average of two hours per day and is used by eight different men with an average service of fifteen years. Samples taken while finishing #1 Pine lumber had a dust concentration as high as 15,519,360 particles ten microns or less per cubic foot of air and a general average of 3,443,712 particles per cubic foot. About 90% of these particles were angular crystalline in appearance under the Konimeter microscope and five microns or less in size; 5% were over five microns in size; 5% were opaque scale-like, ten microns or less in size. There was no hood over this sander and the dust produced was thrown into the shop air.

A 6 in. x 18 ft. Belt Sanding machine (#3 Production Cloth Minnesota Mining Company) runs on average from four to six hours a week and is used by four different men, with an average service of four years. This work was formerly done by hand on a lathe with sand paper. Samples taken while finishing the outside of a barrel had an average dust concentration of 481,440 particles ten microns or less per cubic foot. These particles were largely angular crystalline in appearance under the Konimeter microscope. About 50% were five microns or less, and 50% were over five microns in size.

(b) <u>Sand Discs or Wheels</u> - These discs run from 40% to 60% of the time and are usually used by everybody in the shop in which they are located. Samples taken during the operation of sand discs or wheels had the following dust concentrations:

| No. | Size (Dia.) | Abrasive Used | Work Being Done | Particles Per Cubic Foot | Characteristics of Dust Particles (Sizes and Percentages Estimated) |
|---|---|---|---|---|---|
| I | 7" | #24 Sand Paper Minn. Mining Co. | Cleaning heads Finished Barrels | 604,160 | Angular crystalline about 50% five microns or less and 50% larger than five microns. |
| II | 24" | #1-1/2 Garnet Paper. Minn. Mining Co. | Squaring Wood Pattern | 623,040 | About 85% angular crystalline two microns or less; 5% quartz-like rounded about 10 microns in size. |
| III | 30" | #40 Grit on Bristol Board. Gardner Machine Co. | Smoothing off Pattern | 1,925,760 | About 90% angular crystalline three microns or less; 10% opaque angular one micron in size. |
| IV | 30" | #2 Garnet Net Back. Gardner Machine Co. | Squaring Wood Pattern | 3,624,960 | About 98% semi-opaque, sand-like, one micron or less, 2% opaque 5 microns or over in size. |

The sand disc in No. I was used in a well ventilated cabinet connected to a 48" motor driven fan by a 7-inch duct. The men wore goggles and "Comfo" respirators. The sand wheels in No. II and No. III had hoods with about 3-1/2 inches water suction connected to a 24" motor driven fan by 4-inch ducts. The men wore neither goggles nor respirators. The wheel in No. IV had an exhaust hood with a 6-inch duct connected to a 24-inch duct which in turn was connected with a 36-inch motor driven fan.

(c) <u>Sand Spindles or Cylinders</u> - Sand spindles or cylinders are used on an average of about two hours per man per day. No hood or suction exhaust has been provided for this equipment. Men using it do not wear goggles or respirators although the dust particles produced are more angular in appearance than those produced by sand discs or wheels.

Samples taken during the operation of Sand Spindles or Cylinders had the following dust concentrations:

| Size (Dia.) | Abrasive Used | Work Being Done | Particles Per Cubic Foot | Characteristics of Dust Particles (Sizes and Percentage Estimated) |
|---|---|---|---|---|
| 3" | #Garnet Paper Gardner Machine Co. | Cutting Inside Core Boxes | 2,322,240 | About 60% quartz-like in appearance, ten microns or over in size; 40% semi-opaque five microns or less in size. |

DUST PRODUCED BY SAND SPINDLES OR CYLINDERS (Concluded)

| Size (Dia.) | Abrasive Used | Work Being Done | Particles Per Cubic Foot | Characteristics of Dust Particles (Sizes and Percentage Estimated) |
|---|---|---|---|---|
| 3-1/2" | #1-1/2 Garnet Paper Minn. Mining Co. | Putting Taper on Pattern. | 877,920 | About 90% angular crystalline two microns in size; 10% opaque five microns or less in size. |

C. - MAKING WOODEN CRATES - Two types of saws are used in preparing lumber for making crates for gasoline pumps and tanks:

(a) Band Saws - Samples taken during the operation of Band Saw had a dust concentration of 453,120 particles ten microns or less per cubic foot of air. All of these dust particles were round, opaque in appearance under the Konimeter microscope and three microns or less in size.

(b) Railroad Saws - Samples taken during the operation of an 18" Railroad Saw had a dust concentration of 3,964,800 particles ten microns or less per cubic foot of air. All of these particles were round, grayish opaque in appearance under the Konimeter microscope and about five microns or less in size. There were also numerous minute gray specks too small to count accurately.

## XII - ROCK EXCAVATION

Rock excavation is usually a dust producing operation which is limited to construction activities in the petroleum industry. The hazardousness of rock excavation depends entirely upon the nature of the rock being excavated, the length of exposure and the methods being followed. The principal sources of dust are rock drilling, blasting, mucking and handling of the rock. Of these, drilling probably produces the greatest amount of dust.

A. - DRILLING - The pneumatic rock drill operates essentially as a crushing device which shatters the rock to a powder at the point of impact. According to Theodore Hatch of the Harvard School of Public Health (N.Y. Ind. Bull. Vol. 15, No. 9 - Sept. 1936) the particles of dust thus generated vary in size from one-quarter inch or larger down to sub-microscopic diameters. The dust is removed from the drill hole by a stream of air or water or a combination of the two introduced through the hollow drill steel. In the case of jack-hammer drilling a considerable amount of rock dust ejected from the hole falls back to be crushed further before it is removed again. Quoting Mr. Hatch:

> "The amount of dust produced by a rock drill is surprisingly large - a jack-hammer, operating at the over-all rate of 100 feet of drilling per day, actually crushes more than 200 pounds of rock in eight hours. Of this, at least five per cent. is in the form of particles smaller than ten microns; hence, more than fifty grams of dust small enough to be air floated is generated per foot drilled. In terms of numbers of particles the figures are enormous - it has been found that a jack hammer produces as much as one billion particles of hygienic interest during one minute of operation".

B. - BLASTING - It is often said that blasting produces the greatest amount of dust in rock-excavation. This statement is contradicted by some authorities who refer to the fact that the blast dislodges a great deal of dust from the rock surfaces deposited there from earlier drilling operation in addition to that actually generated by it. Under this condition blasting is undoubtedly followed by a higher dust concentration than in the case when all the dust produced by drilling is captured and conveyed to a remote collector so that only that actually generated by the explosion escapes into the air.

While it is undoubtedly true that if drilling is done dry, there will be deposition of some of the dust on the surfaces of the excavation and later be raised by blasting, however, dust from this source is minimized if drilling is done wet, because the slushed out particles tend to form agglomerates, which are not so readily raised by the blasting operation. Also, when good practice is followed, the face and sides are wet down with water before blasting, and in mining work, there is a continuous water spray that is started onto the heading before the blast takes place and continued for some time after to help allay the dust and to wet down the material, so that dust raised during mucking will be at a minimum.

C. - MUCKING - The amount of dust produced by mucking and other rock-handling operations varies greatly with the nature of the operation. On open excavation it is probably of little importance, but in confined sources as in tunnels and mines the dust concentration associated with rock handling may reach dangerous levels.

D. - DUST CONTROL - Methods for the control of dust in rock excavation as suggested by Mr. Hatch include:

(a) - <u>Wet Drilling and Wetting Down Rock Walls and Muck Piles</u> - In general it may be said that water is less effective against quartz-bearing rock than against silica-free material such as lime-stone. The usefulness of water is limited when freezing temperatures are encountered and it produces objectionable working conditions especially for overhead drill operators and is certainly to be avoided if a pneumonia hazard exists. A fundamental objection to the wet method is that the dust is not removed from the scene of operation but simply suppressed near its source where it remains to be thrown into the air by a subsequent disturbance such as blasting.

(b) - <u>General Ventilation</u> - The purpose of general ventilation is to dilute the dusty air with sufficient clean air to bring the concentration down to a satisfactory level. Two precautions are required:

1st. - the fresh air itself must be free from dust and
2nd. - it must be properly distributed through the workings to insure maximum mixing with the dust laden air.

(c) - <u>Dust Exhaust Hoods on Drills and Other Mucking Operations and Local Sources of Dust</u> - Effective dust control can be secured by means of a dust trap which surrounds the drill steel at the rock surface. The dust-laden air is captured as it emerges from the drill-hole by the inflow of clean air into the trap. To be effective, the inlet velocities must be great enough to prevent the outward movement of the dust and sufficient velocity must be maintained at all points within the trap to prevent settling and clogging. The collected dust is conveyed by the air-stream through hose and piping to a suitable dust separator in which the air is freed from its dust load and thus is discharged from the apparatus as clean air. Traps of different designs are required with various drilling operations and special supporting devices are necessary to hold the trap in proper alignment with the several operating positions. (NOTE: The dust trap is satisfactory under many conditions, but again under many other conditions has not proved satisfactory. RSB)

The dust dispersed during mucking, as well as that arising from rock drilling, can be controlled by local exhaust ventilation and requires no elaborate apparatus.

(d) - Personal Protection By Means of Respirators and Positive - Pressure Masks - An effective respirator or a positive-pressure mask supplied with an adequate quantity of dust-free air provides the wearer with protection when it fits the face properly and is worn continuously in dusty atmospheres. Respirators and masks have a legitimate place in the field of silicosis control, especially to provide protection against infrequent unexpected dust concentrations but cannot be recommended as a substitute for dust control in continuous operations.

# 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 of control cannot be depended upon to provide the first line of defense; in this respect it may be likened to the use of personal immunization as a primary safeguard against the spread of typhoid fever. Dust respirators and air masks do, however, have a definite place in the field of dust control, especially as an emergency measure, as a means of protection on infrequent dusty occupations and as an adjunct to other more fundamental methods of prevention.

Reports made to the National Silicosis Conference, called by the Secretary of Labor in February (1937) to study specific phases of the silicosis problem and present suggestions for its solution, contained many recommendations by qualified authorities on the subject which have been successfully employed under actual operating conditions. Briefly summarized measures for the control of dust and the prevention of pneumoconiosis include:

A. - DESIGN PLANT FOR DUST CONTROL - Much can be accomplished through design when new buildings are contemplated or when old buildings are to be remodeled. For instance, structural projections and ledges may be minimized to prevent the accumulation of dust that might later be released into the atmosphere by air currents or by building vibration caused by travelling cranes, vibrating machinery, and equipment that have large reciprocating parts. The Engineering Committee recognized the fact that our present day engineering and structural materials for factories do not permit elimination of innumerable ledges and projections without prohibitive building and roofing costs. However, building interiors should be so contructed that they may be easily cleaned by washing, hosing, vacuum cleaning or brushing. In some cases operations may be located over gratings, beneath which equipment is provided for removing the materials and dust that fall through.

B. - PROVIDE BUILDING VENTILATION - Natural ventilation should usually be considered only an adjunct in removing or reducing dust in the air. Even though it is possible to have high roofs in one-story structures which will give the greatest benefit from natural ventilation, such methods cannot be relied upon to provide complete protection in dusty operations. Where mechanical ventilating systems are provided, care should be taken to prevent strong drafts from open windows and doors destroying the effectiveness of the system. Guards and shields should be placed in the vicinity of hooded and partially enclosed processes to prevent such a condition.

C. - STORE DUSTY MATERIALS IN DUST-TIGHT BINS - Dusty materials should be stored in dust-tight bins, tanks, or enclosures, but each structure of this type should be provided with a breather or vent stack -- perhaps with an exhaust fan in the stack -- to permit the air displaced during loading to be carried outside the building. Basements may be used for storage purposes but should not be used for dusty manufacturing operations.

D. - ENCLOSE MATERIAL HANDLING EQUIPMENT - Excessive dust created by mechanized material - handling equipment can usually be controlled by provision of adequate housing and application of exhaust systems. Some materials can be kept in a moist condition while being handled, but when this is done, the material may dry out and be dispersed into the atmosphere as dust.

E. - ISOLATE DUSTY PROCESSES - Where possible, several or all dusty processes may be isolated from the rest of the plant. This sometimes permits the installation of a more compact exhaust system resulting in more efficient operation and lower maintenance cost.

F. - PROVIDE WET METHODS OF OPERATION - Water, oil, and other liquids may be used effectively:

1. To suppress dust at the point of origin in such operations as rock-drilling; handling, pulverizing, and milling rock and ore; grinding metal on grindstones; abrasive-wheel cutting of granite and sandstone.

2. To prevent the re-dispersion of dust that has settled on the floors, walls, and other surfaces such as in the granite industry and in foundries.

G. - DESIGN EQUIPMENT TO CONTROL DUST - When new machinery or other equipment is contemplated, the manufacturer can frequently be encouraged to include dust control features such as exhaust hoods as an integral part of the design and construction.

H. - PROVIDE EXHAUST SYSTEMS - In some operations, exhaust systems may be installed to remove dust at its point of origin. In many cases several small systems are preferable to a larger system. Any mechanical ventilation system should be designed to meet at least the minimum requirements of local State laws or industrial codes, or lacking such requirements, should be installed according to the best accepted practice.

Dust Arresters - Provision of dust arresters will prevent hazardous dusts from being circulated into other parts of the plant or into the neighborhood. The location of dust arresters is very important, particularly if dry types of arresters are used. Provision should be made for removal of the collected dust without its escape into the area where the arrester is located.

I. - ESTABLISH MAINTENANCE AND GOOD HOUSEKEEPING PROCEDURE - Good housekeeping is unquestionably the cheapest single method of controlling dust. Maintenance goes with it hand in hand. The best equipment in the world will not control dust if superintendents, foremen, and workers are careless and disorderly in their work. Eight suggestions are advanced by the Conference Committee:

1. If dust-tight equipment is installed it should be inspected at regular and frequent intervals and all defects should be corrected as soon as they are detected.

2. Operations should be performed in a manner that will create the minimum amount of dust.

3. Use water under pressure where possible to clean building interiors.

4. If practicable, combine water with air for cleaning purposes. All cleaning should be done, if possible outside of working hours and men engaged in this operation should be provided with dust respirators.

5. Vacuum cleaning removes dust without dispersing it elsewhere.

6. Brushing is particularly adaptable for cleaning buildings of the older type of construction.

7. Low-pressure steam can sometimes be used to advantage.

8. A responsible person should be assigned the task of supervising maintenance and housekeeping activities. Among other things he should make tests from time to time to ~~make sure~~ that the dust control program is achieving the desired results.

J. - PROVIDE RESPIRATORS - The Conference Committee was of the unaminous opinion that "dust elimination must be given primary consideration in solving the silicosis problem". Nevertheless, when known methods of elimination are not applicable or are ineffective, respirators should be provided as "a last resort and for occasional exposure only. Rotation of personnel under these conditions is advisable." The report definitely states that there will always be places where other methods will be inapplicable and ineffective, and respirators will be required for doing the work, also that there will be situations where respirators will be the primary means of protecting the workmen. The scope of good use of respirators is considerably beyond that of occasional exposure. The need of rotating personnel depends on the type of work done and the supervision given the workmen. In some operatins, respirators are as much a part of the workman's equipment as his tools. Certainly, it cannot be expected that a person can wear a respirator for several hours continuously - but how many jobs are there that would require a person to keep the respirator on continuously for an extended period of time. The common practice in the majority of industrial occupations is that the person is intermittently exposed and is afforded many opportunities for the periodic removal of the respiratory protective device. The two general types of respirators which the Committee considered suitable for protection against silica dust are:

(a) Air-purifying respirators that filter out the dust particles.

(b) Supplied-air respirators in which dust-free air breathed by the worker comes to him from an uncontaminated outside source.

Most respirator manufacturers have submitted their devices for testing and approval by the U.S. Bureau of Mines, and only those which have been approved should be used.

(a) <u>Air-Purifying Types of Respirators</u> - Of the air-purifying class, the type most commonly used is the mechanical filter respirator for mechanically-generated dust. These respirators give no protection from gases and vapors. They generally consist of half facepieces to which are attached an exhaust valve and a filtering medium that removes the dust from the inhaled air; some are equipped with a filter medium that removes paint mists and some fumes. They are light in weight and inexpensive. Filter pads must be changed at certain intervals, depending on the concentration of dust. Some types restrict the field of vision. The general requirements of a safe and suitable Mechanical filter respirator are (1) adequate protection, (2) reasonable comfort and convenience, (3) an acceptable service life period of protection, (4) easy cleaning and sterilization, and (5) low cost of maintenance in good serviceable condition.

Studies of mechanical filtration by fibrous materials made by such agencies as the United States Bureau of Mines (U.S. Bur. of Mines, Tech. Paper No. 394 (1926) and U.S. Pub. Health Bull. No. 177 (1928)) and the Harvard School of Public Health (Journ. Indust. Hyg. 9,26 (1927)) revealed that filtering efficiency varies with the particle size and the amount of solid particulate matter retained; also that the resistance to air flow varies with the amount of solid particulate matter retained and the rate of air flow. After all, the fundamental basis for judging the suitability of a respirator is whether or not the amount of dust that is unretained or escapes through the filter under conditions of practical use is below the amount that would be harmful to breathe. This is not related to any percentage efficiency. In order to meet the Bureau of Mines requirements for approval, a respirator must satisfactorily remove dusts of the following size characteristics:

| | | | | | |
|---|---|---|---|---|---|
| 99 | per cent | smaller | than | 2.80 | microns |
| 95 | " | " | " | 1.80 | " |
| 90 | " | " | " | 1.40 | " |
| 80 | " | " | " | 1.00 | " |
| 70 | " | " | " | 0.85 | " |
| 60 | " | " | " | 0.72 | " |
| 50 | " | " | " | 0.60 | " |

It will be noted that 80 per cent of the dust used in these approval tests is below one micron (1/25,000th of an inch) and 50 per cent is below 0.6 microns. Canisters will not remove dusts of these characteristics and should not be used as dust respirators.

In order to obtain the desired protection, it is essential that the facepieces of the mechanical-filter respirators fit the face of the workman snugly but with a minimum of head-band tension. A simple practical test, suggested by Carlton E. Brown of the U.S. Bureau of Mines Experiment Station in Pittsburgh, Pennsylvania (Jour. Indust. Hyg. Feb. 1937 Vol. 19, No. 2, p. 98), that anyone can run to determine whether a respirator facepiece is making a tight seal, is to wear it in a high concentration of coal dust. The time of the test can be shortened by blowing a stream of air containing a high concentration of coal dust around the edges of the facepiece. The location and approximate magnitude of the leaks are shown by streaks of coal dust on the part of the face covered by the facepiece. Another test, according to Mr. Brown, consists of plugging the intakes of the respirator and then attempting to inhale. This type of test could well be supplemented by the Coal dust test.

(b) <u>Supplied Air Respirators</u> - Industrial processes such as pneumatic drilling, abrasive blasting and spray coating have introduced atmospheric conditions for which the air-purifying type of respirators are not particularly suitable. Certain kinds of pneumatic drilling are responsible for dust concentrations so high that they would rapidly overload a dust respirator. The operator of an abrasive blasting outfit must be protected not only against the inhalation of air containing high concentrations of dust, but also against impact and abrasion of the head and shoulder by the rebounding abrasive and loosened abraded material. Spray coating is responsible frequently for pollution of the surrounding atmosphere by a combination of particulate matter (mists that are liquid particles or a combination of solid and liquid particles) and harmful vapors resulting from the evaporation of the liquid vehicle of the coating used in the spray gun.

Since these operations are carried out frequently in isolated places and at different locations at various times, they do not lend themselves always to general control measures. Therefore, supplied air respirators perform a definite service. The types in general use are those commonly known as hose masks, air-line respirators, and abrasive blasting respirators such as sand blast masks, helmets, and hoods.

Supplied-air respirators have the following advantages for routine non-emergency use over those of the air-purifying respirators such as gas masks, mechanical-filter respirators and the combination of gas mask with a mechanical filter:

1. NO resistance to inhalation.

2. Freedom from inward leakage of contaminated air.

3. Protection against all kinds of contaminants and even against atmospheres deficient in oxygen which will not poison or irritate the skin.

4. The Inflowing air reduces excessive perspiration and tends to cool the face.

5. When a hand-operated blower is used a second person is always present. (With an approved mask, provided the facepiece is tight, the wearer can inhale enough air through the hose to escape if the blower should stop).

<u>The Air-Line Respirator</u> consists of a tight-fitting facepiece, a loosely fitting facepiece or even a helmet or hood covering the head and extending down over the neck or shoulders. The air supplied to these respirators has been largely that obtained from the compressed air source used in the performance of the work, as in sand blasting, pneumatic drilling and spray painting. This air is frequently contaminated with objectionable and, in some instances, harmful substances which, to some extent, can be removed by means of air-purifying appurtenances. In discussing "Respiratory Protective Devices" in the February (1937) issue of the Journal of Industrial Hygiene and Toxicology, Mr. C. E. Brown of the United States Bureau of Mines wrote:

"Using air from the ordinary compressed air system found in industry to supply respirators is not to be indiscriminately recommended. These compressed air systems are usually of the high pressure, internally lubricated, reciprocating-compressor type. The air supplied by these systems is contaminated frequently with malodorous constituents such as vapors, mists and products of decomposition of the compressor lubricant, slugs of water, and rust from the pipe line. All or most of these contaminants can be removed probably by some of the commercial air purifiers sold for this purpose. A pressure-reducing mechanism should be used also in the line to prevent any possibility of sudden accidental blasts of high-pressure air from injuring the lungs of the wearer of the respirator. With a compressor of this type there is always the possibility, however rare it may be in well-kept systems, of the generation of carbon monoxide due to overheating of the compressor lubricant (Jour. Indust. Hyg. 18, 461 (1936)). This danger can be minimized or eliminated by the use of temperature controls or carbon monoxide alarms on the compressor which, of course, should be so maintained as to prevent the generation of carbon monoxide.

"The trend in supplied-air respirators is to use special low-pressure, externally lubricated, positive-pressure air-supply devices. Most of the objections to the high-pressure reciprocating-type compressor do not apply to an air-supply of this kind. Since these devices are not common in industry, however, it is usually necessary to purchase a special one for use with the respirator. Since air purifiers, pressure-reducing mechanisms, and special compressor-control or alarm mechanisms are not necessary, the price of this respirator complete with air-supply device should not exceed that of the other type of respirator without the air supply system.

"The use of a special air-conditioning unit to regulate the temperature and humidity of the air supplied to the respirator wearer is desirable."

The minimum air supply for a respirator designed to use all the air for respiratory needs at a high degree of efficiency is generally agreed among Industrial Hygienists to be at least four to six times the air breathed per minute. As a general class, respirators with loose-fitting facepieces, hoods, or helmets require 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.

Abrasive Blasting Respirator - 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) Acceptance and Use of Personal Respiratory Protection by Workmen - 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 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 <u>quantity</u> 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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July Fifteenth
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R S Bonsib

R. S. Bonsib
Chief Safety Inspector
Standard Oil Co. (N.J.)