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INDIA–JEFFERS

in great part by white-collar workers, and the financial arrangements involve purchasing the dwelling with the assistance of the employer. Apart from such special examples, the company town planned from the start by the employer for his workers is becoming an incident in the past growth of industry.

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INDUSTRIAL HYGIENE. The application of the combined techniques of engineering, chemistry, physics, and medicine to the control of the environment of the industrial worker, in order to protect his health, is the major concept of industrial hygiene. Employment of medical and nursing principles to improve the health of a group of employees, entirely apart from any occupational hazards, is a secondary concept.

Infectious diseases, with a few exceptions, are not typically occupational in origin and are not a major concern of the industrial hygienist. Occupational diseases, prevention of which is the chief purpose of industrial hygiene, are most commonly caused by dusts, fumes, vapors, gases, irritating chemicals, and abnormal physical factors in the environment of the worker.

Dust Diseases.—*Silicosis*, a disease of the lungs caused by inhalation of dust containing free silica, is perhaps the most important occupational disease. The American Public Health Association defines silicosis as a "disease due to breathing air containing silica (SiO_2), characterized anatomically by generalized fibrotic changes and the development of miliary nodulation in both lungs, and clinically by shortness of breath, decreased chest expansion, lessened capacity for work, absence of fever, increased susceptibility to tuberculosis. . . ."

Ordinarily silicosis is developed only after several years of work in a dusty environment; but when dust concentrations are unusually high, it may follow exposure of only a year or two. Combined silica (silicate) does not cause silicosis. The form of free silica most commonly encountered in nature and responsible for most cases of this disease is quartz. Occupations in which silicosis may present a hazard include mining, tunneling, stonecutting, pottery manufacturing, sandblasting, and other foundry operations.

Asbestosis is a lung disease caused by inhalation of asbestos fibers. The changes produced are unlike those of silicosis. The fibrosis is diffuse and not nodular, and there is less susceptibility to tuberculosis. However, there is evidence that asbestosis may be associated with lung cancer.

Byssinosis is a lung disease contracted by cotton mill workers, especially in England.

Siderosis is a nondisabling condition characterized by a deposit of iron oxide in the lungs, frequently observed among welders and miners of iron ore.

Berylliosis results from the inhalation of beryllium oxide and certain other beryllium compounds. While its chief symptoms refer to the respiratory tract, it is considered by some authorities to be a systemic disease. The greatest concentration of cases has been in the fluorescent lamp industry, where the phosphors (fluorescent powders) [illegible] coat the inside of the lamps formerly contained beryllium. Short exposure to high concentrations of beryllium compounds, particularly soluble compounds such as the fluoride, may result in pneumonitis. Both forms of the disease are frequently fatal.

Heavy Metal Poisoning.—*Lead poisoning* ranks next to silicosis among occupational diseases. Formerly it was associated chiefly with the painting trade; now it is rarely encountered among house painters, but is found frequently in such diverse industries as storage-battery manufacturing, nonferrous foundries, lead smelters and refineries, plastics manufacturers, and automobile assembly plants. The commonest symptoms are colic, weakness of the wrists, and anemia.

Mercury intoxication, as observed in industry, usually results from inhalation of the vapor. It was formerly common among felt hat makers, who knew it by the descriptive term, "hatter's shakes." Many countries and various states of the United States ban the use of mercury-treated fur for hat manufacturing; but there are many other industrial uses of mercury.

Manganese poisoning from the inhalation of high concentrations of the dust of manganese compounds may result in damage to the nervous system and partial paralysis. Typical symptoms are a stumbling gait and mask-like facial expression. The disease is most prevalent in smelting and mining operations.

Cadmium poisoning most frequently results from inhalation of fumes of heated cadmium, and takes the form of a severe chemical pneumonitis. Chronic cadmium poisoning among workers engaged in the manufacture of cadmium-nickel storage batteries has been reported in Sweden and France.

Zinc fume fever is a transient illness resulting from inhalation of freshly formed fumes of zinc oxide. It occurs chiefly among brass founders and welders of galvanized metal.

Other heavy metals, such as arsenic, vanadium, thallium, and uranium, are toxic and produce occasional occupational intoxications.

Organic Solvents.—*Benzene*, or benzol, is one of the most dangerous of the common solvents. Absorption of the vapor not infrequently results in blood changes which may progress to aplastic anemia, a fatal disease. Because of its toxicity, the use of benzene in rubber cements and lacquer formulations has been virtually abandoned in the United States; but it is still employed in paint removers and as a raw material in the chemical industry.

Carbon tetrachloride, widely used as a cleaner because it is volatile and will not burn, is a dangerous kidney and liver poison. At present it is probably the number-one toxic solvent problem in the United States.

Carbon disulphide was formerly used in the rubber industry, but is now found chiefly as a raw material in viscose rayon manufacture. It produces mental symptoms, leading in extreme cases to insanity. Major episodes of carbon disulphide poisoning have been reported in Poland and Italy.

Other solvents which have produced serious occupational intoxications include tetrachlorethane, ethylene chlorohydrin, and dioxane.

Pesticides.—The use of toxic chemicals to control insect, fungus, and rodent pests has created some serious occupational hazards. Methyl bromide, a gas used as a fumigant, also to some extent as a fire extinguisher, damages the central nervous system and also is a lung irritant. Parathion

... necessarily hazardous to workers.

Occupational Cancers.—The hydrocarbons present in coal tar, and in some oils derived from petroleum, are markedly carcinogenic, at least to the skin. Cancer of the scrotum was formerly a not uncommon affliction among chimney sweeps in England. Mule spinners in that country frequently contracted the same condition by contact with lubricating oil. Tumors of the bladder, found in abnormal frequency among workers in dye plants, have been traced to beta-naphthylamine and benzidine. Aniline, which was formerly blamed, has been shown not to cause this disease. A high incidence of lung cancer has been observed among workers in plants manufacturing chromates. The exact compound responsible has not been definitely determined. So far there have been no similar reports from other industries in which chromium compounds are used. Arsenic compounds have been reported to cause cancer of the skin and also of the respiratory organs.

Radioactive substances are among the most dangerous carcinogenic agents. A very high death rate from cancer of the lung has been observed in uranium mines in Czechoslovakia where high concentrations of radon were present in the air. Tumors of the bone developed in many workers who used radioactive luminous paints without proper precautions. These individuals had absorbed radium, which was deposited in the bones.

Skin Diseases.—Dermatoses, or diseases of the skin, are the commonest of occupational diseases. The most frequent causes are solvents, oils, and alkalis. Substances whose use is frequently associated with outbreaks of dermatitis include chromates, *p*-phenylene diamine, and hexamethylene tetramine.

Infectious Diseases.—A few of the infectious diseases are frequently occupational in origin, such as anthrax (wool sorters and tanners), Weil's disease (fish handlers, sewer workers), and brucellosis (slaughter-house employees).

Illness from Physical Conditions.—Physical conditions which may bring on occupational illness include excessive temperatures (heat stroke), high atmospheric pressures (bends), ultraviolet and infrared radiation (eye injury and skin burns), and X-rays and radiation from radioactive sources. The latter may cause blood changes, skin burns, blindness, and, as noted above, cancer.

TESTING AND CONTROL

Air Analyses.—The essence of industrial hygiene is the measurement of harmful conditions, particularly the concentration of dusts, fumes, gases, or vapors in the workroom atmosphere.

Mineral dusts are determined by a counting procedure. Ordinarily only the particles below a certain size (5 to 10 microns in diameter) are considered significant. In the United States an impinger containing water or alcohol is commonly employed for collecting dusts. A small amount of the suspension is placed in a shallow cell and the number of particles counted under a microscope. Frequently a light-field setup is used. In England the dust is usually collected dry in a thermal precipitator. In South Africa a konimeter, a dry impingement device with a built-in microscope, is widely employed.

Dust concentrations are expressed as numbers of particles per cubic centimeter of air or as ... less than a million particles per cubic foot in air that is relatively free from dust, to several hundred million in highly dusty operations.

Toxic dusts and fumes, such as those from lead, cadmium, and manganese, are usually determined chemically. They may be collected by means of the impinger, with a portable electric precipitator, or on a filter paper. Concentrations are expressed in milligrams per cubic meter of air, and micro-methods of analysis are usually necessary to determine the small amounts of substance present.

Vapors can be adsorbed on activated charcoal or silica gel, and then determined by chemical or physical methods. Flammable vapors can be measured directly by means of a portable detector. Instruments are also available for the direct determination of chlorinated hydrocarbon vapors, and the portable interferometer can be used for the field estimation of many vapors.

Gases are usually absorbed by bubbling the air through a suitable chemical reagent. However, direct chemical testing devices are available for certain gases and vapors in the air, such as carbon monoxide, hydrogen sulphide, benzene, and sulphur dioxide.

Biochemical Tests.—Analysis of urine or blood for toxic substances is an alternative method of measuring exposure. Urinalyses are useful for such heavy metals as lead, mercury, and uranium. The ratio of inorganic to total sulphates (urine sulphate test) is affected by absorption of benzene. The blood contents of lead and of carbon monoxide (carboxyhemoglobin) are useful indices of exposure to these substances. The radon content of expired air is a measure of the radium stored in the body.

Tests to indicate early damage to the body or changes which precede measurable damage are also employed. Examples are chest X-rays to detect early stages of silicosis, asbestosis, and other occupational lung diseases; measurements of methemoglobin in the blood to determine effects of nitrobenzene and allied substances; tests of the cholinesterase activity of the blood, which are a delicate index of absorption of the organic phosphate insecticides, such as parathion. Coproporphyrin in urine is a sensitive test for very early stages of lead poisoning.

Control Measures.—Pre-employment and periodic medical examinations are advisable for workers in occupations in which harmful dusts, fumes, or radiations are present. Individuals with a predisposition to the disease caused by a given agent should avoid an occupation in which it is present in sufficient concentration to produce a hazard. Removal of workers from hazardous exposures at the first sign of illness may prevent the disease from becoming serious. This phase of industrial hygiene often finds the medical profession and organized labor in conflict, since transfer of a worker from a hazardous occupation in which he is skilled to a safer occupation may involve economic hardship.

When a health hazard is shown to be present, by air tests, bio-assay, or other procedures, reduction or elimination of the exposure is indicated. The chief methods of achieving this end are as follows:

(1) Substitution of a less toxic material. Examples: use of steel shot for sandblasting in place of sand (quartz); substitution of naphtha for benzene in rubber cements.