16
Environmental Safety and Industrial Hygiene

16.1. GENERAL INTRODUCTION

Safety considerations are inseparable from the principles of good design and operation and so have been a constant theme in our discussion of the chlor-alkali process. The preceding chapters deal with the practical details of direct protection of personnel in the workplace. They refer frequently to the programs and publications of various organizations with special interest in industrial safety. Other publications [1,2] also discuss operating safety and provide guidance in design and operation. In this chapter, we consider safety more generally and also provide more quantitative information on hazard levels. To put those hazards in perspective and show the degree of success the industry has had in coping with them, consider the following [3]:

1. In 40 years of production, transport, and use in Western Europe, the number of fatalities caused by exposure to chlorine is equal to the number of road fatalities on a typical weekend in Belgium
2. A chlorine plant worker faces the following relative risks of accidental death

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<tbody>
<tr>
<td>At work</td>
<td>1</td>
</tr>
<tr>
<td>At home</td>
<td>5</td>
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<tr>
<td>In an automobile</td>
<td>11</td>
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These are calculated from Van Diest's data [3] on the arbitrary assumption of 45 hr spent at work, 110 hr at home, and 13 hr in an automobile. In the 1930s, 11 fatalities occurred in the industry per million tons of chlorine produced worldwide. By the 1980s, it had dropped to 0.15 (0.04 in the Euro Chlor (EC) countries). The 1.5 fatal accidents suffered in $10^8$ exposure hours compare favorably to 3 in the chemical industry as a whole and 5 in all manufacturing industry.

After discussing the hazards associated with various materials and process conditions in Sections 16.2 and 16.3, this chapter turns to the prevention and the mitigation
of accidents (Section 16.4). Personal protective equipment (PPE) and administrative programs are both covered. There is an emphasis on process safety management (PSM) and hazard analysis programs. Finally, we discuss methods to reduce the effects of the release of chlorine. The chapter closes with a discussion of waste minimization and disposal (Section 16.5). While this covers all the principal wastes from a chlor-alkali plant, it concentrates on those containing mercury.

There are many ways in which toxic materials may act to harm the body and several ways in which they may be enabled to do harm. The latter include contact, ingestion, and inhalation. A given material can present a hazard by all three routes (hydrochloric acid is an example), but more frequently one route predominates. Materials such as sulfuric acid and caustic soda or potash are corrosive to tissue and are primarily contact hazards. The familiar major episodes with mercury are due to ingestion. Chlorine and asbestos are primarily inhalation hazards.

An ingested or inhaled material usually requires a bodily process to spread throughout the system or to reach an organ where it accumulates. At the same time, some is eliminated from the body or rendered harmless. It is therefore possible to establish safe limits for most materials below which conversion and elimination prevent dangerous accumulation. These limits appear throughout the literature and on material safety data sheets (MSDS). Contact hazards, on the other hand, usually act locally and immediately. These hazards can be mitigated by dilution, but this reduces the usefulness of most materials and is not a practical approach in a production area.

Ingestion hazards are not a major issue in the workplace. Rarely does someone drink from a beaker of sulfuric acid. There is a first line of defense against inhalation hazards. Their concentrations in the environment can for the most part be kept below dangerous levels. PPE is the second line, used in case of release or infrequent work in a hazardous situation (e.g., opening of equipment or pipelines). Complete protection against contact hazards requires absolute prohibition. Methods for achieving this include confinement of the hazard, good work practices, and the use of protective equipment.

With its many references to safety regulations and supervisory agencies, this chapter is especially rich in abbreviations and acronyms. A glossary of some of these terms is included at the end of the chapter.

16.2. MATERIALS HAZARDS

The subsections that follow cover the hazards associated with the various materials used and produced in a chlor-alkali plant. These include chlorine, hypochlorites, caustic soda and potash, hydrogen, hydrochloric acid, sulfuric acid, mercury, asbestos, nitrogen trichloride, and miscellaneous materials.

Exposure limits for toxic materials in the atmosphere often appear as Threshold Limiting Values (TLVs) or their equivalents. TLVs are not official or consensus standards [4], and their publishers advise against adopting them as a matter of course. They should be viewed as one source of data, fixed without regard to cost–benefit analysis or