CHEMICAL PROCESS INDUSTRIES

Table of Contents

Page

1.0 SCOPE

The chemical process industries include many diverse facility types that have various hazards. These facilities range from simple and low hazard, to complex and high hazard. This data sheet covers basic physical and human element programs generally applicable to chemical process industries. The associated sub-occupancy data sheets (Data Sheets 7-111A, 7-111B, 7-111C, etc.) provide more specific guidance for individual facility types, hazards, and processes.

1.1 Hazards

The chemical process industries have many of the same hazards as general industry, including exposures to natural hazards, equipment breakdown, and fire and explosion. In addition, the occupancy may have an increased number of hazards generated by the process itself, including such things as handling high-hazard chemicals, high temperatures and pressures, and breakdown of high-value equipment. Addressing these process hazards requires a high level of understanding of both the hazards themselves and management and protection systems that can prevent or mitigate them.

Process safety programs are a foundational component in preventing major loss events. An integrated safety culture (including the philosophy of inherently safe design, and robust management systems for process safety and instrumented safety systems) is critical for preventing incidents. Passive and active protection systems are needed to prevent small events from escalating into larger ones. This includes active fire protection, isolation and shutoff, and drainage and containment for ignitable liquids and flammable gases.

1.2 Changes

October 2024. Interim revision. The following changes were made:

A. Added new recommendations for the evaluation of chemical facilities located in earthquake zones.

B. Section 2.6.1 was expanded to include elements for asset integrity monitoring programs for these facilities.

2.0 LOSS PREVENTION RECOMMENDATIONS

2.1 Introduction

2.1.1 Use FM Approved equipment, materials, and services whenever they are applicable. For a list of products and services that are FM Approved, see the *Approval Guide*, an online resource of FM Approvals.

2.2 Construction and Location

2.2.1 Conduct a facility siting study in accordance with Data Sheet 7-14, *Fire Protection for Chemical Plants*. This includes temporary buildings and construction. Also consider equipment spacing for maintenance activities, replacement, and firefighting activities.

2.2.2 Use noncombustible, FM Approved Class 1 construction materials for all important buildings and structures. Where ignitable liquids or flammable gasses are used, provide construction in accordance with Data Sheets 7-32, *Ignitable Liquid Operations*, and/or 7-14, *Fire Protection for Chemical Plants*. Ensure building construction is suitable for the environment, considering such things as corrosion resistance and compatibility of materials.

2.2.3 Provide explosion prevention and mitigation measures for combustible dust in accordance with Data Sheet 7-76, *Combustible Dusts*.

2.2.4 Where unstable materials or high-hazard reactions exist that cannot be adequately vented or present an explosion hazard, provide barricades, blast walls, or space separation to isolate the hazard in accordance with Data Sheet 7-28, *Energetic Materials*.

2.2.5 Outdoor processes: Locate processes handling ignitable liquids above their flashpoint, flammable gasses or liquefied flammable gasses outdoors, in open structures with minimal enclosure.

2.2.6 Indoor processes: If it is not possible to install processes outdoors and there is a flammable gas or ignitable liquid handled at or above its atmospheric boiling point with a closed-cup flash point at or below 425°F (218°C), and materials with a boiling point below 100°F (38°C), install damage limiting construction (DLC) in accordance with Data Sheet 1-44, *Damage-Limiting Construction*.

2.2.6.1 Install ventilation systems to prevent the accumulation of flammable vapor-air mixtures in the process areas in accordance with Data Sheet 7-32, *Ignitable Liquids Operations*.

2.3 Process Hazards/Safety

2.3.1 Establish a formal process safety program in accordance with Data Sheet 7-43, *Process Safety*. The level of implementation will vary based on the specific hazards present.

2.3.2 Where unstable materials or chemical reaction hazards exist (intentional or otherwise), adhere to the recommendations in Data Sheet 7-46, *Chemical Reactors and Reactions*. This includes ensuring the chemistry is well understood and the appropriate protection features are provided.

2.4 Protection

2.4.1 Manufacturing Areas

2.4.1.1 Processes handling ignitable liquids: Protect ignitable liquids used in manufacturing processes in accordance with Data Sheet 7-32, *Ignitable Liquids Operations*, or Data Sheet 7-14, *Fire Protection for Chemical Plants*, depending on the volumes, flow-rates, and the ability to shut down the flow of burning liquids.

2.4.1.2 Processes handling flammable gasses: Protect flammable gas manufacturing processes in accordance with Data Sheet 7-14, *Fire Protection for Chemical Plants*. Where the gasses are used for fuel purposes only, provide protection in accordance with Data Sheet 7-54, *Natural Gas and Gas Piping*, and Data Sheet 7-55, *Liquefied Petroleum Gas (LPG) Storage in Stationary Installations*.

2.4.1.3 Processes without ignitable liquids or flammable gasses: Where combustible construction or occupancy are present, provide automatic fire protection per Data Sheet 3-26, *Fire Protection for Nonstorage Occupancies*. Do not provide less than HC-2 protection for manufacturing buildings. Where significant plastic processing equipment is present, do not use less then HC-3 protection.

2.4.2 Storage

2.4.2.1 Ignitable liquid storage in portable containers: Protect these materials in accordance with Data Sheet 7-29, *Ignitable Liquids in Portable Containers*.

2.4.2.2 Storage tanks: Protect external storage tanks in accordance with Data Sheet 7-88, *External Ignitable Liquid Storage Tanks*. Protect internal storage tanks in accordance with Data Sheet 7-32, *Ignitable Liquids Operations*. Protect pressurized storage tanks in accordance with Data Sheet 7-55, *Liquefied Petroleum Gas (LPG) Storage in Stationary Installations*.

2.4.2.3 Miscellaneous hazardous chemical storage: Chemicals such as blowing agents, energetic materials, organic peroxides, oxidizers, cellulose nitrate, aerosol products, hydrogen, etc., may present specific storage hazards and require protection in accordance with the material stored. See the specific data sheets that apply to those chemicals.

2.4.2.4 General storage warehouses: Protect general storage warehouse without any hazardous chemical storage per Data Sheet 8-9, *Storage of Class 1, 2, 3, 4, and Plastic Commodities*. This also applies to parts and maintenance storage buildings, with rack or floor storage.

2.4.3 Process Control Rooms

2.4.3.1 Protect process control rooms in accordance with Data Sheet 5-32, *Data Centers and Related Facilities*.

2.5 Equipment and Processes

2.5.1 Equipment

2.5.1.1 Ensure equipment and systems are designed in accordance with the appropriate codes and standards.

2.5.2 Isolation and Shutoffs

2.5.2.1 Ensure there is a safe way to shut off the flow of hazardous, corrosive, or flammable/ignitable materials. Shutdown may be automatic or manual with trained emergency response, depending on the consequences. For ignitable liquids/gasses refer to Data Sheet 7-32, *Ignitable Liquids Operations*, or 7-14, *Fire Protection for Chemical Plants*.

2.6 Operation and Maintenance

2.6.1 Establish and implement an asset integrity monitoring program in accordance with FM Property Loss Prevention Data Sheet 9-0, *Asset Integrity*. Ensure corrosion under insulation (CUI) of insulated pipes and vessels is included in the corrosion monitoring program.

2.6.1.1 For locations exposed to tropical cyclones and/or earthquake zones as established in sections 2.10.2 and 2.10.3, include process structures, piping and equipment in the asset integrity monitoring program with emphasis on the following:

- Corrosion inspections to legs and supports of vessels, lateral and cross bracing, restraint and anchorage systems
- Visual inspection to detect missing or deteriorated bolts, broken hangers or brackets, signs of cracking or tearing, etc.
- Insulation and strapping material integrity (vessels and piping in tropical cyclone zones)

2.6.2 Where safety controls, alarms, and interlock systems are provided, ensure the operation and maintenance is suitable for the hazards. See Data Sheet 7-45, *Safety Controls, Alarms, and Interlocks*, for further information.

2.6.3 Ensure emergency/safety operation procedures are well understood and address the expected actions to be taken by the operators.

2.7 Training

2.7.1 Establish operator training programs in accordance with Data Sheet 10-8, *Operators*. Ensure training programs cover normal operating conditions, transient operations, and emergency/upset conditions.

2.8 Utilities

2.8.1 General

2.8.1.1 Identify critical utilities and services to develop a utility support system study. Include utility demands and susceptibility to interruption. Consider redundancy and exposure to maintenance outages, fires, explosions, natural hazards, supply restrictions, exposures from adjacent plants, etc.

2.8.1.2 Keep up-to-date documentation and one-line drawings for all utilities and services.

2.8.2 Cooling Towers, Cooling Water

2.8.2.1 Design and protect cooling towers in accordance with Data Sheet 1-6, *Cooling Towers*. This may include the development of a detailed contingency plan.

2.8.2.2 Provide hydrocarbon detection in process cooling water where leakage of ignitable liquid or flammable gas could contaminate the water-return system.

2.9 Contingency Planning

2.9.1 Equipment Contingency Planning

When equipment breakdown would result in an unplanned outage to site processes and systems that are considered key to the continuity of operations, develop and maintain a documented, viable equipment contingency plan (ECP) per Data Sheet 9-0, *Asset Integrity*. See Appendix C of that data sheet for guidance on the process of developing and maintaining a viable equipment contingency plan. Also refer to guidance on sparing, rental, and redundant equipment mitigation strategy in that data sheet.

2.9.2 Sparing

Sparing can be a mitigation strategy to reduce the downtime caused by an equipment breakdown, depending on the type, compatibility, availability, fitness for the intended service, and viability of the sparing. For general sparing guidance, see Data Sheet 9-0, *Asset Integrity*.

See the associated sub-occupancy data sheets for specific recommendations and guidance on equipment contingency plan (ECP), routine, and/or equipment breakdown sparing.

2.10 Natural Hazards

2.10.1 Freeze Conditions

2.10.1.1 For guidance on recommendations to prevent damage due to freeze conditions, see Data Sheet 9-18, *Prevention of Freeze-Ups*.

2.10.2 Windstorm

2.10.2.1 Ensure outdoor process structures, vessels and equipment, including flares and process stacks, are designed and installed for the expected wind pressures in accordance with ASCE-7 or similar standard outside the U.S.

2.10.2.2 Provide adequate securement of insulation on piping and vessels to withstand anticipated wind speeds.

2.10.2.3 For cooling towers wind guidance, see Data Sheet 1-6, *Cooling Towers*.

2.10.3 Earthquake

2.10.3.1 Introduction

The recommendations in this section are applicable to facilities located in FM 50-year through 500-year earthquake zones as defined in FM Property Loss Prevention Data Sheet 1-2, *Earthquakes*, where flammable gases and/or ignitable liquids with a flash point below 100°F (38°C) or that are handled above their atmospheric flash point are present.

2.10.3.2 Construction and Location

2.10.3.2.1 Design and construct buildings, process structures, equipment, vessels and piping to resist earthquake forces according to the latest seismic design codes and regulations. Provide all the necessary seismic anchorage, bracing, restraint and flexibility as applicable for process equipment, vessels and piping, as well as all the equipment and systems listed in Data Sheets 1-2, *Earthquakes* and 1-11, *Fire Following Earthquake*.

2.10.3.2.2 Design fire protection systems and fire pump systems to ensure reliability during and after an earthquake in accordance with FM Property Loss Prevention Data Sheets 2-8, *Earthquake Protection for Water Based Fire Protection Systems* and 3-2, *Water Tanks for Fire Protection*.

2.10.3.3 Process Release Controls

2.10.3.3.1 Provide processes with seismically activated safety shutoff valves (SSOV). Include associated pumps and compressors to be arranged for automatic controlled shutdown. This can be accomplished by installing seismic sensors, interlocked to shutdown SSOV's and pumps/compressors. One or more seismic sensors can be utilized on a polling system to initiate a trip (i.e., two out of three sensors needed for shutdown). Arrange the location of the SSOVs for a limited release according to FM Property Loss Prevention Data Sheet 7-14, *Fire Protection for Chemical Plants*. For additional information and guidance on actuation and non-actuation requirements, see Data Sheet 1-11, *Fire Following Earthquake*.

3.0 SUPPORT FOR RECOMMENDATIONS

3.1 Occupancy Overview

Chemical processing industries are facilities in which raw materials undergo chemical or physical conversion during their processing into finished products. In these facilities the products differ chemically from the raw materials as a result of undergoing one or more chemical reactions and/or physical transformations during the manufacturing process. The chemical process industries broadly include the traditional chemical industries, both organic and inorganic; the petrochemical industry, which produces most plastics, synthetic fibers, and synthetic rubber from petroleum and natural-gas raw materials; and a series of related facilities in which chemical processing plays a substantial part.

4.0 REFERENCES

4.1 FM

Data Sheet 1-6, *Cooling Towers*
Data Sheet 1-44, *Damage-Limiting Construction*
Data Sheet 3-26, *Fire Protection for Nonstorage Occupancies*
Data Sheet 5-23, *Design and Protection for Emergency and Standby Power Systems*
Data Sheet 5-32, *Data Centers and Related Facilities*
Data Sheet 7-14, *Fire Protection for Chemical Plants*
Data Sheet 7-28, *Energetic Materials*
Data Sheet 7-29, *Ignitable Liquids in Portable Containers*
Data Sheet 7-32, *Ignitable Liquids Operations*
Data Sheet 7-43, *Process Safety*
Data Sheet 7-45, *Safety Controls, Alarms and Interlocks*
Data Sheet 7-46, *Chemical Reactors and Reactions*
Data Sheet 7-54, *Natural Gas and Gas Piping*
Data Sheet 7-55, *Liquefied Petroleum Gas (LPG) Storage in Stationary Installations*
Data Sheet 7-76, *Combustible Dusts*
Data Sheet 7-88, *Ignitable Liquid Storage Tanks*
Data Sheet 8-9, *Storage of Class 1,2,3, 4, and Plastic Commodities*
Data Sheet 9-0, *Asset Integrity*
Data Sheet 9-18, *Prevention of Freeze-Ups*
Data Sheet 10-8, *Operators*

4.2 Other

American Society of Mechanical Engineers (ASME). *ASME Boiler & Pressure Vessel Code. Section VIII, Pressure Vessels*.

American Society of Civil Engineers (ASCE), ASCE 7-22, 2022 Ed. *Minimum Design Loads and Associated Criteria for Buildings and other Structures*

APPENDIX A GLOSSARY OF TERMS

Combustible dust: Any organic material (agricultural, plastic, chemical, coal, etc.), unoxidized metal particles, or other oxidizable materials (e.g. zinc stearate) should be considered combustible. Test involving the application of spark, match fire, Bunsen or Merker burner flame to small layers or piles of material may help in identifying such materials but can result in false negatives.

Corrosion under insulation: External corrosion due to moisture within the insulation system (also referred to as “under-insulation corrosion”). The moisture remains in contact with the pipe for an extended period of time, or may condense under the insulation and return to the pipe wall. The insulation may contain chloride ions, making the moisture much more corrosive. Process fluids containing chlorides, acids, or caustics also may penetrate the insulation system.

Damage-limiting construction (DLC): A type of construction that consists of both pressure-resistant and pressure-relieving ceiling and/or walls that allows the internal pressure buildup from a deflagration explosion to release safely to a designated external area.

Flash point: The minimum temperature at which sufficient vapor is liberated to form a vapor-air mixture that will ignite and propagate a flame away from the ignition source (flash fire, not continuous combustion).Evaporation will take place below the flash point, but the quantity of vapor released is not sufficient to produce an ignitable vapor-air mixture. A flash point can be determined by using either a closed- or open- cup test apparatus. The closed-cup test will produce a lower flash point than the open-cup test because it provides greater vapor containment (i.e., increases vapor accumulation). The closed-cup flash point test is used to classify a liquid because it is conservative (i.e., produces the lowest flash point for the liquid) and represents the condition in which most liquids are handled (i.e., most liquids are kept in closed containers or equipment).

Ignitable liquid: Any liquid or liquid mixture that will burn. A liquid will burn if it has a measurable fire point. Ignitable liquids include flammable liquids, combustible liquids, inflammable liquids, or any other term for a liquid that will burn.

Process control room: A cut off and/or isolated room in which personnel are available 24/7 to operate a process from a central or remote location. The process control room is typically integrated with an input/output room and/or cable spreading room to control the functions of equipment. Process control is extensively used in industry and commonly enables mass production of continuous processes such as paper, pharmaceuticals, chemicals, and electric power as well as other industrial processes. Process control rooms may also be unattended and operated remotely.

Storage tank: Any vessel having a liquid capacity that exceeds 60 gal (230 L), is intended for fixed installation, and is not used for processing.

APPENDIX B DOCUMENT REVISION HISTORY

The purpose of this appendix is to capture the changes that were made to this document each time it was published. Please note that section numbers refer specifically to those in the version published on the date shown (i.e., the section numbers are not always the same from version to version).

October 2024. Interim revision. The following changes were made:

A. Added new recommendations for the evaluation of chemical facilities located in earthquake zones.

B. Section 2.6.1 was expanded to include elements for asset integrity monitoring programs for these facilities.

January 2023. This interim revision includes a new section and guidance for natural hazard events in chemical plants. The following major changes were made:

A. Added new windstorm recommendations applicable to process structures, vessels, piping and equipment with emphasis on insulation and asset integrity elements.

January 2021. Interim revision. Minor editorial changes have been made.

October 2020. Interim revision. The following significant changes were made:

A. Added new section on cooling towers and cooling water.

B. Added equipment contingency planning and sparing guidance.

July 2019. This is the first publication of this document.