FILE NAME: National Safety Council (NSC)

DATE: 1946

DOC#: NSC118

DOCUMENT DESCRIPTION: NSC - Accident Prevention Manual for Industrial Operations

ACCIDENT PREVENTION MANUAL

for INDUSTRIAL OPERATIONS

ACCIDENT PREVENTION

MANUAL

FOR INDUSTRIAL OPERATIONS

THIS **MANUAL** is published by the National Safety Council as a part of the service materials provided for its industrial members.

The MANUAL is revised from time to time. The comment of its users is therefore solicited in matters of accuracy and completeness, particularly in regard to hazards arising from the introduction into industry of new materials, new equipment and new processes.

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 Committee and to other consultants, who examined preliminary drafts and proofs, and who gave invaluable advice by correspondence and in conference.

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

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 They are valuable complements to the MANUAL, but in no sense are they superseded by it.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.

TABLE VII-B—TABLE OF CHEMICAL HAZARDS

(See paragraphs immediately preceding Table)

Substance	Flash point ° F.	Explosive limits % by volume		Auto-ignition temperature ° F.	Probable safe concentration for 8-hr. exposure	Usual mode of entrance to body	Signs and symptoms of poisoning
		Lower	Upper				
acetaldehyde	—17	4.0	57	365	less toxic than formaldehyde	inhalation	Irritation of eyes and respiratory tract, cough, difficult breathing, night sweats.
acetanilide	345	.....	.....	.....	less toxic than aniline	inhalation, ingestion	Blueness of lips and fingertips, confusion, dizziness.
acetic acid	104	4.0	.....	1050	.....	.....	Powerful skin irritant.
acetone	0	2.55	12.8	1000	200 p.p.m.[1, 2]	inhalation	Irritation of skin, eyes, and upper respiratory tract.
acetylene	gas	2.5	80	635	none adopted extremely low toxicity	inhalation	Headache, nausea, suffocation at very high concentrations.
acrolein	.....	.....	.....	.....	<1.0 p.p.m.[3]	inhalation	Extreme irritation of the eyes, skin and respiratory tract.
acrylonitrile	32	3.05	.....	898	20 p.p.m.[4]	inhalation	Hydrogen cyanide effect due to decomposition in body.
aluminum (powder)	.....	.035 oz./cu.ft.	.....	1085	none adopted	.....	.....
ammonia	gas	16	25	1204	100 p.p.m.[1]	inhalation	Severe irritation of eyes and respiratory passages, cough, caustic action on skin.
amyl acetate—n	76	1.1	.....	714	400 p.p.m.[1, 2]	inhalation	Irritation of eyes and respiratory tract, headache and dizziness, cough, nausea.
amyl alcohol—n	100	1.2	.....	700	100 p.p.m.[2]	inhalation	Same as amyl acetate.
aniline	168	.....	.....	1000	5 to 7 p.p.m.[5]	absorption through skin, inhalation or ingestion	*Acute:* weakness, dizziness, blueness of lips, fainting, possible death. *Chronic:* disturbances of equilibrium, nausea, vomiting, diarrhea, eczema, sleepiness and irritability.

TABLE OF CHEMICAL HAZARDS—*Continued*

Flash point	Explosive limits	Auto-ignition temperature	Probable safe concentration for	Usual mode of entrance to body	Signs and symptoms of poisoning

TABLE OF CHEMICAL HAZARDS—*Continued*

Substance	Flash point ° F.	Explosive limits % by volume		Auto-ignition temperature ° F.	Probable safe concentration for 8-hr. exposure	Usual mode of entrance to body	Signs and symptoms of poisoning
		Lower	Upper				
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.

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.

Titanium, tungsten, molybdenum, germanium. No cases of poisoning due to these elements, used in the steel industry, have been reported. The chlorides hydrolize to produce acids which are irritating.

Industrial poisons (Gases)

Oxygen. Atmospheres extremely rich in oxygen are unlikely to occur industrially, but it has been shown that prolonged exposure to high concentrations are irritating to the respiratory tract. Nascent oxygen, in the form of *ozone*, is also an irritant.

Hydrogen is inactive physiologically and is of interest only because of its explosive nature. In its evolution from plating baths it may act, by means of small bubbles, as a carrier for toxic or irritating substances.

Nitrogen, used occasionally in industry as an inert gas to prevent explosive mixtures, may displace oxygen to a dangerous extent. In those who work under increased atmospheric pressure, nitrogen, because of its physiological inertness, may cause severe damage when released from the tissues. Nitrogen's hydride, *ammonia,* is extremely irritating to the eyes and the respiratory tract.

The toxic oxides of nitrogen have become important because of their formation during the high temperatures of welding operations. Whenever nitric acid is used, the formation of these gases should be considered. They act as acids, irritating the respiratory tract so severely that pulmonary edema and pneumonia may result. *Nitric oxide* exerts its action by the oxidation of hemoglobin to methemoglobin with resultant loss of oxygen transport.

Of the nitrogen-containing salts, the nitrates and nitrites cause physiological disturbances. The *cyanides,* which are included here because of their nitrogen content, are widely used in plating and metal treating. They are extremely toxic, especially in contact with acid, when they form *hydrogen cyanide. Cyanogen,* used for fumigation, is also dangerous.

Acid gases (chlorine, bromine, iodine, hydrogen fluoride, hydrogen chloride, sulfur dioxide, hydrogen sulfide, oxides of nitrogen and phosgene) have in some instances been referred to elsewhere in the manual.* Some, like hydrogen sulfide, may have other than local irritant actions (see above).

The effects of these gases depends to a large degree upon the site of irritation and this, in turn, is determined by the solubility of the gases in water. Those with a high solubility exert their greatest effect in the upper respiratory passages. Those with a lower solubility, and those, like *phosgene,* which hydrolize to form acids, reach the deeper portions of the lungs and bronchi.

As a rule, the results of exposure to this latter type are more severe, for no early irritation occurs to give warning. The insidious, delayed effects may end in pulmonary edema, pneumonia, and death. This effect is also true of a larger number of organic compounds of comparable character.

Helium (also other rare gases). Not significant toxicologically, helium is now of value for supplying to divers a mixture with oxygen to prevent compressed-air illness. (See "increased atmospheric pressure," Page 459.) This mixture eliminates the effects due to nitrogen, which is soluble in body tissues.

Carbon monoxide. The most common cause of gas poisoning, carbon monoxide, is not only encountered in practically every industry, but also in everyday life. It acts as an asphyxiant by forming a stable compound with hemoglobin, thus preventing transport of oxygen by the blood.

Acute poisoning is the most frequent form, but signs of chronic exposure are recognized. The dioxide of carbon may displace air and thus produce asphyxia. It is a powerful respiratory stimulant and may produce disturbing physiological effects when excessive concentrations are present in the inspired air.

Industrial poisons (Organic compounds)

Aliphatic hydrocarbons. Of this group, the compounds most common to industrial use are the *gasolines, naphthas, benzine, kerosene, fuel* and *lubricating oils.* They have wide application, being used as solvents, cleaners, degreasers and as vehicles in paints.

Their vapors will produce headache, dizziness, nausea, vomiting, stupor and unconsciousness. They act as irritants to the skin and are common causes of industrial

*See Part VII "Chemical Hazards."