CHAPTER 22

HAZARDOUS MATERIALS

Although performance-based design approaches are relatively new to the building construction and fire safety arenas, such approaches have been in widespread use in the hazardous materials arena for quite some time. Numerous regulatory programs enacted by the federal government in the 1980s and 1990s encouraged or required the use of performance-based risk management techniques for many facilities and processes involving hazardous materials, and the documentation associated with these programs served as an excellent resource for use in the development of Chapter 22.

The objective and functional statements found in Chapter 22 were replicated in Section 801. This was done in an effort to provide correlation and consistency between the building and fire provisions within Parts II and III of this code, respectively. Additionally, as opposed to replicating the applicable performance requirements between the two chapters, it was decided to simply reference Chapter 22, Hazardous Materials, within Section 801.3.

Users of Chapter 22 will note that the technical provisions from two such federal programs, Process Safety Management (PSM) and Risk Management Planning (RMP), served as the specific source for most of the performance requirements now found in Chapter 22. Those unfamiliar with these programs will note that PSM falls under the auspices of the U.S. Occupational Safety and Health Administration (OSHA) and RMP falls under the auspices of the U.S. Environmental Protection Agency (EPA). The source regulations can be found in Titles 29 and 40 of the Code Federal Regulations. The balance of the performance requirements in Chapter 22 were developed to include topic areas currently covered by the *International Fire Code* that were not reflected in the PSM or RMP rules and to include the reporting requirements set forth in SARA Title III. All together, the performance requirements in Chapter 22 fully cover the regulatory topic areas for hazardous materials that are encompassed in the *International Fire Code*.

To the greatest extent possible, the drafting committee endeavored to maintain consistency between Chapter 22 and the existing PSM and RMP programs. By doing so, the committee avoided unnecessarily "reinventing the wheel" and helped reduce the potential for conflict between local and federal regulations for hazardous materials. In addition, recognizing the value of industry's experience in applying the PSM and RMP rules, the committee enlisted the assistance of industry representatives in the drafting effort for Chapter 22.

While closely tied in concept to the IFC and federal PSM and RMP rules, there is at least one major difference between Chapter 22 and these other documents. Chapter 22 does not make use of prescriptive, material- and quantity-based thresholds as a baseline for determining when the chapter applies. However, this should not be taken as an indication that the PSM- and RMP-type rules in Chapter 22 are mandatory in all cases. In fact, the exact opposite is true; they will never be mandatory.

Chapter 22 and the PSM- and RMP-type rules therein present an optional method of design, and where it is advantageous to an owner to use this method, the Chapter 22 approach may be preferable. Presumably, this would involve a facility that is already required to follow Federal PSM and/or RMP rules. Where it is not advantageous to an owner to use performance-based design methods, prescriptive codes will undoubtedly be used. Operators of small facilities that are exempt from federal hazardous materials regulations will likely avoid performance-based design methods because the requirements in the prescriptive IFC and IBC will be less onerous.

SECTION 2201

HAZARDOUS MATERIALS

2201.1 Objective

The intent and scope of Chapter 22 is similar to the intent and scope of Chapter 27 of the IFC prescriptive code: to protect occupants of the building, people in the surrounding area, emergency response personnel, and property from acute consequences associated with unintended or unauthorized releases of hazardous materials. Like the prescriptive IFC and IBC, the performance code encourages the use of both accident prevention and control measures to reduce risk.

It is not the intent of this code or the prescriptive codes to regulate all hazardous materials. Within the scopes of building and fire codes, hazardous materials are generally defined as those materials that are acutely dangerous to people or property. Building and fire codes usually defer regulation of materials that present only a risk of chronic or environmental effects to other regulatory agencies, such as OSHA or the EPA in the United States. Exposure of workers to hazardous materials in the normal course of their jobs is also beyond the scope of building and fire codes. Such workplace safety issues are instead regulated by occupational safety and health codes, which in the United States fall under the jurisdiction of OSHA.

Hazardous materials regulated by building and fire codes are typically classified into two major categories: physical hazards and health hazards. Physical hazard materials are those materials that present a risk of fire, explosion, or accelerated burning, and include the following:

- Explosives and blasting agents
- Flammable and combustible liquids
- Flammable solids and gases
- Organic peroxide materials
- Oxidizing materials
- Pyrophoric materials
- Unstable (reactive) materials
- Water reactive solids and liquids

Health hazards materials are those materials that present a risk of acute health consequences from a short-term exposure, and include the following:

- Toxic and highly toxic materials
- Corrosive materials

When developing a performance-based design involving hazardous materials concerns, consideration should be given not only to the foregoing classifications but also to the quantity, state, situation (storage/use), arrangement, and location of materials and processes.

2201.2 Functional statements

Chapter 22 includes two functional statements that serve the overall objective of the chapter. These two statements focus on reducing the probability of unsafe conditions involving hazardous materials and minimizing the consequences of an unsafe condition, if one occurs. The concepts can be summarized as prevention and control. Specific means by which these functional statements can be accommodated are listed below in the performance requirement section.

The code includes some additional functional statements that are relevant to hazardous materials but are not included in the text of Chapter 22. These include some of the functional statements found in Chapter 4: Reliability, and Chapter 18: Management of People.

2201.2.1 Prevention

This section invokes the need for consideration of accident-prevention techniques. Such techniques might include administrative policies and procedures specifying safe practices. Clearly, it is preferable from a safety standpoint to prevent accidents as opposed to dealing with consequences after a release or failure has occurred. Nevertheless, it is important to provide for an appropriate degree of consequence management as well because it is not reasonably possible to prevent all accidents. Hence, the need for the functional statement in Section 2201.2.2.

2201.2.2 Mitigation

Management of consequences can be accomplished in a variety of ways. The most effective methods are those that quickly detect and respond to abnormal conditions before severe consequences occur. Limit switches with integral process-shutdown capability are an example of such an approach. Other approaches to consequence management involve the use of protection methods to limit consequences once a spill or release has occurred. Spill containment systems, ventilation systems, fire sprinkler systems, and fire-resistive construction methods are all examples of protection methods that limit consequences.

2201.3 Performance requirements

Recognizing that functional statements are deliberately broad in their effort to establish general direction, the code provides performance requirements as a means by which the principles embraced in functional statements can be accomplished. The principles embodied in the performance requirements set forth in the performance code are generally consistent with those embodied in prescriptive codes. However, performance-based design methods allow a more systems-oriented approach because prescriptive codes don't generally recognize the beneficial interaction of various protection methods. Therefore, prescriptive design methods usually result in unnecessary and inefficient redundancies in design. In many cases, these undesirable consequences can be avoided when performance-based design methods are utilized.

2201.3.1 Properties of hazardous materials

Section 2201.3.1 correlates with the reporting requirements set forth in SARA Title III and to some degree with the prescriptive reporting requirements set forth in some model fire codes. Compliance with these reporting requirements can be accomplished through the use of MSDSs, inventory reports, SARA Title III reporting documents (which are typically mandatory under federal law), etc.

This section ensures that interested parties will have access to information about the characteristics of hazardous materials that are located on site.

2201.3.2 Reliability of equipment and operations

Equipment and operations at facilities regulated by federal PSM rules should have little trouble demonstrating compliance with the requirements of Section 2201.3.2. The PSM rules generally address this topic area.

At facilities that are not required to comply with PSM rules, the selection of equipment and design of operations would have to go through a great deal of scrutiny by qualified individuals. In addition, equipment manuals and operational protocols would need to be developed and followed, as applicable.

2201.3.3 Prevention of unintentional reaction or release

Facilities regulated by RMP rules are required to evaluate the potential consequences of various release scenarios on the surrounding area, and therefore many such facilities provide safety systems to reduce these potential consequences, recognizing that the consequence analysis information must be made available to the public.

Depending on the classification and state (solid, liquid, or gas) of hazardous materials stored or used at a given site, a variety of mitigation measures may be provided to comply with this provision. Such measures might include process controls, spill control and containment systems, and ventilation controls.

2201.3.4 Spill mitigation

This requirement is primarily derived from provisions in the prescriptive IFC. As a general rule, storage facilities are regarded as less likely candidates for dangerous spills than facilities that involve dispensing or processing operations. In addition, dangerous spill conditions are probably more likely to occur in facilities with large quantity vessels or systems than those with only small containers. Information that may be useful in determining whether a spill is plausible and whether dangerous conditions would result include the following:

- Specific material and process hazards involved
- A block flow diagram for the facility
- Piping and instrument drawings
- A list of all safety devices, showing their location, design basis and capacity, date of installation, etc
- Equipment manufacturers' operational instructions, including safe operating limits for the equipment
- Equipment drawings and specifications that reflect built and installed equipment

2201.3.5 Ignition hazards

The primary design and operating intent is to ensure that flammable and combustible materials are always completely controlled in accordance with process design parameters. However, where flammable and combustible hazardous materials are present, a degree of redundancy is sometimes necessary to provide an additional level of safety. Where there is a plausible risk of spills or leaks, such as in loading and unloading or packaging operations, additional measures such as ignition source controls are prudent. To that end, process design and operation should ensure to the greatest degree possible that ignition sources are kept away from areas where flammable or combustible hazardous materials are present. Where separation is not feasible, ignition source controls may be warranted. Such controls may involve the following:

- Electrical classification of areas where flammable hazardous materials might be present.
- Classification of mobile equipment that might operate in areas where flammable hazardous materials might be present.

- The use of grounding systems and equipment to minimize the potential for sparking in areas where flammable hazardous materials might be present.

2201.3.6 Protection of hazardous materials

This section directs the designer and the operator to review and ensure that vessels or systems containing hazardous materials are not exposed to or are protected from damage by external fire. The design should focus first on reducing the possibility for fire or other hazards, such as vehicular impact, and second on isolating hazardous materials from exposure to unsafe conditions, such as a fire.

All storage areas and systems should be formally reviewed to find and correct any sources of exposure to fire, including the following:

- Nearby storage of combustibles
- Nearby hot-work operation
- Nearby vehicular operation

All systems subject to fire exposure should be formally reviewed to ensure adequate protection, including the following:

- Sprinkler installation
- Insulation of equipment
- Fire-resistive barriers

2201.3.7 Exposure hazards

This section directs the designer and the operator to review and ensure that vessels or systems containing hazardous materials are not subject to damage from internal fire, chemical reaction, or explosion. The design criteria should be first to reduce the risk of an internal fire or explosion, and second, where the first is not feasible, to design vessels and systems in such a manner that loss of integrity will not occur in an overpressure situation.

All systems should be formally reviewed to identify and correct any sources of internal fire, explosion, or overpressure. The review should include the following:

- The potential for inadvertent or improper mixing of reactive components
- The potential for overheating of unstable materials
- The potential for inadequate venting of unstable reaction byproducts
- The potential for inadequate dilutent material supply

Where overpressure or explosion conditions cannot be reasonably ruled out, the design should consider overpressure protection, containment, and explosion control systems.

2201.3.8 Detection of gas or vapor release

This section is derived from the IFC. The section ensures that hazardous vapor releases are detected and/or mitigated before they can harm individuals or property. In occupied areas, detection of a vapor release may be by sight, smell, or an automatic detection system. For many hazardous materials such as chlorine or ammonia, vapor releases are readily evident before concentrations are truly hazardous based on the presence of vapor fog or a noxious odor. Where this is not the case, automatic detection systems and alarms may be warranted. Sensors can take the form of ambient sampling devices at strategic area locations, sampling devices in key vent streams, or specially designed leak-detection systems such as acoustic emission systems. The performance measurement is the ability of the sensing equipment or operators to provide adequate warning so that safety precautions can be taken before unsafe conditions are present.

Mitigation-based solutions can range from special process equipment designs to elaborate ventilation and air scrubbing systems. Where practical, the simplest mitigation consists of over-design of the process system so that the likelihood of release is extremely low. The performance measurement of a ventilation or treatment system is the reduction of the concentration of the hazardous material in the workplace and nearby environment to levels that are not acutely hazardous.

2201.3.9 Reliable power source

This section is derived from the IFC. It is essential to safety to ensure that a reliable power supply is provided for systems that are critical to safety. Some examples of systems that may require a reliable power supply include mechanical ventilation systems, treatment systems, gas detection and alarm systems, and emergency shutdown systems. The reliability needs of the system are related to the potential risks associated with system failure.

A reliable power source does not necessarily equate to a generator or a battery system. The type of system to be used depends on the relative level of hazard that might result in the event of a power failure, and in some cases, such as those where hazardous processes shut down upon loss of power, a connection ahead of the building main disconnect switch may be adequate to qualify as a reliable source. Guidance on the selection and performance requirements for power supply systems providing an alternate source of electrical power can be found in the *National Electrical Code* and NFPA Standard 110: Standard for Emergency and Standby Power Systems.

2201.3.10 Ventilation

In many cases involving hazardous materials, ventilation must be provided to limit the risk of creating an emergency condition. Ventilation might be necessary during both normal and abnormal operating conditions. Some examples of operations that may require ventilation are storage or processing of flammable and combustible liquids or gases inside of buildings, drum filling operations inside of buildings, laboratory use of chemicals, and dust handling systems. Ventilation may also be used as a means for reducing vapor concentrations below lower flammable limits in areas where ignition sources are present or for pressurization of areas to isolate hazardous vapors.

Guidance on the performance requirements for ventilation systems can be found in a number of sources, including OSHA 29 CFR 1910.106, Flammable and Combustible Liquids; NFPA 30, Flammable and Combustible Liquids Code; NFPA 69, Explosion Prevention Systems; NFPA 45, Laboratories Using Chemicals; NFPA 70, *National Electrical Code*; and NFPA 497, Recommended Practice for Classification of Flammable Liquids, Gases or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas.

2201.3.11 Process hazard analyses

This section establishes an administrative safety control addressing process hazard analysis. Guidance on process hazard analysis techniques can be found in the OSHA PSM regulations, 29 CFR Part 1910.119. The process hazard analysis must be appropriate to the complexity of the process and must identify, evaluate, and control the hazards involved in the process. The analysis can be accomplished through various methods. Some of these are “What if,” Process Hazard Analysis, HAZOP, fault tree, etc. A person trained in these and other hazard evaluation techniques should be employed to complete this analysis.

2201.3.12 Written procedures and enforcement for pre-startup safety review

This section establishes an administrative safety control addressing pre-startup safety review procedures. Guidance on techniques for written documentation of pre-startup safety review procedures can be found in the OSHA PSM regulations, 29 CFR Part 1910.119. Pre-startup safety reviews are typically necessary when new facilities are prepared for operation and where existing facilities are modified to a degree that is significant enough to require a change in the process safety information.

A pre-startup safety review should confirm that prior to the introduction of highly hazardous chemicals to a process, the following verifications have been accomplished at a minimum:

- Construction and equipment is in accordance with design specifications.
- Safety, operating, maintenance, and emergency procedures are in place and are adequate.
- For new facilities, a process hazard analysis has been performed and recommendations have been resolved or implemented before startup; for modified facilities, requirements contained in management of change documents have been met.
- Training of each employee involved in operating a process has been completed.

2201.3.13 Written procedures and enforcement for operation and emergency shutdown

This section establishes an administrative safety control addressing written documentation of operating procedures and emergency shutdown procedures. Guidance on developing written documentation for operating procedures and emergency shutdown techniques can be found in the OSHA PSM regulations, 29 CFR Part 1910.119. Overall, there are 14 elements that employers covered by PSM are required to complete to meet the Federal PSM regulations. Two elements that relate to this section are as follows:

- 29 CFR1910.119 (c): This element requires that employees and their representatives be consulted on the development and conduct of hazard assessments and the development of chemical accident prevention plans and provide access to these and other records required under the federal law.
- 29 CFR1910.119 (f): This element requires that written operating procedures for the chemical process including procedures for each operating phase, operating limitations, and safety and health considerations must be developed and implemented.

2201.3.14 Written procedures and enforcement for management of change

This section establishes an administrative safety control addressing management of change. Guidance on developing written documentation for management of change can be found in the OSHA PSM regulations, 29 CFR Part 1910.119. The PSM element that relates to this section is as follows:

29 CFR 1910.119 (l): This element requires a review of the technical basis for the proposed change; the impact of change on safety and health; possible modifications to operating procedures and process safety information; the necessary time period for the change; and authorization requirements for the proposed change.

Employees involved in operating a process and maintenance and contract employees whose job tasks will be affected by a change in the process should be informed of and trained in the change prior to startup of the process or affected part of the process.

2201.3.15 Written procedures for action in the event of emergency

This section establishes an administrative safety control addressing emergency response planning. Guidance on developing written documentation for an emergency response plan can be found in the OSHA PSM regulations, 29 CFR Part 1910.119. The PSM element that relates to this section is 29 CFR 1910.119 (n), which references other portions of the federal regulations. Such plans may include identification of actions to be taken by employees in the event of an emergency and the assignment of a staff liaison who can assist emergency response personnel.

2201.3.16 Written procedures for investigation and documentation of accidents

This section establishes an administrative safety control addressing accident investigation and reporting. Guidance on accident investigation and reporting can be found in the OSHA PSM regulations, 29 CFR Part 1910.119. The PSM element that relates to this section is 29 CFR 1910.119 (m).

Some of the guidelines specified in the federal regulations include the following:

- The need for an incident investigation team to be established, consisting of at least one person knowledgeable in the process involved, a contract employee if the incident involved work of the contractor, and other persons with appropriate knowledge and experience to thoroughly investigate and analyze the incident.
- The need for a report to be prepared at the conclusion of each investigation, including at a minimum: date of incident; date investigation began; description of the incident; factors that contributed to the incident; and recommendations resulting from the investigation.
- The need for establishment of a system to promptly address and resolve the incident report findings and recommendations, and to document resolutions and corrective actions.
- The need for accident investigation reports to be reviewed by all affected persons whose job tasks are relevant to the incident findings, including contract employees where applicable.

2201.3.17 Consequence analysis

This section establishes an administrative safety control addressing an analysis of off-site consequences. Guidance on accident investigation and reporting can be found in the EPA RMP regulations, 40 CFR Part 68. These regulations amend the accident release prevention requirements under Section 112 (r) of the Clean Air Act.

EPA's RMP rules are a good source of examples for alternate release scenarios for a particular site, and, through the identification and analysis of plausible release scenarios, changes can be implemented to minimize the probability and consequences of a release. A plausible release is one that has occurred in the past or could occur under reasonable single-system failures.

Devices that normally use some kind of motion or energy to prevent or minimize the release represent active mitigation controls. Active mitigation controls might include valves, switches, pumps, and blowers. Passive mitigation controls include devices that are permanently in place and have an inherently safe design that allows them to be in effect at all times. Passive mitigation controls might include dikes, walls, ponds, and sumps.

The off-site consequence analysis can be accomplished through various methods. Some of these are "What If," Process Hazard Analysis, HAZOP, and fault tree. A person trained in these and other hazard evaluation techniques should be used to complete this analysis.

2201.3.18 Safety audits

This section establishes an administrative safety control addressing safety compliance audits.

Guidance on safety audits can be found in the OSHA PSM regulations, 29 CFR Part 1910.119.

The PSM element that relates to this section is 29 CFR 1910.119 (o).

On a routine basis, each facility must review its continuing compliance with each of the sections in Chapter 22 and other related chapters. The word "periodic" reflects a need for adequate frequency to have reasonable confidence that safety programs, features, and systems will perform as intended. Recognizing that many code sections contain issues that change very little over time, compliance audit frequencies will not be the same for all programs features and systems, and depending on the particular safety element, the audit frequency may range to as much as three-year intervals under the PSM regulations.

2201.3.19 Levels of impact

Each facility must satisfy the required design performance levels that are applicable to hazardous materials. These performance levels are defined in Section 304 as follows: mild, moderate, high, and severe. These definitions help in standardizing performance-based design approaches. The intent of assigning design performance levels is to define the people and area impacted by an unwanted release of hazardous materials and the degree to which people and property are impacted.

With respect to hazardous materials, a mild impact event might equate to an incident that has a minor effect or damage on the people and property immediately involved in the work activity.

A moderate impact event might result from an incident that involves a moderate spill and/or fire that has significant local consequences to the people and property in the immediate area of the work activity and within logical containment boundaries around the area. This area might include a room or small warehouse.

A high impact event might result from a large spill of noncombustible materials, a room and contents fire, or a small deflagration. Such an event would be contained within the boundaries of the facility and would affect only the people and property within that boundary.

A severe impact event might result from a very large spill of noncombustible materials, a fire that extends beyond primary containment boundaries, or a large deflagration or detonation. Such an event would not be contained within the boundaries of the facility and would affect people and property outside that boundary, perhaps including the general public.

Life-safety and property protection can be looked at somewhat independently. Society generally has a lower tolerance for risks related to life-safety than it does for property loss. This should be kept in mind when addressing the level of impact that can be tolerated.

Magnitudes of design events are specified as a means of indicating size of an incident that must be handled by a building or facility: a small spill, for example; a localized fire; or a large explosion. Magnitudes of design events relate to performance groups in that magnitudes specify the "threat" or "size" of an initiating incident, and performance groups limit the tolerable level of damage that might occur as a result of such incidents.

Sections 2201.3.19.1 through 2201.3.19.7 provide guidance on choosing the events to analyze. This guidance includes a review of factors to be addressed such as the use of the room or area, occupant risks, and importance to the community. Four scenario sizes must be defined: small, medium, large, and very large. As with fire, hazardous materials events are not events independent of the building's or facility's contents, layout, construction, or its occupants. Therefore, these factors need to be addressed when determining the scenarios. This process must include a thorough engineering analysis with proper justification.