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* INDUSTRIAL WORK CLOTHES : THEIR PROVISION AND LAUNDERING *
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INDUSTRIAL WORK CLOTHES : THEIR PROVISION AND LAUNDERING

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Modern petroleum technology and the production of synthetic hydrocarbon materials have introduced a number of compounds and processes which may adversely affect the health of workers unless certain precautionary measures are practiced. Among these precautionary measures which are receiving ever-increasing consideration, at the present time, is the issuance of industrial work clothing to employees and the installation of plant laundry facilities to insure that such clothing is properly cleaned and maintained.

Appropriate work clothes, properly fitted and maintained, play a prominent part in an industrial worker's health and efficiency. This is especially true when persons are working with more or less toxic or carcinogenic materials or where cleanliness is a factor in the maintenance of product quality. Consequently, many of the more progressive industrial organizations, such as E.I. duPont de Nemours & Company, the American Cyanamid Company and the Borden Company, have for years supplied their employees with work clothing and have instituted a laundry service.

More than twenty years' experience has definitely shown that this practice pays substantial dividends, both financial as well as improved public and employee relations. At the same time, there has been very little difficulty or resentment resulting from the provision of work clothes and their laundering on the part of employees in the past not receiving this service nor from local outside laundries and merchants.

In order to obtain definite data as to the practical aspects of providing work clothing and the operating of plant laundries, visits have been made to the Chambers Works of the duPont Company at Deep Water, New Jersey; American Cyanamid Company, Calco Chemicals Division's plant at Bound Brook, New Jersey; and Borden's Farm Division laundry at East New York, New York. The information obtained during these visits is herewith briefly summarized:

ISSUANCE OF INDUSTRIAL WORK CLOTHES

Work clothes are usually issued upon requisition from the employee's foreman or supervisor at a store-room at one end of the Employee Service Building (Wash and Locker Rooms) or adjacent thereto. There appears to be no uniform practice as to the type of clothing supplied which obviously is determined by the nature of the man's work. Cotton garments make up the major bulk of the clothing, with the exception of men handling acids who are given wool shirts.

In order to facilitate keeping records of clothes issued, a 3" x 3" card file is usually kept. A sample of such a card is this one used at the Bound Brook Plant of the American Cyanamid Company:

Name		Locker No.	
Clock No.		Days Employed	
Notice To Paymaster			
Outside Clothing		Underwear	
Chest	Jumper	Chest	Shirt
Waist	issued	Waist	issued
Leg	Overalls	Leg	Drawers
Back		Back	
Sign _____			
Employee			

Chambers Work: Upon employment all operators and maintenance men are given two pairs of trousers, two shirts, two suits of long underwear, two large towels (Turkish), a cake of soap and a pair of wooden-soled sandals. These sandals are worn while going to, from and taking shower baths. They are obtained from the Reece Wooden Shoe Company, Columbus, Nebraska and cost about fifty cents a pair. Upon requisition from his foreman, an employee receives two new towels every six weeks and a new cake of soap every two weeks. The first issue of clothing is free after which employee is supplied with two new issues a year at half price, upon requisition from the foreman. All clothing contaminated or damaged to such an extent that it must be discarded is replaced at Company expense. Clothing supplied to employees must be returned when they are terminated.

Bound Brook Plant: Originally all production men were given cover-alls, underwear, soap and towels but recently the Union has insisted that this service be extended to maintenance men. Three sets of clothes are furnished a year. A set includes two pairs of drawers (winter or summer weight), two suits of long-sleeved under-shirts (winter or summer weight), two suits of cover-alls or two dungarees and two jackets. Formerly this clothing had to be paid for over three pay-days, but it is now free. The towels are "heavy duty" 22 inches by 24 inches in size. The underwear is Utica Knitting Company, flexible rib, steam shrunk. The cover-alls are "Army Surplus" or "Franklin Overalls from Paterson, New Jersey. All clothing is stencilled with the employee's check number with "Hercules Indelible Ink, obtained from H. Kohnstamm & Company, Inc. 63-91 Park Pl., New York, N.Y. at \$4.90 per quart. This ink is especially effective as it will withstand numerous washings.

Borden Company: Uniforms, overalls, coats, pants, aprons, caps and towels are furnished free for all plant men (Production Workers), platform men, foreman, wholesale drivers and laboratory technicians. Towels and socks are supplied to office employees and to men in the Printing Shop. Uniforms and towels are changed daily.

LAUNDERING OPERATIONS

Plant Laundries are usually located where the utilities (water, steam, gas and electricity) are readily accessible for example, in one corner of the Employee's Service Building (wash and locker rooms) such as at the Bound Brook Plant of the Calco Chemicals Division of the American Cyanamid Company or in a separate building such as the 30 ft. x 60 ft. corrugated iron building at the Chambers Works of the duPont Company. Borden's laundry for the Metropolitan Area is a part of their Atlantic Avenue Pasteurizing Plant.

EQUIPMENT - The necessary laundry equipment depends upon the type and quantity of work clothes to be processed. Most cotton and woolen work clothes with the exception of white uniforms, are simply washed and dried and not ironed. The necessary equipment is listed below:

Charters Works: One 42" x 72" Troy Premier Washer (2 sections) manufactured by the American Laundry Machinery Company. Capacity 300 lbs. dry clothes. Used for overalls, coveralls, jackets, etc. One 36" x 54" Washer (2 sections) manufactured by the Troy Manufacturing Company. Capacity 200 lbs. dry clothes and used for under towels and socks.

One 40" x 18" Mercury Extractor, manufactured by the Troy Manufacturing Company and has a capacity of 225 wet clothes. One 28" x 10" Extractor manufactured by the American Laundry Company and has a capacity of 75 lbs. of underwear per hour. These centrifugal extractors remove approximately 50 percent of the water during the 15 minutes operating time. Both extractors are equipped with safety devices which prevent covers from being opened when machines are in operation.

One 40" x 64" Dryer and two 36" x 90" Dryers manufactured by the American Laundry Machinery Company. The two dryers use forced steam-heated air and each dries 225 pounds of wet clothes per hour at a temperature of 180°F. Wool clothes are put on hangers and dried slowly overnight in a steam-heated (3 radiators) plant fabricated room at a temperature of about 130°F. This room can handle about 200 pounds of wet clothes per day.

Bound Brook Plant: One 42" x 64" Norwood Washer and two 42" x 54" Norwood Cascade Washers manufactured by the American Laundry Machinery Company. One 50" and one 30" Notrax Extractors manufactured by the American Laundry Machinery Company. Twelve Zone-Air Dryers manufactured by the American Laundry Machinery Company. This laundry also has an overhead monorail system for transporting laundry from the washers to the extractors and then to the dryers.

Borden Company: Four Stainless Steel Smith Drum Washers made by the American Laundry Machinery Company. Three Extractors made by the American Laundry Machinery Company. One Norclone Dryer. All of this equipment has been in service about 20 years.

Modern Equipment: Considerable progress has been made during recent years in the design of laundry machinery for high production sterile-clean washing with lowest possible manpower demand since most of it is push-button controlled. Here are some examples of recent equipment now being manufactured by the American Laundry Machinery Company, Cincinnati, Ohio:

"CASCADE AUTOMATIC WASHER" unloads mechanically in less than a minute. Washes laundry in shortest possible time. Self contained -- requires no additional equipment or supplementary unit for operation. Streamlined design -- all moving parts enclosed for safety. Full-skirted front -- ends gutter-splash and seamy filers. Proved design -- saves supplies steam and water. Built to do the job better, faster, at less cost. Uses AC 220 volts, 60 cycle, 3 phase electric power. Price f.o.b. Cincinnati:
42" x 54" with 4 HP motor, Capacity 225 lbs. dry clothes, \$5130.00
42" x 64" with 7 HP motor, Capacity 300 lbs. dry clothes, \$6210.00

"CASCADE AUTOMATIC CONTROL" is designed for use as a companion unit with any American Cascade Washer, to automatically perform all operations of the best predetermined washing formula. It saves washman 39 separate operations. Price f.o.b. Cincinnati for Full Automatic Control, \$1500.00, for Semi-Automatic Control, \$960.00.

WATER EXTRACTION is designed to remove surplus water from washed laundry work more rapidly. It also increases production and cuts labor costs by eliminating all manual handling of work from time it is unloaded from the washers until it is deposited mechanically at the damp assembly or various finishing department. Price f.o.b. Cincinnati for the 50" size, the most generally used, with a capacity of 320 lbs. is \$5860.00.

ZONE-AIR DRYING TUMBLER incorporates an entirely new principle of tumbler engineering which enables it to dry all classifications of laundry work rapidly and at extremely low cost due to concentration of heated air in "zone" where work is most thoroughly opened up for greatest exposure to the drying air. This results in lower steam and power costs and sweeter smelling work -- because greater effectiveness of the high-velocity, heated air makes drying less dependent on heat. Work is dried more naturally, as when hung in a strong, warm breeze. Price of the 36" x 30" ZONE-AIR DRYING TUMBLER complete is \$745 f.o.b. Cincinnati, Ohio.

LAUNDRY PERSONNEL - The Chambers Works Laundry staff has a foreman and seven men on the 8:00 A.M. to 4:00 P.M. shift and one man on the 4:00 P.M. to 12:00 Midnight. The wage rate at present is \$1.37 per hour plus a \$3.00 per day bonus.

The Bound Brook Plant Laundry has a staff of a foreman and eleven men: Three men on day shift, six men on afternoon shift and two men on the midnight shift. Two women working one shift of eight hours making necessary garment repairs. All men start at the hiring rate of \$1.035 per hour for 30 days; \$1.065 per hour for the next 60 days, after which the washers and countermen get \$1.10 per hour.

The Borden Company's laundry has a foreman at \$71.00 per week, five women at \$44.00 per week, one seamstress at \$46.00 per week, a driver at \$61.00 per week who collects and delivers the laundry from the various branches and stations.

There appears to be very little labor turnover among the plant laundry workers. The average service at the Borden Laundry is 15 years, 8 years at the Chambers Works Laundry and 5 years at the Bound Brook Plant Laundry.

AMOUNT OF LAUNDRY PROCESSED - The Chambers Works Laundry does from 750 to 850 bundles (pants, shirts, underwear, socks, towels, coveralls and jumpers) per day. This is approximately 4,000 pieces or about two tons dry weight.

The Bound Brook Plant Laundry on an average does about 3600 coveralls, 7200 suits of underwear and 1000 towels per 24 hours.

The Borden Laundry is the only one of the laundries visited that finishes any work, the others only do "rough dry work". On the average they finish weekly 480 coats, 480 pants, 200 aprons, 12 caps, 10,000 towels, 175 unionalls, and 75 shirts. In the Rough Dry class, the daily average output is 1000 coats, 1000 pants, 80 towels and 40 unionalls.

LAUNDRY PROCEDURES - There is, of course, some variation in the laundry procedure at the various laundries visited, however, the procedure at the Chambers Works Laundry which is outlined below, is typical:

Canvas laundry bags, each containing approximately 20 bundles, are received daily from the various change houses by garage truck. Each bundle is tied and tin-tagged, showing man's check number, name and change-house. The bags are opened and bundles placed on sorting table. One man removes tag and passes bundle on to another worker who enters name and number on a laundry check sheet. First man then calls out pieces by name (pants, shirt, socks, etc.), which second man enters on check list. A numbered identification safety pin (10 to a set obtained from H. Kohnstamm & Company, Camden, New Jersey), is pinned to each piece of clothing. Clothes are separated in laundry baskets as to woollens, towels, underwear, and socks; pants, shirts, etc. The clothes are then washed as follows:

A. Clothes (not from dye operations):

Operation	Gals. of H ₂ O in Washer	Ingredients Used	Amt. per 100# Dry Clothes	Temp. of Water	Running Time
Rinse	78	Water	---	100°F.-120°F.	5 Min.
Wash	38	Perlite	8 oz.	----	----
		Simplex	16 oz.	160°F.	10 Min.
Suds	38	Simplex	16 oz.	160°F.	10 Min.
Rinse	78	Water	---	170°F.	5 Min.
Rinse	78	Water	---	140°F.	5 Min.
Rinse	78	Water	---	Cold	5 Min.
Rinse	78	Water	---	Cold	5 Min.

B. Clothes from Dye Operations are washed as above with the exception that 12 ozs. of Perlite (alkali) is used instead of 8 ozs., and 24 ozs. of Simplex instead of 16 ozs.

C. Greasy and Paint Stained Clothing:

Operation	Gals. of H ₂ O in Washer	Ingredients Used	Amt. per 100# Dry Clothes	Temp. of H ₂ O	Running Time
Wash	38	(Perlite (Pentrol (Marcoloid	16 oz. 1 Pt. 40 oz.	180°F. --- ---	10 Min. --- ---
Suds	38	Simplex	32 oz.	170°F.	10 Min.
Rinse		Water	---	160°F.	5 Min.
Rinse		Water	---	100°F.	5 Min.
Rinse		Water	---	100°F.	5 Min.
Rinse		Water	---	Cold	5 Min.

D. Wool Clothing (Not from Dye Operations) are washed in 78 gallons of water at 100°F. with one pint of DuPont LS Paste per 100 lbs. of dry clothes for 10 minutes and given two rinses with 78 gallons of water at 100°F. for 5 minutes each.

E. Wool Clothing from Dye Areas is given same treatment as above except for an extra wash. Laundry bags are washed daily with wool clothing.

(The compounds: Perlite, Simplex, Pentrol and Marcoloid used in the washing operations are products from H. Kohnstamm & Co., New York and Chicago. DuPont LS Paste is a DuPont product.)

Flame Resistant Treatment of Clothing: After clothes have been washed and wrung, they are left in the large wringer (extractor, where approximately 40 gallons of Fire Retardant CN (An ammonium sulfate product made by the DuPont Company) solution (1.1 Sp. gr) is added. Clothes are soaked in this solution for two minutes, wrung and dried. The solution is recovered, brought up to the original strength and reused. All pieces of flame-treated clothing are stamped (3 diagonal bars) with water soluble yellow dye ("Lithosol" F Yellow 3 G Paste, a dye starch mixture made by Chambers Works DuPont Company Technical Laboratory and applied by a rubber stamp), before they are returned to the areas. This gives area supervision a check on men who are required to wear such clothing.

Sorting and Bundling: After clothes have been dried they are sorted on numbered hooks on moveable racks. The racks are then rolled to outgoing "bundling" table where each man's clothes is checked with original "check list", then bundled. Bundles are packed in the Change House Laundry Bags (which have been laundered). After tying up and tin-tagging a carbon copy of the "check list" is placed in each bag which is of value to the change house attendants in handling distribution of clothing.

Sharp articles, such as razor blades, left in pockets of dirty clothes presents a serious hazard. Care must be exercised in handling laundry pins. Clothing contaminated with toxic materials such as Betanaphthylamine, Benzol, etc., are given special treatment at the Laboratory before being sent to the Laundry. They are kept separate and handled with rubber gloves.

Bound Brook Plant Laundry Procedure: The washing operation at the Bound Brook Laundry is very similar to that outlined above except that all coveralls are given a 10 to 15 minute soak in an agitated solution of 4 pounds of Soda Ash in 80 gallons of water at 150°F., rinsed, then washed for 20 minutes in 9 ozs. 92% Armour's Soap Powder in 60 gallons of water at 150°F. in a Norwood Cascade Washer, rinsed, placed in a centrifugal extractor for 20 minutes and dried 20 to 30 minutes in a Zone-Air drier.

The following formula has been recommended for laundering work clothing soiled with grease and grime:

"Use a mixture consisting of 2 parts by weight of Sodium Metasilicate to 1 of soap, or 4 parts of Sodium Metasilicate to 3 of soap, and add sufficient to the wheel to give desired amount of suds. For flat work and some colored goods, 3 parts by weight of soap and 2 parts of Sodium Metasilicate.

USEFUL LIFE OF GARMENTS - The Chambers Works of the duPont Company report that coveralls and underwear on the average withstands 15 to 20 washings before they must be replaced. This is probably due to the type of compounds encountered rather than to the laundering operations.

The Bound Brook Plant of the Calco Chemicals Division has found that the life of their coveralls is 150 washings; and their underwear, about 200 washings.

Total Cost Of Laundering Work Clothes - According to Mr. A. C. Pease, General Superintendent of the Bound Brook Plant Laundry the total cost (including labor, materials, rent, light, steam, water, interest and amortization) of laundering work clothes is \$0.032 per pound of dry clothes. The cost of labor and materials alone is only \$0.016 per pound of dry clothes. The best price that could be obtained from outside local laundry was \$0.08 per pound dry clothes.

Mr. W. E. Kite, Foreman of the Chambers Works Laundry reports that the total cost, including all direct and indirect charges was about \$0.03 per pound of dry

We were unable to secure the cost per pound of work clothes laundered at the East New York Laundry of Borden's Farm Products, however, here are the prices charged against the various departments having work done.

ROUGH DRY WORK

Coats	\$0.05
Pants	0.05
Towels	0.015
Rags	0.015
Union-Alls	0.10
Machine Covers	0.395
Dish Cloths	0.015
Pulver Bags	0.10

FINISHED WORK

Coats	\$0.095
Pants	0.095
Drivers' Shirts	0.11
Overalls	0.125
Towels	0.03
Nurses' Uniforms	0.315
Doctors' Coats	0.315
Union-Alls	0.14

C O N C L U S I O N S - At all points visited there was general agreement that it was "good business" to provide work clothes and underwear to employees on jobs which involved exposure to toxic and irritant materials or particularly dirty jobs involving oil, grease, grime and soot. It was also generally agreed that a plant laundry properly equipped and operated was a profitable investment which insured that work clothes would be properly laundered and maintained.

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DEPARTMENT OF THE INTERIOR
UNITED STATES BUREAU OF MINES
JOHN W. FINCH, DIRECTOR

INFORMATION CIRCULAR

SOME PROBLEMS OF RESPIRATORY PROTECTION IN THE
PETROLEUM INDUSTRY, WITH SUGGESTIONS
FOR THEIR SOLUTION



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BY

G. M. KINTZ AND H. C. FOWLER

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INFORMATION CIRCULAR

DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

SOME PROBLEMS OF RESPIRATORY PROTECTION IN THE PETROLEUM INDUSTRY, WITH SUGGESTIONS FOR THEIR SOLUTION¹

By G.M. Kintz² and H.O. Fowler³

Proper respiratory protection of workmen, regardless of the industry or the individual occupation, is fundamental for their health, safety, and efficiency. The problems involved in providing this protection have virtually the same elements, although it is unlikely that two jobs, even on the same type of work, will have exactly the same hazards. Satisfactory solution of problems created by atmospheric conditions that are unsafe or detrimental to the health and efficiency of workers can be reached only after careful analysis of individual circumstances. The specific impurity in the air to which each worker on each job is exposed must be determined, its dangers recognized, and effective protective measures taken - measures that not only protect but offer a minimum of inconvenience to the worker. Health and safety studies of respiratory hazards require a broad knowledge of the physiological effects produced by various dusts, mists, fumes, and gases and of the physical and chemical reactions that permit quantitative detection and elimination of these substances from the air breathed by workmen.

The literature pertaining to protection against toxic gases in the petroleum industry is extensive, but writings dealing with dusts and other noxious air-borne material peculiar to that industry are relatively few. Accordingly, this paper deals mainly with hazards of the latter type and makes no suggestions as to protection against them. By drawing on the experience of other industries it is hoped that the information will help to promote greater health and safety among workmen and assist safety, personnel, and compensation departments in the petroleum industry to meet their individual problems, whether they pertain to burning lead, spraying paint, sand-blasting, cleaning and repairing tanks and stills, or other occupations in which men are exposed to respiratory hazards.

In preparing the following discussion of dust and related hazards in the petroleum industry, material has been drawn freely from and frequent reference is made to a series of publications prepared recently by the Health

The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U.S. Bureau of Mines Information Circular 6915."

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and Safety Branch of the United States Bureau of Mines, entitled *Review of Literature on Effects of Breathing Dusts, with Special Reference to Silicosis*.

Some idea of the importance of the problem of respiratory protection and the tremendous cost incident to this type of hazard may be gained from the following figures:

South Africa has paid over \$65,000,000 in compensation for silicosis alone and has an additional outstanding liability of \$34,000,000; in 1932 claims totaling \$5,000,000 were allowed. In Wisconsin during 1932 approximately \$207,000 was paid in compensation for occupational diseases, and from 1930 to 1932, inclusive, the indemnity cost of the State for occupational diseases increased over 80 percent, while accident compensation, in contrast, fell more than 30 percent⁵. The experience of other States in this regard could be cited, but in this discussion it will suffice to observe that lawsuits in the courts of the United States at present involve claims of more than \$100,000 for silicosis, and Sappington⁶ estimates that these claims increased nearly 200 percent over those in the previous year. Although some of these claims will not be allowed and other cases will be thrown out of court litigation is expensive, and judgments of the order of \$14,000 and \$21,000 are not uncommon. Hundreds of cases are being settled for smaller amounts.

An increasing interest in social security is evidenced by laws now being considered and passed in many States relating to hazards caused by occupational diseases and to compensation for people affected by these diseases. The interest of industries also is increasing in this vital problem, which is not new. However, because industry generally has not taken a greater interest in preventive measures in the past, much future trouble may be expected, and large sums of money probably will be paid as compensation.

An indication of the growing realization of the importance of proper atmospheric conditions is found in the annual expenditures now being made to air-condition office buildings, factories, and many working places by means of

- 4/ Harrington, D., and Davenport, Sara J., *Review of Literature on Effects of Breathing Dusts, with Special Reference to Silicosis*. Part I. Chapter 1. Definition and Classification of Dusts. Chapter 2. Sources of Exposure to Dusts. Chapter 3. Physiological Effects of Breathing Dusts: Information Circular 6835, Bureau of Mines, 1935 68 pp.. Part II-A. Chapter 4. Prevention of Dust Diseases (Sections 1 and 2): Information Circular 6840, Bureau of Mines, 1935 117 pp. Part II-B. Chapter 4. Prevention of Dust Diseases (Sections 3 - 5): Information Circular 6848, Bureau of Mines, 1935 210 pp. Part III-A. Chapter 5. Economic and Legal Aspects of Dust Disease in Industry (Sections 1 and 2): Information Circular 6857, Bureau of Mines, 1935 266 pp.
- 5/ Griff, W.M., *The Responsibility of the Health Department for Occupational Disease Control*: Safety Engineering, vol. 68, September 1934, pp. 123-126.
- 6/ Sappington, C.O., Discussion of paper by Dick, P.O., *Role of X-Ray in Industrial Hygiene*: Ind. Med., vol. 4, 1935, p. 161.

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ventilating systems of proper design to keep the air free of hazardous substances. Although the scope of this paper is confined to discussions of individual protection against respiratory hazards, the importance of a positive system for properly ventilating buildings, specific work, or working places should not be overlooked.

Many people believe that silica dust is the only dust that affects the lungs adversely and that silicosis is a disease that has been recognized only in comparatively recent years. Neither idea is correct, nor is the use of respiratory protective equipment new. Hippocrates, born about 460 B. C., spoke of a metal digger as a man who breathed with difficulty and had other symptoms similar to those found in silicosis. Celsus, a Roman medical writer who lived in the first century, wrote: "By far the most terrible form of emaciation is that which the Greeks called phthisis. It spreads to the lungs. On top of this ulceration occurs and a fever, which at times disappears and at other times reappears." According to Harrington and Davenport⁸, "Probably the oldest published datum regarding the harmfulness of exposure to dust is the statement in Pliny's Natural History that Minium (red oxide of lead) refiners in the factory envelop their faces with loose bladders, which enable them to see without inhaling the fatal dust." This reference is of special historical interest, as it is probably the first mention of protective equipment against the hazards of dust. Pliny lived from 25 to 79 A.D.

From about 1551, when Amatus Lusitanus reported that "most workers occupied with the preparation of gypsum and lime died of lung phthisis," reports of the disease and various steps of protection against it have been more or less continuous. Phthisis now is considered generally as being synonymous with tuberculosis, and although many people use the word "silicosis" as a general term, actually the application is only to disease caused by silica dust. Pneumoconiosis (from the Greek pneumon, lung, and konis, dust) is the general term now being applied to all dust diseases of the lungs, whether caused by fibrous or nonfibrous substances, and it is likely that this word will be heard more and more. Other names given special dust diseases are silicatosis, anthracosis, siderosis, and asbestosis, which are caused, respectively, by the fine particles of various silicates, coals, iron or iron ores, and asbestos.

To facilitate the following discussion the subject has been divided into four subheadings:

1. What is a dangerous "atmosphere"?
2. Detectors for testing possible hazardous atmospheres.
3. Equipment for protection.
4. Use of equipment by workers.

⁷ According to Business Week, May 2, 1956, p. 19, \$48,000,000 was spent for air conditioning in the United States in 1935.

⁸ Work cited, Int. Circ. 6835, p. 9.

WHAT IS A DANGEROUS ATMOSPHERE?

A safe atmosphere is more easily defined with accuracy than a dangerous one. A possible definition for a dangerous atmosphere is: An atmosphere is dangerous when it contains one or more foreign substances, such as gas, dust, mist, or fumes, in sufficient quantity to be harmful or explosive, or when it does not contain enough oxygen to allow working with maximum efficiency or to support life, or when the temperature and humidity are too high for human endurance.

Research has ascertained that under some circumstances certain gases (such as hydrogen sulphide, carbon monoxide, chlorine, and sulphur dioxide), certain fumes (such as mercury vapor, acid, and lead-burning fumes), and certain mists (such as paint, lacquer, and some insecticide sprays) are dangerous to health. Other examples could be named in each of the above categories. Some authorities believe that breathing any kind of dust may lead to injury of the lungs if it is in sufficient concentration and breathed long enough, although to date this theory has not been accepted generally. Some persons claim (and there are cases that appear to bear out the theory) that the presence of an irritating gas or air of abnormal content will cause the dust to affect the respiratory organs more readily.

Dust need not be visible to be dangerous; in fact, virtually all the experts believe that the most dangerous dust particles cannot be seen by the naked eye. They range in size from 0.5 micron to 2 microns or possibly up to 5 microns. (A micron is one-thousandth of a millimeter or approximately 1/25,000 inch.) Harrington and Davenport² state:

The size of particles in prolonged suspension in the air is more likely to be under 5 microns than over; probably the most dangerous dust is that ranging from 2 microns to 0.5 micron or smaller because these palpable particles readily remain in suspension in the air for long periods of time. The size of fume particles ranges from 1 to 0.2 micron in diameter. In other words, it is thought that the smaller the particles the greater the danger, although there may be a lower limiting size as well as a higher one. Unless especially warned, employers and workmen are prone to regard impalpable nonvisible dust as altogether harmless. Dust particles under 5 microns in size readily pass through the mouth and nose, traverse the bronchial passages, and lodge in the alveolar tissue, from which remote parts of the lung structure they usually cannot be dislodged by hawking or coughing.

No one seems to be able to state with exactness the safe size and number of dust particles that may be in the air. An information circular in preparation by the Health and Safety Branch of the Bureau of Mines includes a statement that mountain air contains 2 large particles per cubic centimeter, while city air contains 15 to 100 such particles per cubic centimeter. The

²/ Work cited, Inf. Circ. 6840, p. 66.

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following regulation of the Industrial Commission of Wisconsin^{10/} is an example of the dust standards that are being set up for industry by some of the States:

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. The commission, its advisory committee, employers, and scientists have agreed on a tentative figure of 15 million countable dust particles under 10 microns in longest dimension with free-silica content of 35 percent in a cubic foot of the air as determined by the 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 would be 3,250,000 countable particles. By countable particles is meant those particles within the range of size from 2 to 10 microns in the longest dimension. Dust particles larger than 10 microns in the longest dimension do not ordinarily reach parts of the body where they can produce injury.

From the foregoing discussion it can be seen that, despite the extended study given to the hazard of dust definite and exact information is meager. Harm to the respiratory system caused by dust, like that caused by gases, mists, and fumes, depends upon the concentration and the length of exposure; but, unlike these substances, the size of the dust particles enters into the hazard. Because of the very nature of this problem, which pertains to certain causes and their effects upon the human body under various and varying circumstances, and because the required technique of dealing with the subject cannot be reduced to the exactness of a mathematical equation, safety engineers and all others concerned with dust hazards will do well to "play safe" by protecting, insofar as feasible, against any atmosphere that is not normal.

Some of the more common occupations in the petroleum industries where respiratory protection may be needed are cleaning tanks, gaging, sand-blasting, handling coke, cleaning coke out of stills, cleaning brick, handling dusty materials (such as fullers earth, cement, lime, gypsum, clays, and dry caustics), certain welding operations, burning lead, burning off paint, paint-spray work, brush painting in close quarters, and the many operations in which workmen are exposed to dust and hydrogen sulphide gas.

About 10 years ago hydrogen sulphide poisoning was considered an outstanding hazard of the petroleum industry. Field and plant workmen knew little or nothing about the toxic effects of hydrogen sulphide, and even safety engineers were at a loss regarding the application of sure and practical methods of protection. That condition has been changed radically, and through persistent education the industry in general knows about hydrogen sulphide gas, workmen respect its toxic qualities, and most companies are fairly well equipped to combat this hazard.

^{10/} See Farrington, D., and Davenport, Sara J., work cited: Inf. Circ. 6840, pp. 86 and 85.

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DETECTORS FOR TESTING POSSIBLE HAZARDOUS ATMOSPHERES

The development and commercial manufacture of efficient and accurate detectors for testing the percentages of poisonous, irritating, and inflammable gases and vapors that may be present in the atmosphere have been great boons to those engaged in health and safety work. Only within recent years has this condition been brought about, and the petroleum industry has made wide use of many of these devices as they have become available in helping solve its problems of protecting the lives and health of its employees. Many safety engineers require one or more of them as an essential part of their safety equipment and are thoroughly familiar with their construction and operation. Even so, a brief review of the operating principles of several detectors is given with full recognition of the fact that the best way to obtain definite knowledge about them and to gain proficiency in their operation is to inspect them and use them under test conditions.

Detectors for Inflammable Gas

Detectors for inflammable gas that are in most common use are known as the J. W., M.S.A., and U.C.O. The several detectors differ in construction but operate on essentially the same principle, namely, that when an electrically heated filament is introduced into an atmosphere containing inflammable gas, the electrical resistance of the filament will vary in direct proportion to the amount of inflammable gas present. The variation of the resistance is recorded on a meter graduated in percentage of gas or percentage of explosibility. The instruments are reasonably accurate for percentages from zero to the explosive limits.

The Burrell detector for inflammable gas has not been used as generally as those that have been mentioned. The operation of this detector is based on the principle that the products of combustion of most inflammable gases have less volume at the same temperature and pressure than the gas that is burned. The decrease in volume is in direct proportion to the amount of gas burned.

A number of continuous inflammable gas detectors are on the market but they are not intended to be used as portable instruments and are not described in this paper.

Detectors for Toxic GasesCarbon-Monoxide detectors

Hoolesite detector. - When carbon monoxide (CO) is passed through ground pumice saturated with iodine pentoxide in the presence of phosphoric acid, free iodine is liberated, which stains the pumice a greenish color. By comparing the shade of green obtained by a measured volume of air with a color scale, the amount of carbon monoxide can be determined. The range of this instrument is 0.05 to 1 percent. Its accuracy depends somewhat on the ability of the individual to estimate the true shade. This device is used extensively by the Bureau of Mines, manufactured-gas companies, and others desiring to ascertain the presence of carbon monoxide.

Pyrotannic acid detector. - This device is compact but requires a little technique in its operation and is used primarily for detecting the presence of carbon monoxide in the blood. It is very accurate and will detect from zero to 0.2 percent of the gas in the air. It operates on the principle that the affinity of carbon monoxide for the hemoglobin of the blood is about 300 times that of oxygen. To test the atmosphere for carbon monoxide a small bottle is filled with the air to be examined, and 0.1 cm³ of blood, which is diluted to 2 cm³ with distilled water, is placed in the bottle. After about 15 minutes of agitation this blood solution is treated with a compound of pyrotannic-pyrogallie acid and the resulting color compared with a standard color scale.

Continuous carbon monoxide detectors. - These detectors are made in stationary and portable models. All models require a supply of electric current. (Dry-cell or storage batteries may be used.) The operation of these instruments is based on the fact that when carbon monoxide passes through a compound known by the trade name of "Hopcalite" it is converted to carbon dioxide and thus generates heat. The amount of heat generated is in direct proportion to the amount of carbon monoxide present. By means of thermocouples the amount of heat is recorded on a dial marked in percentage of carbon monoxide present. These instruments are accurate, the portable type having a dial graduated to 0.01 percent.

Carbon monoxide-detector ampoule. - This device consists essentially of a solution of palladium chloride in acetone-water, which is sealed in a small glass vial surrounded by absorbant cotton. When the vial is crushed the solution saturates the cotton. The ampoule is then hung in the atmosphere to be tested for approximately 10 minutes. If carbon monoxide is present the solution on the cotton will become gray to grayish, depending on the concentration.

Hydrogen Sulphide Detectors

Although hydrogen sulphide (H₂S) has a definite odor (tharp-called "rotten-egg" smell) in minute quantity, the odor cannot be depended upon to give warning; generally speaking, as long as the hydrogen sulphide can be smelled the person exposed to the gas is safe.

M.S.A. hydrogen sulphide detector. - Chemists of the Bureau of Mines recently have perfected a portable means of detecting hydrogen sulphide. The detector depends upon the use of silver cyanide on activated alumina. When a measured volume of the air containing hydrogen sulphide is forced through a tube containing this material it turns black, and the length of the discoloration in the tube is a measure of the percentage of the gas present.

Lead acetate paper. - This method has been used to detect hydrogen sulphide, but it is not positive and its accuracy is limited. The method consists of saturating a piece of absorbant paper with lead acetate and placing the paper in the atmosphere to be tested. Discoloration indicates that hydrogen sulphide is present.

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Detector for Atmosphere Deficient in Oxygen

Flame Safety Lamp

Lack of oxygen in the air can cause death as readily as most toxic gases. The quickest (though not always the safest) way to tell whether an atmosphere is deficient in oxygen is to see if a flame will burn in it. It is not advisable to use an open flame for this purpose because of the possible presence of explosive gas. At present the flame safety lamp is the best portable device for determining whether enough oxygen is present to support life. However, the lamp is not a foolproof device, and a number of explosions with heavy loss of life have resulted from its misuse. In fact, some large petroleum organizations now prohibit the use of the flame safety lamp. Only a properly assembled flame safety lamp should be used and then only by a person who has been trained in its use and fully understands its hazards, construction, and proper assembly.

Instruments for Counting and Recording Amount of Dust in Air

A number of different devices are on the market and in use for determining the size and amount of dust particles in the air. To operate these instruments requires practice and skill. In general, a sample of the dust particles in the atmosphere is collected by some suction method, taken to the laboratory or similar place, and counted by means of a microscope or by weighing. Some of the instruments used are the impinger, electrical precipitator, and theable, Owens jet dust counter, and nomimeter. Recently other instruments have appeared on the market, such as the continuous dust recorder invented by Professor Drinker and the Picklen-Ott dust camera.

Human beings cannot depend upon their sense of smell or sight to tell whether or not an atmosphere is dangerous. Animals usually have a far superior sense of smell and sight than is possessed by human beings but even they cannot always indicate whether poisonous gases, dust, fumes, or mist are present in the surrounding atmosphere. Either chemical analysis or the proper detector should be used to indicate the presence of gas. Dependence upon smell, sight, taste, or any other human sense in an effort to determine the presence of a poisonous or otherwise harmful gas, mist, fume, or dust is a dangerous practice.

EQUIPMENT FOR PROTECTION

Selection of the proper individual equipment to condition the air breathed by men working on a job with a potential respiratory hazard is very important. Before a selection is made most of the following question must be answered:

1. Is there enough oxygen to support life?
2. What toxic or asphyxiating gases are present and what are their concentrations and characteristics?
3. What dusts, mists, fumes, or combinations of these are present and in what concentration?
4. How long will the period of exposure be?

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5. What is the temperature and humidity of the atmosphere where men will be working?

6. Under what conditions will men be working? That is, will they be in cramped quarters and is the opening small through which they must enter or leave?

7. Will a continuous current of air be ventilating the enclosures?

8. Will work be routine or emergency?

9. Will work cover a large or small area?

10. How much of the head and body should be protected? That is, will it be sufficient to cover just the nose and mouth or should the eyes or even the entire head be protected?

11. What is the physical condition of the worker and what are his facial characteristics?

The answers to these questions will largely indicate the proper type of protective equipment to be selected. The selection will be limited further when the following advantages and disadvantages of the more common types are considered.

Canister-Type Gas Mask

This protective equipment consists of a full or half facepiece, or a mouthpiece and nose clip, which is attached by means of a flexible rubber tube to a canister hung in front of or on the back of the wearer.

Advantages. - The mask is light in weight, occupies little space, is easy to transport, and filters out most dusts and mists if the gases or mists are present in limited percentages or quantities.

Disadvantages. - The mask cannot be worn with safety in an atmosphere deficient in oxygen or in an atmosphere containing more than 2 percent, by volume, of any toxic gas except ammonia, when it will give protection to 3 percent. The facepiece must fit tightly to the face; any leaks indicate that the mask is ineffective and may cause death to the wearer. The mask can be worn only in that class of gas for which the canister is designed - the type N (all-service) canister protects against limited percentages of all gases. In a warm and humid atmosphere or during hard work the face perspires, the resistance of the canister increases rapidly, and the mask becomes uncomfortable to wear; sometimes, too, the rubber may irritate the skin. The mask can be worn in safety only for the length of time indicated on the canister. A man may enter a dangerous atmosphere without one or more other persons being present, a practice that, even with any type of respiratory-protective equipment, exposes the wearer to the hazard of losing his life. Some prominent petroleum organizations prohibit the use of canister gas masks and stipulate that emergency respiratory protection must be obtained by using a suitable fresh air-hose mask.

Dust Respirators

Dust respirators 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.

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Advantages. - They are light in weight and inexpensive; those approved by the United States Bureau of Mines are effective.

Disadvantages. - They cannot be worn in an atmosphere that contains toxic gases or fumes or that is deficient in oxygen. Filter pads must be changed at certain intervals, depending on the concentration of dust or gases. The facepiece must fit tightly to the face and has the same disadvantage as the canister type mask in warm, humid atmospheres. Some types restrict the field of vision.

Self-Contained Oxygen Breathing Apparatus

This apparatus consists chiefly of a mouthpiece fastened by a flexible hose and various reducing valves to a tank of oxygen under high pressure; it is a rather complicated machine and weighs 12 to 21 pounds for the half-hour type and about 40 pounds for the 2-hour type.

Advantages. - The machine can be worn in any atmosphere that will not irritate or poison the skin, when properly assembled and equipped with the proper rubber parts in good condition.

Disadvantages. - It is bulky, heavy, and rather expensive to purchase and maintain; the wearer must have special training in its use before he can wear it with safety. (This apparatus is not in general use in the petroleum industry.)

Hose Masks and Air-Line Respirators

Hose Masks and Respirators with Positive Air Supply

These masks have essentially the same type of facepiece as described for the canister mask, but instead of being fastened to a canister, it is connected to a supply of fresh, pure air. The supply may be furnished by a blower, hand or electrically operated, or by an air compressor, the intake of which should be in pure air.

Advantages. - The mask is light in weight and costs little to maintain. The air is supplied under positive pressure; therefore, as long as the pure air supply is maintained there is little danger that the worker will inhale through a leak around the facepiece. The inflowing air reduces excessive perspiration and tends to cool the face. When a hand-operated blower is used, a second person is always present. (With the approved mask, provided the facepiece is tight, the wearer can inhale enough air through the hose to escape if the blower should stop.) Permissible hose masks can be worn in any atmosphere that will not poison or irritate the skin, but the directions on the approval plate should be followed explicitly.

Disadvantages. - The mask and blower cost more than a canister mask. The area of travel 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.

Hose Mask Without Positive Air Supply.

This mask is essentially the same as the hose mask just described, except that it is not connected to a blower. The intake of the hose is placed in fresh air, and the wearer pulls or sucks the air through the hose.

Advantages. - The mask can be worn in any atmosphere that will not poison or irritate the skin, although it is not recommended for use in highly toxic gases.

Disadvantages. - It must fit tightly to the face. The distance the wearer may travel is very limited. It may be uncomfortable to wear the face-piece in hot, humid atmospheres, and the air manifestly should be pure at its source.

Helmet-Type Respirators

This protective equipment consists of a hood with windows that fits loosely over the head and shoulders; a supply of fresh air, at least 6 cubic feet per minute, is blown into the hood.

Advantages. - The head and shoulders are covered, protecting the skin against abrasives. The incoming air cools the head. It is relatively safe to wear in dusty atmospheres but is not approved for use in poisonous gases or fumes, in which its safe use is doubtful.

Disadvantages. - The mask should be worn only in places from which the wearer can escape without danger if the air supply should fail, as it gives absolutely no protection in case of such failure.

The Bureau of Mines will approve equipment of any of the above types if such equipment meets the Bureau's test requirements, and many types are now on the market. As suggested, with reference to detectors for testing possible hazardous atmospheres, definite knowledge of the construction and operation of protective equipment should be gained by inspection.

USE OF EQUIPMENT BY WORKERS

Selecting the 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.

Many plans that look workable on paper could be suggested for establishing respiratory protection, but in practical operation difficulties usually are experienced. Probably the simplest plan is first to "sell" the supervisor

official, which should not be difficult if he is safety-minded; otherwise, strict orders from higher officials may be necessary. Then the worker must be "sold" by education, possibly accompanied by strict and fair supervision and discipline.

When the hydrogen sulphide problem first presented itself in oil fields of the southwestern United States and at refineries processing high grade crude oils, the statement was often made that the men could not or would not work with respiratory protective equipment. Usually it was found that statements were based upon prejudice or lack of knowledge rather than fact. Systematic educational work has overcome this prejudice largely and has proved to the workmen and the industry that suitable protection is needed and can be obtained in dangerous concentrations of gas.

CONCLUSION

There is still a tremendous amount to be learned about industrial hazards. One thing, however, is certain - there is a very definite tendency to require compensation for them. If companies and safety engineers wish to keep compensation costs at the minimum and to promote the health and safety of the workmen, they will lose no time in taking adequate precautionary measures. A forward-looking employer will take steps to become fully informed of the nature of occupational hazards and on methods and equipment likely to aid in combating them in order that he may put his house in order. He will make every possible effort to have each working place ventilated as thoroughly as practicable. He will see that every workman or any other person wears proper protective equipment when exposed for a prolonged period to an atmosphere containing dust, mists, or fumes in sufficient concentrations to be dangerous or when exposed for short periods to atmospheres that contain considerable quantities of harmful gases or dusts.

Financial expenditures probably will have to be made to avoid hazardous atmospheres and to provide protective equipment, and time and thought will be required to perform this work and to educate workmen in the necessity of wearing the proper protective equipment.

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