INDUSTRIAL HEALTH

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PREFACE

Books, including this one, tend to give the reader an impression that the world is replete with immutable facts and unchanging ideas and that there is only one best way of doing almost anything. The world does change, however, and many immutable facts change right along with it despite their representation by the unchanging written word. This book does not contain a list of threshold limit values (TLV's) for chemicals or for any physical agents. Threshold limits published by the American Conference of Governmental Industrial Hygienists (ACGIH) are updated annually, but this book is not. Few things are so out of date as last year's TLV list. Similarly, there is a positive dearth of analogous data for radioactive materials, air and water pollutants, or legislated standards. Instead, in this text, underlying principles are emphasized, assigning much of their application to current publications such as TLV's, Hygienic Guides, ANSI standards, and scientific journals, all well designed to further the constant battle against information obsolescence.

This book began as the outline of a survey course taught mainly to senior and graduate civil engineering students and ended as an expanded version of that outline fleshed by the ideas of many people. It is, in systematic form, a collection of useful fundamentals and principles behind man's attempt to evaluate and control hazards that abound in his environment. Because they are most immediate, occupational hazards are stressed, ranging from those of chemical toxins to those of various energy forms. Many of the materials and energies are found also in the home, farm, or garden.

The reader is assumed to have some familiarity with science and scientific methodology but no particular background beyond that is necessary. A review of organic chemical nomenclature important in the field is presented in Appendix A, and a glossary of terms mainly from medicine and physiology appears in Appendix B.

Many people contributed to this book but only a few can be thanked. Jim Mellender devised the algorithms and wrote the programs that allowed me to computerize my file of abstracts and then to search it with extreme rapidity. Both computers used for this purpose belong to the Medical College of Wisconsin; much of the abstract file was developed during my employment with that institution.

Marquette University personnel and especially those in the College of Engineering were particularly encouraging throughout all phases of manuscript preparation. A special debt is owed to my students, who helped shape the lecture outlines with questions and comments; to Dean Ray Kipp and Civil Engineering Department chairmen Al Zanoni, and, later, Bill Murphy, who helped ease the burdens of my academic life to allow more time for writing.

At home my wife and two sons not only helped by taking over many of my husbandly and fatherly chores but participated actively in the book production process. Writing could not have been done without their aid.

Much of the industrial hygiene I know can be traced back to The Dow Chemical Company and especially to the man who was responsible for my choice of this above all other fields, Harold Hoyle. Both he and Warren Cook, my friend and thesis advisor at the University of Michigan, taught me well so that the mistakes herein are mine, not theirs.

J. E. P.

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1

ENTRY AND TOXIC ACTIONS OF CHEMICAL SUBSTANCES

Toxicity is a property of matter. It is a biological property in much the same way that mass is a physical property. It is an extrinsic, as opposed to intrinsic, property because toxicity is a function of the amount of material. (Mass is an extrinsic physical property.) Toxicity is the ability of a material to injure a living organism by other than mechanical means. The toxicity of a material is not altered by the way it is handled, by its temperature, or by its physical state, but the toxic hazard posed by the material may be greatly influenced by these and by many other external factors. The *toxic hazard* of a material is the likelihood of injury and an evaluation of hazard must consider, in addition to toxicity, physical and chemical properties, physical state, method of handling, and other factors that influence the probability of contact with significant amounts of the material.

Of course not all hazards are toxic hazards. Hazards arise from various forms of energy and from mechanical sources as well as from toxicity. Mainly on the basis of historical precedent, mechanical hazards such as falling, tripping, caught in or between, and fire/explosion are considered to be the province of people who call themselves safety engineers, safety professionals, or safety specialists, and that field is generally called *safety*. All other hazards, and in particular those associated with materials, pressures, and energies encountered by man in his occupations, fall into the field called *industrial hygiene*.

Routes of Entry

While the inherent toxicity of a material is not dependent on how that material gets into the body unless the material is altered chemically by entry, the route of entry is normally specified in expressions of absolute or relative toxicity. This is so because the efficiency of absorption of materials by the body varies with the route of entry, and injection with a hypodermic needle is the only way of being certain that 100% of a dose has been absorbed. Even though drug abuse may be an important industrial problem, injection of industrial chemicals is not. Instead, attention must be focused on entry by the routes of ingestion, skin absorption, and inhalation.

Ingestion

Workmen rarely eat or drink the materials they handle, even in a candy factory, and therefore ingestion is an important route of entry only in cases where the *acute* (short term or single dose) or *chronic* (long term or repeated dose) toxicity by this route is very high. For materials with high oral toxicities, the small amounts that may be transferred to the mouth from the hands on a sandwich or a cigarette may be enough to be cause for concern. This is so with most radioisotopes, some of the metals, and many of the organophosphate insecticides. In general, if the material has an acute oral LD_{50} (lethal dose for 50% of the animals fed) of 1.0 mg/kg or lower, precautions against oral contact should be taken if ingestion is a possible route of entry.

Note that the word *poison* has been avoided. Poison has legal connotations as it is defined in several laws that need not concern us here. Toxicologists and environmental health engineers usually avoid using the word *poison* except in circumstances required by law (labels, for instance) or to mean simply *too much*.

Skin Absorption

Rather than being an absolute barrier, man's skin acts as a selective filter. Some materials such as water-soluble salts are almost absolutely excluded but others such as phenol, hydrogen cyanide, and aniline are readily absorbed through the intact skin. Intact skin is more of a barrier than is abraded or lacerated skin, indicating that the skin does offer at least some resistance to penetration of all materials. Even though some materials