

DANGEROUS PROPERTIES of INDUSTRIAL MATERIALS

A Completely Revised and Enlarged Edition of
HANDBOOK OF DANGEROUS MATERIALS

by

N. IRVING SAX

*Consultant on Industrial Safety
Nuclear Development Corporation of America
White Plains, N. Y.*

Assisted by

LEONARD J. GOLDWATER
*Professor of Occupational Medicine
Columbia University
New York, N. Y.*

WILLIAM B. HARRIS
*Chief, Industrial Hygiene Branch
Health and Safety Laboratory
U. S. Atomic Energy Commission
New York, N. Y.*

JOHN H. HARLEY
*Chief, Analytical Branch
Health and Safety Laboratory
U. S. Atomic Energy Commission
New York, N. Y.*

JOSEPH J. FITZGERALD
*Supervisor of Radiological Chemistry and Physics
Knolls Atomic Power Laboratory
General Electric Company
Schenectady, N. Y.*

MILTON S. DUNN
*Medical Director, Pennselaer Division
General Aniline and Film Corp.
Pennselaer, N. Y.*

REINHOLD PUBLISHING CORPORATION, NEW YORK
CHAPMAN & HALL, LTD., LONDON

SECTION I TOXICOLOGY

Leonard Goldwater, M. D.
Professor of Occupational Medicine
Columbia University
New York, N. Y.

This section has been prepared for the purpose of providing a certain amount of background for those who may be called upon to understand and interpret data which are largely medical in nature, rather than for physicians or others who have been specially trained in the field of industrial toxicology.

Toxicity Defined

Toxicity is the ability of a chemical molecule or compound to produce injury once it reaches a susceptible site in or on the body. Toxicity hazard is the probability that injury may be caused by the manner in which the substance is used.

Acute. This term will be used in the medical sense to mean "of short duration." As applied to materials which are inhaled or absorbed through the skin, it refers to a single exposure of a duration measured in seconds, minutes or hours. As applied to materials which are ingested, it refers generally to a single quantity or dose.

Chronic. This term will be used in contrast to "acute" and means "of long duration." As applied to materials which are inhaled or absorbed through the skin, it refers to prolonged or repeated exposures of a duration measured in days, months or years. As applied to materials which are ingested, it refers to repeated doses over a period of days, months or years. The term "chronic" will not refer to severity of symptoms but will carry the implication of exposures or doses which would be relatively harmless unless extended or repeated over long periods of time (days,

months or years). In this book the term "chronic" includes exposures which might also be called "sub-acute," i.e., somewhere between "acute" and "chronic."

Local. This term refers to the site of action of an agent and means that the action takes place at the point or area of contact. The site may be skin, mucous membranes of the eyes, nose, mouth, throat, or anywhere along the respiratory or gastrointestinal system. Absorption does not necessarily occur.

Systemic. This term refers to a site of action other than the point of contact and presupposes that absorption has taken place. It is possible, however, for toxic agents to be absorbed through a channel (skin, lungs or intestinal canal) and produce later manifestations on one of those channels which are not a result of the original direct contact. Thus it is possible for some agents to produce harmful effects on a single organ or tissue as a result of both "local" and "systemic" actions.

Absorption. A material is said to have been absorbed only when it has gained entry into the blood stream and consequently may be carried to all parts of the body. Absorption requires that a substance pass through the skin, a mucous membrane, or the air sacs (alveoli) of the lungs.

Toxicity Ratings

An explanation of the toxicity ratings is given in the following paragraphs:

U = Unknown. This designation is given to substances which fall into one of the following categories:

- (a) No toxicity information could be found in the literature and none was known to the authors.
- (b) Limited information based on animal experiments was available but in the opinion of the authors this information could not be applied to human exposures.
- (c) Published toxicity data were felt by the authors to be of questionable validity.

0 = No toxicity. This designation is given to materials which fall into one of the following categories:

- (a) Materials which cause no harm under any conditions of use.
- (b) Materials which produce toxic effects on humans only under the most unusual conditions or by overwhelming dosage.

1 = Slight toxicity

- (a) Acute Local. Materials which on single exposures lasting seconds, minutes or hours cause only slight effects on the skin or mucous membranes regardless of the extent of the exposure.
- (b) Acute Systemic. Materials which can be absorbed into the body by inhalation, ingestion or through the skin and which produce only slight effects following single exposures lasting seconds, minutes, or hours, or following ingestion of a single dose, regardless of the quantity absorbed or the extent of exposure.
- (c) Chronic Local. Materials which on continuous or repeated exposures extending over periods of days, months or years cause only slight harm to the skin or mucous membranes. The extent of exposure may be great or small.
- (d) Chronic Systemic. Materials which can be absorbed into the body by inhalation, ingestion or through the skin and which produce only slight effects following continuous or repeated exposures extending over days, months or years. The extent of the exposure may be great or small.

In general, those substances classified as having "slight toxicity" pro-

duce changes in the human body which are readily reversible and which will disappear following termination of exposure, either with or without medical treatment.

2 = Moderate toxicity.

- (a) Acute Local. Materials which on single exposure lasting seconds, minutes or hours cause moderate effects on the skin or mucous membranes. These effects may be the result of intense exposure for a matter of seconds or moderate exposure for a matter of hours.
- (b) Acute Systemic. Materials which can be absorbed into the body by inhalation, ingestion or through the skin and which produce moderate effects following single exposures lasting seconds, minutes or hours, or following ingestion of a single dose.
- (c) Chronic Local. Materials which on continuous or repeated exposures extending over periods of days, months or years cause moderate harm to the skin or mucous membranes.
- (d) Chronic Systemic. Materials which can be absorbed into the body by inhalation, ingestion or through the skin and which produce moderate effects following continuous or repeated exposures extending over periods of days, months or years.

Those substances classified as having "moderate toxicity" may produce irreversible as well as reversible changes in the human body. These changes are not of such severity as to threaten life or produce serious permanent physical impairment.

3 = Severe toxicity.

- (a) Acute Local. Materials which on single exposures lasting seconds or minutes cause injury to skin or mucous membranes of sufficient severity to threaten life or to cause permanent physical impairment or disfigurement.
- (b) Acute Systemic. Materials which can be absorbed into the body by inhalation, ingestion or through the skin and which

can cause injury of sufficient severity to threaten life following a single exposure lasting seconds, minutes or hours, or following ingestion of a single dose.

- (c) Chronic Local. Materials which on continuous or repeated exposures extending over periods of days, months or years can cause injury to skin or mucous membranes of sufficient severity to threaten life or to cause permanent impairment, disfigurement or other irreversible change.
- (d) Chronic Systemic. Materials which can be absorbed into the body by inhalation, ingestion or through the skin and which can cause death or serious physical impairment following continuous or repeated exposures to small amounts extending over periods of days, months or years.

Toxicology Defined

In simple terms, toxicology may be defined as the study of the action of poisons on the living organism. Industrial toxicology is concerned with the human organism and consequently lies within the broad field of medicine. Since medicine cannot be considered an exact science in the same sense as chemistry, physics or mathematics, *toxicologic phenomena cannot always be predicted with accuracy or explained on the basis of physical or chemical laws.* It is this unpredictability which frequently reduces conclusions and decisions to opinion rather than fact.

Poison Defined

In attempting to define the term "poison," a major consideration is that of quantity or dosage. A poison may be defined as a substance which causes harm to living tissues when applied in relatively small doses. It is not always easy to make a clear-cut distinction between poisonous and nonpoisonous substances. (See further discussion on p. 4).

Effective Dosage

Generally speaking, industrial toxicology is concerned with the effects of substances which gain entry

into some part of the human body. Almost any substance can cause harm when applied directly to the skin. Among the factors which are concerned in effective dosage, the most important are:

- (1) Quantity or concentration of the material.
- (2) Duration of exposure.
- (3) State of dispersion (size of particle or physical state, e.g., dust, fume, gas, etc.).
- (4) Affinity for human tissue.
- (5) Solubility in human tissue fluids.
- (6) Sensitivity of human tissues or organs.

Obviously there are possibilities for wide variations in any of these factors.

Methods of Expressing Effective Dosage:

- (1) Maximum Allowable Concentration (MAC).

For gases and vapors the MAC value is usually expressed in parts per million (ppm), that is, parts of the gas or vapor per million parts of air.

For fumes and mists, and for some dusts, the MAC is usually given as milligrams per cubic meter (mgm/m^3) or per 10 cubic meters of air.

For some dusts, particularly those containing silica, the MAC is usually expressed as millions of particles per cubic foot of air MPPCF.

MAC values have gained wide acceptance in industrial toxicology as a means of expressing concentrations of potentially harmful substances. They purport to represent the greatest amount of a substance to which persons may be exposed for 8 hours a day for a period of months or years without danger to health.

Literal acceptance of this concept is dangerous for the following reasons:

- (a) A great majority of all published MAC values are based either on speculation, opinion or limited experimentation on rats, mice, guinea pigs or other laboratory animals. In very few instances have the values been established firmly on a basis of examinations of human subjects correlated with adequate environmental

observations.

- (b) Concentrations of toxic or harmful materials in any working environment rarely remain constant throughout a work day. The occurrence of "surges" is well known.
- (c) Industrial exposures frequently involve mixtures rather than single compounds. Very little is known about the effects of mixtures.
- (d) Individuals vary tremendously in their sensitivity or susceptibility to toxic substances. The factors controlling this variability are not well understood. It should not be assumed that conditions which are safe for some individuals will be safe for all.
- (e) For some substances, concentrations which may be considered "safe" may still result in discomfort or annoyance.
- (f) A single MAC value is usually given for substances which occur in the form of salts or compounds of different solubility or in different physical states (e.g., lead, mercury).

If the above limitations are understood and accepted, the published MAC values can be used to great practical advantage. Their principal usefulness is in connection with the design of ventilating systems (see Section 2). Ventilation engineers must have a concrete figure to serve as the basis for the design of ventilating equipment. It should not be assumed, however, that attainment of concentrations at or even below the published MAC limits will necessarily prevent all cases of occupational poisoning; nor should it be assumed that concentrations which exceed the given limits will necessarily result in cases of poisoning. The concept known as Haber's Law, which involves the product of concentration and time ($C \times T = K$), expresses an index of the degree of toxic effect. This too, may be misleading, since little is known of the relative effectiveness of large doses over a short period of time as compared with smaller doses over a longer time period.

(2) Minimal Lethal Dose and LD50 Test.

In experimental toxicology it is common practice to determine the quantity of poison per unit of body weight of an experimental animal which will have a fatal effect. (A scale commonly used is milligrams of poison per kilogram of body weight.) That amount per unit of body weight which will cause even one fatality in a group of experimental animals is known as the minimal lethal dose (MLD). A more commonly used figure in experimental industrial toxicology is the amount which will kill one-half of a group of experimental animals. This is known as the LD50 test (Lethal Dose 50 per cent) representing 50 per cent fatalities.

The Manufacturing Chemists Association bases its definition of the term "poison" on this test. In its publication entitled "Warning Labels" (4th edition) it states the following: "Poison: A chemical or mixture of chemicals which falls within any of the following categories:

- (a) Produces death within 48 hours in half or more than half of a group of 10 or more laboratory white rats weighing 200-300 grams at a single dose of 50 milligrams or less per kilogram of body weight, when administered orally; or
- (b) Produces death within 48 hours in half or more than half of a group of 10 or more laboratory white rats weighing 200-300 grams, when inhaled continuously for a period of one hour or less at an atmospheric concentration of 2 milligrams or less per liter of gas, vapor, mist, or dust, provided such concentration is likely to be encountered by man when the chemical product is used in any reasonable foreseeable manner; or
- (c) Produces death within 48 hours in half or more than half of a group of 10 or more rabbits tested in a dosage of 200 milligrams or less per kilogram body weight, when administered by continuous contact

resulting anemia is responsible for the production of many of the symptoms accompanying arsine poisoning; other symptoms result from the hemolysis itself, and occur during the excretion of the hemoglobin. Hemoglobin and its degradation products are commonly found in the urine. Less commonly whole blood may be passed. Occasionally, the renal tubules may be plugged by debris, with resultant suppression of urine. Jaundice, which may be severe, is a common result of the hemolysis. Frequently there is edema of the lungs, which may be accompanied by cyanosis. Kidney damage is common in patients surviving acute effects of the gas.

Signs of poisoning usually develop within several hours of exposure. Headache, dizziness, nausea and vomiting, epigastric pain and weakness occur early, followed by tea-colored urine, or bloody urine in the more severe cases. Some time later, albumen and casts may appear in the urine, or, in serious cases, there may be suppression of urine. Jaundice and tenderness over the liver may appear about the same time. Blood examination shows an anemia which may be marked. In fatal cases, the patient may develop delirium, followed by coma and death. During the acute stage of poisoning and for some weeks after, arsenic may be demonstrated in the urine. See also Arsenic and Arsenic Compounds.

Fire Hazard: Moderate, when exposed to flame (Section 6).

Explosion Hazard: Moderate when exposed to flame (Section 7).

Disaster Control: Dangerous; when heated to decomposition, it emits highly toxic fumes of arsenic; can react vigorously with oxidizing materials.

Ventilation Control (use moderate rate): Section 2

Storage and Handling: Section 7

ARSPHENAMINE

Synonym: 3-Diamino-4-dihydroxy-1-arsenobenzene hydrochloride.

Description: Light yellow, hygroscopic powder.

Formula: $C_6H_4As_2N_2O_2 \cdot 2HCl \cdot 2H_2O$

Constant:

Mol. Wt. 475.0

Toxicity: See Arsenic Compounds.

Disaster Control: See Arsenic Compounds.

Ventilation Control (use moderate rate): Section 2

Personnel Protection: Section 3

Personal Hygiene: Section 3

First Aid: Section 1

Storage and Handling: Section 7

ASBESTOS PARTICLES

Synonym: Asbestos dust.

Toxic Hazard Rating:

Acute Local: Irritant 1; Inhalation 2

Acute Systemic: 0

Chronic Local: Inhalation 3

Chronic Systemic: U

MAC: ACGIH (accepted); 5 million particles per cubic foot of air.

Toxicology: The essential lesion produced by asbestos dust is a diffuse fibrosis which probably begins as a "collar" about the terminal bronchioles. Usually, at least 4 to 7 years of exposure are required before a serious degree of fibrosis results. There is apparently less predisposition to tuberculosis than is the case with silicosis.

Clinically, the most striking sign is shortness of breath of gradually increasing intensity, often associated with a dry cough. In the early stages physical signs are absent or slight; in the later stages rales may be heard, and in long-standing cases there is frequently clubbing of the fingers. In early stages of the disease the chest x-ray reveals a ground-glass or granular change, chiefly in the lower lung fields; as the condition progresses the heart outline becomes "shaggy" and irregular patches of mottled shadowing may be seen. Asbestos bodies may be found in the sputum.

At autopsy, the pleurae are thickened and adherent and thin subpleural fibrous plaques are often present. Where the disease is far advanced there are usually

Toxic Rating Code: 0 = None 1 = Slight 2 = Moderate 3 = High U = Unknown

large areas of fibrosis, with emphysematous changes in the apices and bases. The alveolar walls are thickened, and the characteristic "asbestos bodies" are found.

Ventilation Control (use normal rate):

Section 2

Personal Hygiene: Section 3

ASCARIDOLE

Description: Liquid.

Formula: $C_{10}H_{16}O_2$

Constants:

Mol. Wt. 168.2

B. P. 115°C @ 15 mm

Density 1.011 @ $13^{\circ}/15^{\circ}\text{C}$

Toxicity: Details unknown. See also Peroxides, Organic.

Fire Hazard: Moderate, by spontaneous chemical reaction (Section 6).

Caution: An oxidizer.

Explosion Hazard: Explodes at 250°C .

Disaster Control: Dangerous; when heated, it emits toxic fumes and may explode; it reacts with reducing materials.

Storage and Handling: Section 7

ASPHALT

Synonyms: Bitumen; petroleum pitch.

Description: Black or dark brown mass.

Constants:

B. P.: $< 470^{\circ}\text{C}$

Flash P. $400+^{\circ}\text{F}$ (C.C.)

Density 0.95 - 1.1

Autoign. Temp. 905°F

Toxic Hazard Rating:

Acute Local: Irritant 2

Acute Systemic: U

Chronic Local: Irritant 2

Chronic Systemic: U

Fire Hazard: Slight, when exposed to heat or flame.

Spontaneous Heating: No

To Fight Fire: Foam, carbon dioxide, dry chemical or carbon tetrachloride (Section 6).

Personnel Protection: Section 3

Personal Hygiene: Section 3

Storage and Handling: Section 7

Shipping Regulations: Section 11.

Coast Guard Classification:
Hazardous Article.

ASPIDIUM

Synonym: Male fern.

Toxic Hazard Rating:

Acute Local: Irritant 1; Allergen 1

Acute Systemic: Ingestion 2

Chronic Local: Allergen 1

Chronic Systemic: U

Fire Hazard: Slight; when heated, it emits acrid fumes (Section 6).

Personal Hygiene: Section 3

Storage and Handling: Section 7

ASPIRIN. See Acetol.

ATABRINE DIHYDROCHLORIDE.

See "Atabrine" Hydrochloride.

"ATABRINE" HYDROCHLORIDE

Synonym: Quinacrine hydrochloride.

Description: Bright yellow crystals.

Formula: $C_{23}H_{26}ClN_3O \cdot 2HCl \cdot 2H_2O$

Constants:

Mol. Wt. 508.9

M. P. Decomposes $248 - 250^{\circ}\text{C}$

Toxic Hazard Rating:

Acute Local: Allergen 1

Acute Systemic: Ingestion 2

Chronic Local: Allergen 1

Chronic Systemic: Ingestion 2

Disaster Control: Dangerous; when heated to decomposition, it emits highly toxic fumes of chlorine.

Personal Hygiene: Section 3

Storage and Handling: Section 7

ATROPINE

Synonym: Daturine.

Description: Colorless, crystalline alkaloid.

Formula: $C_{17}H_{23}NO_3$

Constants:

Mol. Wt. 289.4

M. P. 115.5°C ; sublimes at 113°C

Toxic Hazard Rating:

Acute Local: Allergen 1

Acute Systemic: Ingestion 3;
Inhalation 3

Chronic Local: Allergen 1

Chronic Systemic: Ingestion 2

Fire Hazard: Slight; on decomposition it emits toxic fumes.

Ventilation Control (use moderate rate): Section 2

Personal Hygiene: Section 3

First Aid: Section 1

Storage and Handling: Section 7

ATROPINE METHYL BROMIDE.

See Atropine.

For detailed discussion of Toxicology, see Section 1

660.2 Sa. 9

RESEARCH LIBRARY	
No. <u>2539</u>	
DATE REC'D <u>Dec 2/57</u>	
ENTERED BY <u>CO.</u>	
JOPLIN, MO.	

DEPOSITION
EXHIBIT

2/19