ACCIDENT PREVENTION

MANUAL

FOR INDUSTRIAL OPERATIONS

PLAINTIFF'S EXHIBIT

NSC-60

ACCIDENT PREVENTION

MANUAL

FOR INDUSTRIAL OPERATIONS

including a statement of methods used in setting up a safety organization, of means used to enlist employee co-operation, and of materials and services offered by the National Safety Council.

Prepared by the engineering staff of the Industrial Division, National Safety Council, with assistance from the Statistical and Traffic and Transportation Divisions on problems relating to their fields.

Especial appreciation is due the many members of the Manual Committée and to other consultants, who examined preliminary drafts and proofs, and who gave invaluable advice by correspondence and in conference.

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Printed by Wm. H. Pool Co.
Chicago, Illinois
1946

INV. '61

FOREWORD

For some years there has been need for a compact source of basic information on accident prevention in industry. The body of safety engineering knowledge has expanded tremendously since the first concerted efforts were made at the beginning of the century to reduce industrial losses. The National Safety Council and many other agencies have in the interim published the result of their experience and research in many forms.

Until the publication of this book there has not been, however, one volume which has presumed to serve as a ready reference which would put the safety director immediately on the trail of the answer to all but the most unusual of his safety problems.

The Safe Practices Pamphlets and Data Sheets, long established as technical publications of the National Safety Council, give more extensive discussion to accident prevention problems than does the MANUAL. They are valuable complements to the MANUAL, but in no sense are they superseded by it.

Obviously no volume could encompass the details of accident prevention engineering for every industrial operation, nor even for the operations common to most industries. Industrial safety in specific application means close analysis of the operation in question, the design and control of equipment and environment so as to reduce the hazard, and the training of the employee toward safe attitudes and practices. The variables of safety in action are infinite. They can be discussed and illustrated in a single volume only in terms of certain common characteristics.

The MANUAL is not a textbook covering the general field of accident prevention theory, nor does it attempt to include the special problems of specialized industries. Neither does it attempt to discuss ways and means by which the employer can properly deal with the off-job hazards of his employees or participate in the public safety problems of his community. The engineering problems of many special industries, and highway, home and farm safety programs are more appropriately a part of other Council publications.

The MANUAL is a comprehensive source of the "how" of safety, intended to be kept at hand for frequent and ready reference by the safety director, the safety engineer and the foreman. It sets forth the principles of safety for activities in which the great majority of manufacturing industrialists engage. It carries these principles into as much detail as it can without contradicting the premise stated above that the application of accident prevention methods to the specific job must remain the responsibility of the engineer. Such application necessarily involves a degree of ingenuity and executive capacity as well as the extensive use of technical materials from the National Safety Council and from other sources.

CONTENTS

eczema, sleepiness and irritability.

TABLE OF CHEMICAL HAZARDS—*Continued*

Substance	Flash point ° F.	Explosive limits % by volume Lower	Upper	Auto-ignition temperature ° F.	Probable safe concentration for 8-hr. exposure	Usual mode of entrance to body	Signs and symptoms of poisoning
antimony (salts)	metal and sulfides flammable				unknown, probably like arsenic	inhalation of dust, ingestion	*Acute:* vomiting, colic, diarrhea, irritation of mouth and throat. *Chronic:* indigestion, loss of weight and appetite, sometimes severe dermatitis.
arsenic	......	......	......	......	0.15 mg/cu.m.[6]	inhalation of dust, ingestion and direct action on skin and mucous membrane	Irritation of skin, loss of hair and nails, perforation of nasal septum, hoarse voice, cough, neuralgic pains, diarrhea.
arsine	......	......	......	......	1 p.p.m.[5]	inhalation	Headache, nausea, vomiting, chills and shivering, jaundice, dark or bloody urine.
asbestos	non-flammable				5 million particles per cubic foot[7]	inhalation	*Chronic:* shortness of breath, asbestos corns.
barium (compounds)	peroxide, chlorate, and nitrate produce violent combustion in flammable materials				none adopted	inhalation or ingestion of soluble salts, direct action on skin	Severe dermatitis from the caustic salts, vomiting, dyspnea, abdominal pain, cyanosis, paralysis.
benzene (benzol)	12	1.5	8	1000	100 p.p.m.[8]	inhalation	*Chronic:* weakness, fatigue, bleeding from the gums and nose, headache, dizziness. *Acute:* inebriation, convulsions, and loss of consciousness.
bromine	......	......	......	......	1 p.p.m.[9]	inhalation direct attack on skin and mucous membranes	Irritation of eyes and respiratory tract, irritation and corrosion of skin, probable lung irritation in acute cases.

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PART XIII

INDUSTRIAL HYGIENE

Plant Facilities

Factors in comfort ventilation*

The comfort, health and efficiency of industrial workers depends, as it does with all of us, upon the condition of the air breathed. Industry is repaid amply by increased production and improved morale of workers for the investment made in proper ventilation of workrooms.

After being confined in work places, air undergoes certain physical and chemical changes which may make it unpleasant or unhealthful. These changes usually include:

- An increase of carbon dioxide
- A decrease of oxygen
- An addition of bacteria
- An addition of odors
- An addition of objectionable dust, fumes, gases or vapors
- An increase in temperature
- An increase or decrease of moisture

Carbon dioxide. The exhaled air contains approximately 100 times more carbon dioxide than does the air breathed into the lungs. This may increase the carbon dioxide content of the room atmosphere, but is of little or no importance from a ventilation point of view, due to the fact that room air is diluted by air leakage from the outside through structural cracks and crevices.

Oxygen. The air breathed into the lungs contains more than 20 per cent oxygen, but the air exhaled contains little more than 15 per cent of this gas, producing a continuous decrease of oxygen in the room air. However, it has been determined that the oxygen content of the room air must be reduced to 15 per cent before any ill effects will be noted.

Inasmuch as the average breath contains only 20 cubic inches of air, it is improbable that the oxygen content of the air in any

*For the engineering aspects of general ventilation and of exhaust ventilation control systems, see Part I "Design and Layout" and the section on local exhaust ventilation in this Part. See References also.

in suspected cases of poisoning from exposure to zinc, these other toxic elements should not be overlooked.

The only significant physiological effect of zinc appears to be metal fume fever. Although of transient character the fever, chills and sweating may be sufficiently severe to cause disability of one or two days' duration. The salts of this metal have an irritant effect on the skin.

Zirconium. No evidence of poisoning due to this metal has been reported. There are, however, certain fire and explosion hazards associated with the handling of the powdered metal and its hydride.

Industrial poisons
(Radio-active elements)

Radium, thorium, uranium, radon, x-ray (See section on radiation, Page 459.)

Industrial poisons
(Metalloids)

Antimony. The action of antimony is similar to that of arsenic and lead, but not so severe. Antimony can be very irritating to the skin and mucous membranes. Systemically, it resembles lead in its gastro-intestinal effects, but it usually causes diarrhea instead of constipation. In suspicious cases both lead and arensic must be ruled out.

Arsenic. A frequent industrial health hazard results from the arsenic sulfide contamination of the ores of heavy metals. Arsenic compounds also have wide application in a number of industries. Whenever contact with acid occurs, there is a possibility of arsine being formed.

Such formation is to be guarded against in the cleaning of tank cars which have contained concentrated hydrochloric or sulfuric acid. Arsine is extremely poisonous, completely destroying the red blood cells in a relatively short time.

Manganese. The most frequent source of manganese poisoning is in ore handling, especially in the dusty operations of separation and grinding. Disturbances of the central nervous system similar to those of paralysis agitans occur, progressing from general muscular weakness, tremors of the extremities, spasticity, emotional upsets, speech peculiarity, mask-like expression, and ultimately complete disability.

Phosphorus. Formerly frequent in the match and fireworks industry, horribly disfiguring phosphorus poisoning is now seldom seen. It has been eliminated by the change from the poisonous white form to the innocuous red phosphorus. The poisoning is always chronic.

Exposure to phosphine (phosphorus hydride) may occur rarely in pickling operations and in the manufacture of ferrosilicon. This gas causes respiratory and gastro-intestinal disturbances, generalized weakness and, if the exposure is great, convulsions.

Selenium. Of increasing industrial application, selenium and its soluble compounds are systemic poisons and irritating to the skin and mucous membranes.

Tellurium is similar to selenium in its effects and symptoms.

Industrial poisons
(Non-metals)

Boron. Compounds of boron are toxic, but no industrial poisoning has been reported.

Carbon disulfide, a widely used solvent, is a strong nerve poison if absorbed continuously.

Chromium. Chromic acid, chromate and *dichromate salts* are extremely irritating to the skin, eyes and all mucous membranes.

Silicon. The dioxide, so-called "free silica," is the cause of a fibrotic disease of the lungs which, if it progresses, will eventually limit the respiratory function.

Exposure for long periods (usually years) to excessive concentrations of finely divided dust containing high percentages of free silica are followed by the characteristic symptoms of this lung disease. Tuberculosis frequently follows. *Asbestos* causes a similar disability.

Sulphur is not a cause of industrial poisoning, but it may produce skin irritation. Some of its compounds, for example, *hydrogen sulfide,* are extremely toxic. It is not only irritating, especially to the eyes, but it has a marked systemic effect in producing paralysis of the respiratory center.

Hydrogen sulfide may be produced in many industries where sulphur-containing compounds, especially sulfides, come in contact with dilute acids. *Sulfur dioxide,* a common result of gas and coal combustion, has the irritant action of all the acid gases on the respiratory tract.

protective equipment will do much to prevent the contact between the skin and the irritant. Aprons, sleeves, gloves, and in fact complete suits of excellent impervious materials are available, and they play a large part in the prevention program when properly used by the worker. See Part XII, "Personal Protective Equipment."

Protective creams and ointments especially designed for different classes of irritants are also effective in minimizing skin contact. However, they must be used regularly and should be applied several times during a shift.

In primary irritation dermatitis, as well as in the sensitization type, personal cleanliness plays a large part in prevention. Frequent washing with a safe industrial soap and warm water will reduce the time during which the irritant can exert its action.

All of the above mentioned principles are also effective against the sensitization type of dermatitis. Here it is most essential to prevent the original exposure, which is the fundamental cause of the allergic state with its accompanying exquisite sensitivity.

Once this stage is reached, the possibility of preventing irritating contacts becomes extremely difficult, for very minute quantities of the substance will then produce a response. It is for this reason that carelessness in handling potential sensitizers must be avoided. If skin contact is prevented from the very beginning, the chance of developing sensitivity is greatly reduced.

The value of estimating sensitivity to skin irritants in the pre-placement selection of workers has probably been exaggerated. The practical difficulties of the determination, to say nothing of the frequent transference of workers about a plant and resulting exposure to many different irritants, make this practice of doubtful value.

However, there are two exceptions to this statement: Negroes seem to tolerate skin irritation much more than whites, and women appear to be more susceptible than men. Other than noting these exceptions, little of value will result from selective placements.

"Cutting oil" dermatitis. The most common skin afflictions arising from contact with cutting oils and compounds seem to be due to mechanical blocking of the hair follicles by the oil and foreign particles as well as to the defatting action on skin which is characteristic of all petroleum products.

Bacteriological studies have failed to reveal the presence of significant numbers of pathogenic organisms in the oils. However, if sterilization is considered, it should be by heating only. Antiseptics are undesirable because of the possibility of skin irritation. Periodic removal of the oil from the machine, so that it may be strained to remove extraneous material, and thorough cleaning of the machine before replacing it are of ordinary sanitary merit.

Frequent change of cutting compounds (oil-water emulsions) is advisable and inexpensive. The old emulsion should be discarded, and the machine should be thoroughly cleaned and refilled with a fresh mix.

Creams and lotions especially designed for protection against cutting oils may also prove of value. In order to reduce the amount of oil thrown upon the workers, shields and guards should be provided for all high speed machines which produce a spray. Sleeves and aprons are also a protection against spray.

Other affections of the skin which are of occupational origin include the serious lesions resulting from exposure to paraffin, pitch, coal tar, arsenic, and certain oils. The cutaneous form of anthrax is also an occupational ailment.

Workers exposed to agents which may produce these conditions should be examined frequently for the presence of skin changes. Here again personal cleanliness plays a large part in prevention. The use of special protective creams has also been found of value.

Principles of industrial disease control

It is difficult to measure the seriousness of the occupational disease problem. On the one hand, there are the effects on worker health, on morale, and eventually on production. On the other, there are the evaluations which have been placed on the costs to industry of compensation, medical care and lost wages.

These figures have never been adequately collected and analyzed, so that estimates vary from a few hundred thousand dollars to several hundred million dollars.

There are two fundamental methods for the control of industrial disease. One is aimed at the process or operation, the other at the individual worker. The first is essentially an engineering function and should be concerned principally with preventive measures. While much of this corrective work will follow the occurrence of clinical industrial disease, its prime objective is to see that no disease ever occurs.

The second method, which has to do with the worker, is medical in character and, while concerned principally with treatment, should also be interested in prevention. Here will be discussed in general the first method, that concerned with the control of the working environment.

Substitution. An ideal method for occupational disease prevention, but one which can only occasionally be achieved, is the exchange of a harmless material for one which is toxic, as in the use of steel shot instead of silica sand in abrasive blasting, non-mercurial carrotting compounds in the production of felt, and the use of less toxic solvents instead of benzol. Such substitution can be brought about only when the toxic material is not essential to satisfactory production.

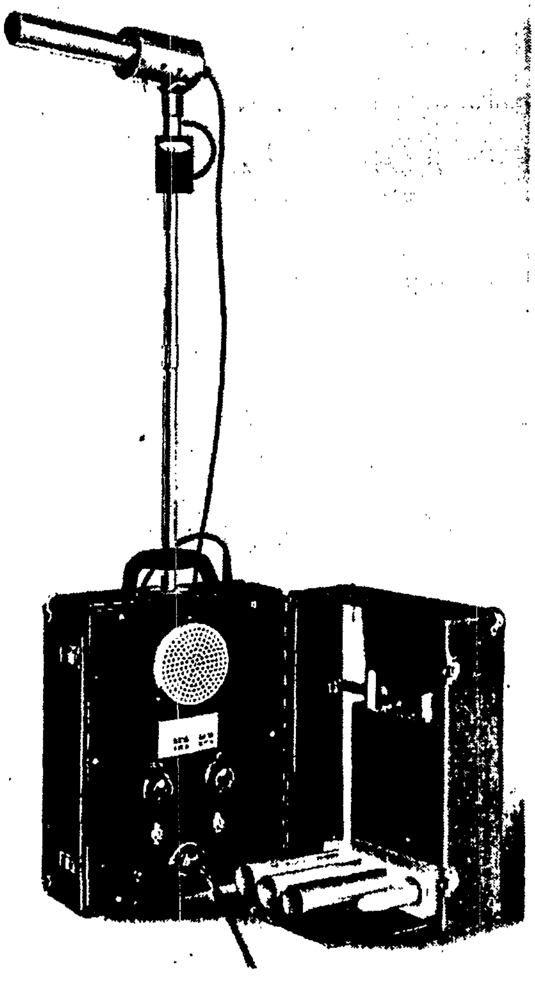

Figure XIII-9. Electrostatic precipitator for the collection of metallic fumes.
Courtesy Mine Safety Appliances Co.

Isolation. For operations in which it is not possible to make substitutions, isolation or enclosure of the hazardous process offers a measure of success. An effective combination control measure is the use of enclosure and exhaust ventilation combined, as in the modern paint spray booth.

Modifications of the complete enclosure may also be utilized. One side, for example, may be open, provided with curtains or a sliding door. Completely enclosed small cabinets are available for sandblasting small objects. These models are equipped with armholes for manipulating the blast hose and with a window through which the operation may be observed.

Process revision. Occasionally a very simple and effective method of control is so to change the operation as to avoid the health hazard. This may take a variety of forms, such as the use of mechanical methods for hand operations, the use of water to subdue dust, careful adjustment of combustion to avoid poisonous gases, and the control of chemical reactions to reduce the escape of toxic gases and vapors.

General exhaust ventilation is designed to control air pollution by means of dilution. Air is either pushed or pulled into the room by means of fans or other propelling devices so that it produces a decrease in the amount of contaminant.

General exhaust ventilation has the virtue of simplicity and relatively low original cost and maintenance. It is particularly effective when large amounts of non-toxic air contaminants must be eliminated, such as smoke, dust, and steam, but it should not often be relied upon to control toxic materials.

Two common faults in general exhaust installations are the lack of provision for make-up air, and permitting short circuiting to occur. In the first case, fans will be inefficient in output and a vacuum may be formed which would create unpleasant drafts through cracks and other openings.