Periodicals — magazines, journals, newsletters, directories; includes all emergency publications issued regularly at least once every two years.

Computer software — census of software covering management of emergency departments, training, exam preparation, data bases, inventory control, networking, accounting systems.

Abbreviations — comprehensive list of abbreviations and acronyms commonly used in the emergency services.

The goal of Specialization Publication Services, Inc., in compiling the book was to provide the emergency services — fire, EMS, law enforcement, hazardous material handling, disaster and hazard reduction, search and rescue, industrial life safety, and loss prevention — with the sources they are most likely to consult for further information or assistance.

I was extremely impressed by the scope and amount of data present. A spot check indicated good coverage — a text I wrote on hazardous materials appears in the book section, the *Journal of Hazardous Materials* was found in the periodicals section, and a training course on hazardous materials I knew of was included. Clearly, one cannot in such a data gathering exercise guarantee compilation, of all the material available, but items I sought were found. Names, addresses and telephone numbers of information sources are given.

GARY F. BENNETT

Guidelines for Engineering Design for Process Safety, Center for Chemical Process Safety of the American Institute of Chemical Engineers, 345 E. 47th St., New York, NY 10017, USA, 1993, 556 pages, price US$ 140.00, ISBN 0-8169-0565-7

Introduction — Chapter 1

This volume of safety in the process industry is designed to help engineers design a safe processing facility with inherently high integrity and reliability. It will also be of significant value and use to plant supervision and management in chemical, petrochemical, and hydrocarbon processing facilities, as well as to safety and accident prevention personnel, environmental process, industrial hygienists and nurses.

The scope includes avoidance and mitigation of catastrophic events that can impact people and facilities in the plant engineering area of concern.

Chapter 2 — Inherently safer plants

Inherently safer plants can be created and operated if the various unknowns or risks are anticipated and acted upon. The potential for major improvements is greater at the earliest stages of process improvements, hence the important role of the plant process engineer.

Once it is accepted that risk management is possible (as one important aspect or part of the process), risks may be classified as (1) inherent or intrinsic; (2) passive; (3) needing active or engineering controls; or (4) procedural, including operating response, and other 'good management' aspects. Examples of each strategy are noted in detail. No one aspect of process safety control will be adequate alone; the process design usually determines what will happen.

Reactors are a key component of the system; several types are illustrated. Storage and transfer of materials are noted, and the piping systems which connect the system are given full importance.

Substitution by development of alternative chemistry using less hazardous materials, reducing inventories or lowered by operating changes, is encouraged. Replacement of volatile organic solvents with aqueous systems or less hazardous organics improve safety, and should be seriously studied. In the plant utility and services, the authors recommend water or steam as the heat transfer media of choice. The questionable future of chlorofluorocarbons after 1996, and possible reduction of other solvents make this topic of serious potential impact.

Attenuation (using materials under less hazardous conditions) may be reviewed with profit. This includes the benefit of storage in a diluted form, and is accomplished by strategies that are either physical (low temperature or dilution), or chemical (such as development of reaction chemistry that operates at less severe conditions). Refrigeration for storage of ammonia, chlorine, and propane are candidates. Refrigeration reduces the rate of release, and hence the size of the hazard zone. Handling solids as a granulate or pellet reduces the risk of dust explosion. Processing under less severe conditions, particularly lower temperature and pressure, increases the inherent safety of a chemical process.

Storage tanks deserve much study, since their role in plant safety has been shown in many incidents. Size, location, proper discharge and filling controls to prevent overfilling are noted. Containment buildings, especially for toxic gases such as chlorine and phosgene, limit the impact of a possible incident. Diagrams showing recommended practices are clearly outlined. Kletz's more extensive version is referenced as more complete. A 6-page reference section concludes the chapter.

Chapter 3, *Plant design*, stresses the importance of proper process and engineering design in the early conceptual stages of plant construction. A process safety review and extenuations are recommended through the life of the plant. This suggests a thorough knowledge of dangerous properties, not a material safety data sheet alone. Reactivity and flammability should not be overlooked as hazards in many operations.

Toxic release under unfavorable conditions may be a major incident. The potential releases should be anticipated and quantified. Impurities in process streams may jeopardize desired reactions and possibly pose a threat to plant and employee safety.

Process conditions (pressure and temperature) often contribute to unwanted incidents. Plant site selection should consider both population density, natural disasters, and transportation.

As the site development proceeds, full consideration should be given to the interplay and interactions of various components. Adequate separation of some components will make for additional safety. A minimum block size of 300 ft. (92 m) by 600 ft. (183 m) with adequate spacing between blocks allows access for fire fighting and other emergency response services.

Arrangement of equipment within a block should be studied. Storage layout and unobstructed access are essential, not just for emergencies but for routine operation. The control room, the nerve center of the plant, deserves careful analysis as to design and location.

Underground piping is a potential for difficulty, if full action is not taken to prevent rupture. Surface drainage and sound foundations are other essentials.

Structural stability, as related to earthquakes, high winds, and excessive cold weather, merit full consideration.

Explosion-resistant versus explosion-proof design of buildings should be recognized; the latter may be more economical in the long haul.

Ventilation, a key element in the control of hazardous materials, should be considered in terms of both general ventilation and hazardous areas requirements (including attention to fume hoods and discharge, and other specific areas).

Failure of utilities, and their effect on production and personnel, is an event to be anticipated and alternate sources (especially electrical) considered.

Having introduced the reader to the general concerns of the plant, specific chapters highlight equipment design, both process and storage. Vacuum systems require special consideration. A three-page table lists the basic causes for process equipment. Process instrumentation is discussed to insure that the essential knowledge is available as needed. Process conditions should be carefully defined before any process vessels are adopted.

Dryers are a special case, where fires and explosions are only one type of hazard. Pumps of various types should be selected from the wide variety of equipment available. Activated carbon absorbers are noted in a full page checklist. Six pages of suggested references and reading concludes this chapter.

Chapter 5, Materials selection, is devoted to materials selection, depending on the requirements of the process. Metal failure is a recognized factor in choice of materials for the equipment. Fabrication and installation, including selection of welding processes, is another aspect frequently overlooked, as is the monitoring and control of corrosion. Three pages of references conclude this chapter.

Chapter 6, Piping systems, highlights the role of pipes in the plant. Special materials, such as thermoplastic pipes, and plastic-lined pipe, as well as double-walled piping including grounding, are noted, and each has its specific use and limitations for some areas. Specific reservations are noted about piping for oxygen, chlorine, phosgene, hydrogen, acetylene, and ethylene oxide, for reasons which are discussed. Five pages of references conclude this chapter.

Chapter 7, Heat transfer fluid systems, notes the precautions needed to design and operate systems which have great potential for harm. Descriptions of several commercially heat transfer fluids are tabulated with their characteristics. Steam heat is compared with heat transfer fluids. Operating temperatures range up to 360 °C.

Chapter 8, Thermal insulation, deals with an important component of many operating systems. Both the combustibility of the insulation itself, as well as the effect of absorbed liquids on the insulation, should be considered. Three pages of references supplement this chapter.

Chapter 9, Process monitoring and control, stresses the importance of monitoring and also its complexity. Various networks and inter-contacts are noted. Backup instruments are often considered in case of failure of the prime recorders. Intrinsically safe instruments, with no electrical circuits, will give greater accuracy. There is growing interest in the use of computers for process control. In addition to basic process control systems, computers have other functions to control interlocks and other important internal systems. The term PES has been widely applied to computer-based systems, which controls, protects or monitors the operation of the plant machinery and various other equipment. From this, layers of protection can be applied to the particular process. An instrumentation and control checklist, plus four pages of references, conclude this chapter.

Chapter 10, Documentation, considers the elements of chemical process safety management and the documents which relate to basic design, equipment specifications, design standards, and safety reviews and records. Such documents are essential to comply with federal, as well as state and local laws. Operating manuals, based on the basic information, become the day-by-day references. Interservices inspection and testing, as well as inspections, are vital to the long-range safety effort. All documents need to be accessible, yet secure and controllable. Material safety data sheets for each chemical should be included, as required by OSHA. An appendix on typical inspection points and procedures is followed by three pages of references.

Chapter 11, Sources of ignition, discusses both the obvious as well as the more obscure ignition sources. Common sources include electricity and static. Lightning, stray currents, overhead high-voltage power lines, and galvanic and cathodic protection from stray currents are also considered. Local chemical reactions, which cannot occur in the system as a whole, catalysts, powerful oxidizers, such as $KMnO_4$ and liquid oxygen, and thermally unstable materials (such as organic peroxides) are examples discussed. Pyrophoric materials are noted; they ignite on short exposure to air. It is noted ignition is predictable and avoidable in the design stage. Five pages of references conclude this chapter.

Chapter 12, Electrical system hazards, considers the classification of areas that handle flammable gases, dusts, and liquids, and must be rated in terms of electrical area classification. Where possible, hazardous locations should be enclosed. A table illustrates the 13 NFPA (National Fire Protection Association) definitions of exposures. Explosion-proof apparatus and intrinsically safe equipment are discussed. Lightning protection is discussed; the current that may be discharged to ground may be between 2 and 200 kA (with some as high as 300 kA). Several diagrams and visuals assist in understanding lightning protection. Bonding and grounding, including power system grounding, and safety ground, is discussed in some detail, as is static electricity protection. A summary of the National Electrical Code area classification (NFPA 70, 1990, Article 500.3) is included with four pages of references.

Chapter 13, Deflagration and detonation flame arresters, considers deflagration as opposed to detonation, and defines the flame arrester, end-of-the-line and deflagration flame. Detonation flame arresters are also discussed. Excellent visuals illustrate these items. Arresters should be approved by an approved organization. Three pages of references conclude this chapter.

Chapter 14, Pressure relief systems, deals with causes of overpressure, relief devices, and problems in sizing relief systems. Two pages of references are cited.

Chapter 15, Effluent disposal systems, discusses containment and disposal from emergency relief systems — namely vents, safety valves, and rupture disks. Flare systems include elevated flares (some as high as 600 feet (183 meters)), and some at ground levels. Low pressure flares and burn pits in isolated areas are mentioned. Incineration systems are discussed in some detail. Two pages of references conclude this chapter.

Chapter 16, Fire protection, stresses the often overlooked importance of fire protection especially when fires are infrequent. A well-trained and organized local fire brigade will supplement the detection alarms. Combustible gas detectors, which sound alarms at 10–30% of the lower flammable limit (LFL) and register high level action, such as shut-down, at 30–50% of the LFL. Fire detectors, which respond to fire itself, and thermal detectors are available, as fixed-temperature detectors. Smoke detectors, often found in control rooms, computer rooms, instrument rooms, office areas and electrical equipment rooms, serve to warn in advance of other detectors, as does the optical flame detector responding to radiant energy. Manual alarms are often installed, especially in larger buildings. Water-based fixed systems, often called sprinklers, are frequently installed in warehouses and flammable liquid storage areas. Water-reactive chemicals must be clearly defined and labeled, and excluded from water systems (such as sodium, potassium, and certain hydrides). Monitoring nozzles, hydrants, and hose lines permits personnel to bring water to the fire. For water-reactive metals, special extinguishers should be provided and personnel trained in their use. Since water cannot be used safely on all fires, foam systems are indicated, including AFFF (aqueous film forming foam) and AR (alcohol resistant foams). Dry chemical systems are useful for fires where water or other foams cannot be used, as for example with magnesium and sodium. (One manufacturer markets 22 different extinguishing agents.) Halon 1301 has been used, especially in computer rooms, but its use may be limited for environmental reasons. Carbon dioxide is another alternative, and is also used widely in portable (5 to 150 pounds) extinguishers as well as in fixed systems, while inerting systems prevent explosion/air mixtures. In designing facilities, passive fire protection should be considered, since they require no electrical or mechanical connections. Fire barriers, fire proofing, thermal insulation, and separation distances are other assists and backups. Four pages of references are included with this chapter.

Chapter 17, Explosion protection, discusses the special hazards with sudden and rapid overpressure, usually due to onset of combustion or to exothermic runaway gas phase chemical reactions. The consequences of these are potentially disastrous. Gases released from an exploding vessel expand isotropically. Flammable limits determine whether a combustible gas or liquid vapor may explode. Some gases support decomposition flames including acetylene, ethylene oxide, methyl nitrate, ethyl nitrate, and hydrazine.

Dusts suspended in air will also support if concentration for combustion, designated the LEL, is achieved, and sufficient ignition energy is at hand. Inert components in a fuel–air mixture may limit the temperature and pressure rise on ignition, or may prevent ignition completely. Nitrogen, carbon dioxide, and water vapor are often used. Metal dusts of magnesium, titanium and zirconium can be inerted by a noble gas such as argon.

Of more potential hazard than unusual deflagration, consider detonation which is a wave travel at or over the speed of sound in the unburned medium. A pressure shock front leads the action of the flame front, often abbreviated as DDT. Vapor cloud explosions (VCEs) can be extremely disastrous events, and may be prevented by avoidance of massive releases of flammables. Another term often cited is boiling liquid expanding vapor explosions (BLEVE), due to sudden loss of containment of a liquid above its normal boiling point. In addition to the vapor cloud created by the BLEVE, a substantial amount of the unevaporated liquid goes into the air as a fine mist. A graph clearly shows the ideal blast wave overpressure versus scaled distance. Reference is made to NFPA 325M, the most complete tabulation of flammable limits.

As mentioned before, inert gases may be used to suppress the flash. Nitrogen is often used, but will react with metal dusts, such as magnesium. Care must be taken if water vapor concentration, or in some cases, carbon dioxide, serves as an oxidizer or release of hydrogen gas. Argon is used instead in such cases.

Flame mitigation inside equipment includes methods that can mitigate the effects of explosions, such as (1) pressure relief with flame ejection; (2) isolation with or without flame ejection; (3) pressure containment; (4) suppression. Venting may be considered for deflagration in a closed process vessel or by low-strength enclosures. A single vent may be located near the middle of an enclosure, with other vents along the longest dimensions of enclosure. Four pages of references conclude the book.

This book is certainly a classic in its field, and it is hoped it will receive wide and serious readership on behalf of chemical plant safety. The CCPS is to be congratulated for this effort in the public, as well as the profession's interest.

HOWARD H. FAWCETT

OSHA Compliance and Management Handbook, by C.C.K. Wang, Noyes Data Corp., Park Ridge, NJ, 1993, 456 pages, price US$ 72.00, ISBN 0-8155-1334-8

The author states he wrote this handbook with two purposes: (1) to help managers comply with standards, rules and regulations of the Occupational Health and Safety Administration (OSHA); (2) to show how occupational safety and health issues can be managed for organizational results.

The handbook provides the following information: • general information on the organization and working of OSHA; • in-depth specifics on OSHA standards and procedures; • how to decipher OSHA in particular and occupational health and safety in general.

This book is written 'from a multi-disciplinary viewpoint' which is not surprising since the author has degrees in chemical engineering, economics, business and law, as it well should be for the field of occupational safety and health draws its information from many different fields of knowledge.