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Ninth Edition

# Fire and Life Safety Inspection Manual

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LEARNING

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# 41

# INDUSTRIAL OCCUPANCIES

*Joseph Versteeg*

NFPA *101*®, *Life Safety Code*®, defines an industrial occupancy as a building, a portion of a building, or a group of buildings used for the manufacture, assembly, service, mixing, packaging, finishing, repair, treatment, or other processing of goods or commodities by a variety of operations or processes. Industrial occupancies include, but are not limited to, the following:

1. Chemical plants
2. Factories of all kinds
3. Food processing plants
4. Furniture manufacturers
5. Hangars (for servicing/maintenance)
6. Laboratories involving hazardous chemicals
7. Laundry and dry-cleaning plants
8. Metalworking plants
9. Plastics manufacture and molding plants
10. Power plants
11. Refineries
12. Semiconductor manufacturing plants
13. Telephone exchanges
14. Woodworking plants

Each building or separated portion of an industrial building should be inspected in accordance with the requirements of its principal use; for example, warehouses as storage occupancies, offices as business occupancies, and auditoriums, cafeterias, and lunchrooms as assembly occupancies. Because of the complexity of industrial occupancies, the inspections can be time consuming.

## OCCUPANCY CLASSIFICATION

Industrial occupancies are subclassified in NFPA *101*® into three types of usage: general, special purpose, and high hazard.

- *General industrial occupancy:* This subclassification involves ordinary and low-hazard manufacturing operations conducted in buildings of conventional design suitable for various types of manufacture. Also included are multistory buildings where floors are occupied by different tenants and, therefore, subject to possible use for types of manufacturing with a high density of employees.
- *Special purpose industrial occupancy:* This subclassification includes ordinary and low-hazard manufacturing operations in buildings that were designed for and suitable only for particular types of operations. Such buildings are characterized by a relatively low density of employees, with much of the area occupied by machinery or equipment.
- *High-hazard industrial occupancy:* Buildings in this subclassification include those having high-hazard materials, processes, or contents. Incidental high-hazard operations in ordinary or low-hazard occupancies that are protected with automatic extinguishing systems or other protection (such as explosion suppression or venting) appropriate to a particular hazard are not considered high-hazard occupancies overall.

Some of the common problems encountered in industrial occupancies include overcrowding, poor housekeeping, poor maintenance of electrical equipment and wiring, inadequate exit facilities, locked or blocked exits, misuse of flammable liquids and heat-producing appliances, and poor maintenance of fire protection systems and appliances. Code enforcement must be rigid and inspection thorough, with some emphasis on fire safety education and prefire planning.

# INSPECTING THE PREMISES

## Occupant Load

The occupant load in industrial occupancies is one person for each 100 $ft^2$ (9.3 $m^2$) of gross floor area, and exits that can accommodate this minimum capacity must be provided in these occupancies. In most plants, the space occupied by workbenches, machinery, and equipment generally tends to keep the occupancy well within the ratio. So-called "sweat shops," however, tend to be the exception with their dense concentrations of workers.

An increased occupant load is permitted if a floor plan showing that proper aisles and adequate exits are available safely to accommodate the increased occupant load is submitted to the authority having jurisdiction. In most instances, overcrowding will be fairly obvious to you during the inspection. In a special purpose industrial occupancy, the occupant load is the maximum number of persons that may occupy the area under any probable conditions.

## Means of Egress

Requirements for exits in industrial occupancies are found in Chapter 40 of NFPA *101*®. Inspectors should be aware of the requirements because they are responsible for seeing that all portions of a means of egress are maintained in a safe and usable condition.

All exits must discharge to a clear and unobstructed path of travel to a public way. Where there is evidence of parked vehicles or other obstructions, signs or barriers should be erected to prohibit the practice. Barriers or fences cannot obstruct the flow of persons exiting the building.

Exits must be clearly illuminated, identified, and accessible. NFPA *101*® requires the placement of exit signs at all exits, which in large buildings may not be readily visible to the occupants possibly because of building configuration and most likely because of machinery and equipment. Where such signs are not readily visible to the occupants, additional signs along the egress path may be required to guide occupants to the exit locations. Note that these additional signs are required only where the way to reach the exit is not readily apparent to the occupants. Frequent evacuation drills are one way to document that occupants know the location of exits. Open every exit door to be sure that it is labeled when required, swings in the direction of egress travel when so required, and that self-closing or automatic-closing devices and mechanisms function properly.

Where pilferage might be a problem, means other than locking are available to prevent unauthorized use of exits. NFPA *101*® permits the use of approved, listed, special locking arrangements on doors in industrial occupancies. All conditions set forth for their use must be followed. Delayed-egress locks and access-controlled egress devices do not prevent the door from opening; rather, they merely delay opening and may require the sounding of an alarm. Special locking arrangements cannot be used in high-hazard areas.

Where exit stairs are required to be enclosed, the enclosure and its protected openings must be of the proper fire-resistance ratings. Handrails must be secure, and stair treads and landings should be slip resistant. Stairways cannot be used for storage or any other purpose, and they must be illuminated.

Every worker must have access to not less than two remotely located exits. The path of travel must be clear, illuminated, unobstructed, and as direct as possible without exceeding maximum travel distances. NFPA *101*® has been adjusted to reflect the fact that spills or items falling off forklifts do occur within the egress route. The code addresses these short-term blockages by requiring management to have a plan and procedures in place to manage and remedy the occurrence so that the blockage is not viewed as a per se violation of the code. Where the exit and path of travel are not clearly visible, signs must be provided to indicate the direction. A short common path of travel to two otherwise remote exits is permitted, except from an area of high hazard. Exit access must not pass through areas of high hazard. When evacuation must be delayed because of the need to shut down an operation safely or for any other reason, the additional provisions governing ancillary facilities contained in NFPA *101*® must be met.

Remember to ensure that all elements composing the means of egress remain in compliance with the requirements during periods of renovation and construction. This is especially important when partitions are erected to separate construction areas from work or production areas. Large loss fires have occurred in all types of occupancies during periods of construction, and industrial occupancies are particularly vulnerable because of their complexity and the work processes performed in them.

Emergency lighting is required in all facilities except those occupied only during daylight hours in which skylights or windows are arranged to provide, during those

hours, the required level of illumination for all portions of the means of egress. Check the type of lighting used and review records of servicing and testing. If battery packs are used for an emergency power supply, there should be an indicator light to show full-charge condition and a test button to check its operability. You must also be aware that the industrial occupancy chapter of NFPA *101*® (Chapter 40) contains requirements for equipment walkways, platforms, ramps, and stairs that differ from the baseline dimensional criteria of Chapter 7 of NFPA *101*®.

## Protection of Openings

When inspecting industrial occupancies, check the integrity of fire barrier walls and fire-rated floor–ceiling and roof–ceiling assemblies. With changing technology, changing operations and processes, and new tenants, industrial plants undergo revisions that create openings and holes through fire-rated assemblies. Pipes, electrical conduits, cable trays, and other penetrating items must be properly sealed and protected. Penetration seals must be made of approved or listed materials and be installed in such a way that they maintain the fire rating of the wall or floor assembly in which they are installed.

Ductwork going through fire-rated assemblies must be equipped with fire dampers unless specifically exempted by code. Where dampers are prohibited, such as for exhaust systems for cooking appliances, such ductwork must not pass through rated assemblies or must be properly enclosed.

Inspectors should check to see that fire doors are of the proper rating for the enclosure in which they are installed and that they are self-closing and positive catching. They should also check that automatic closure devices and mechanisms operate properly. Any obstructions that could interfere with the fire door closing completely must be removed (e.g., wooden wedges or the door being tied open). Examine the tracks of vertical sliding and roll-up doors for mechanical damage, especially when the openings are used by industrial trucks. Consideration should be given to installing guards to prevent stock from being piled up against the door or vehicles from striking it. Make sure that all doors get closed at the end of the business day, and inspect each door for evidence of excessive wear and tear, modifications to the door, or other defects that make its continued use suspect. Maintenance and testing of these doors should be done in accordance with NFPA 80, *Standard for Fire Doors and Other Opening Protectives*.

You should check all vertical openings, such as conveyors, elevators, stairs, dumbwaiters, and refuse chutes, for proper enclosure and to be sure that all openings are properly protected and of the proper fire rating. Also check that pipe chases and other vertical recesses are firestopped.

Ensure that fire shutters have proper automatic closing devices and that such mechanisms are operable. On building exteriors facing fire exposure hazards, doors and windows should be checked for the proper rating and glazing. The glazing of all fire doors that are permitted to have glass should also be examined to ensure that the glazing is of the proper size and thickness and installed properly in acceptable frames.

## Hazardous Materials

You must determine the properties of all of the materials used in industrial plants and see that they are stored and handled safely. To do this, especially with chemicals, you must have good reference sources. Because inspection is not an emergency activity, you can record what is found, how it is stored and handled, and then do additional research. If the research indicates that special precautions are required, you will need to perform a follow-up inspection to ensure that such precautions are being taken. Use caution, because the handling of the material—for example, the handling of flammable liquids that release vapors—can pose a significant potential for a hazard and should be corrected immediately.

Once a material has been identified, classified, and categorized by the degree of its physical and chemical properties, half the work has been done. You must then determine whether there are excessive amounts of materials for the fire area and for the provided level of protection. You must also determine the requirements for and the adequacy of the venting, if provided; whether electrical equipment has been classified properly; whether electrical wiring is in good condition and properly maintained; and whether there are ignition sources.

Production and process areas should contain only those amounts of hazardous materials that are necessary to the immediate process or operation. The maximum amount should be limited to the needs of one day or one shift, and then only when relatively small amounts are used. Inspectors must be sure to inspect the methods used to transfer hazardous materials from the shipping container or bulk storage area into the process or operation area. They should also look for possible ignition sources.

Many hazardous industrial processes have been fully evaluated, and standards have been established for their safe operation. The *National Fire Codes®* contain all of the codes and standards for safe operation of the most common industrial processes and many that are not common. In addition, the National Fire Protection Association (NFPA) *Fire Protection Handbook* covers a broad range of fire hazards that are found in major industrial occupancies. NFPA 400, *Hazardous Materials Code* consolidates all the fire and life-safety requirements applicable to handling, storage, and use of hazardous materials into one single comprehensive resource and offers detailed criteria to help with your evaluation. Inspectors should use this material when evaluating hazardous industrial processes and also when conducting inspections.

In situations in which there is no established standard to follow, inspectors must use their judgment in identifying the process or operational hazards and determining whether they are being controlled properly. The protection afforded must be appropriate to the hazard or hazards, and ignition sources must be controlled. A relatively small hazardous process incidental to the main operations, such as a small paint spray booth, should not change the classification of the entire area to one of high hazard. Inspectors should look for the installation of a special extinguishing system, such as carbon dioxide or dry chemical, because very often it is required by a standard to provide protection of the process. They may also find that the installation of draft curtains or special venting arrangements are required.

In the chemical and allied industries, there are hundreds of different processes and thousands of variations that may be beyond your ability to evaluate. This is not to say that inspectors should skip inspecting these premises or give them only a superficial inspection. Inspectors should identify all of the chemicals used and their hazardous properties, and they should then place them in broad classifications, such as corrosive, flammable, combustible, unstable, or reactive, based on the degree of hazard. You should ask to see a copy of the Material Safety Data Sheet (MSDS). An MSDS is provided by the manufacturer, compounder, or blender of the chemical and contains information about the chemical composition, physical and chemical properties, health and safety hazards, emergency response, and waste disposal of the material. Evaluating storage, transfer method, compatibility, and so on can give you a good indication of whether safe practices are being followed.

Some general questions concerning the various processes can be asked:

- Is there an operator's manual?
- Is the operator trained?
- Does the manual cover the hazards of the materials, the safe and critical temperatures and pressures, the proper sequence for adding materials, and the consequences for failure to follow a formula exactly?
- Does the process have fail-safe automatic controls?

Asking many additional questions can help you make a limited evaluation.

To obtain meaningful information, inspectors must gain the confidence of management and show that they can be trusted with trade secrets and confidential information. Because there are trade secrets in every phase of industry, inspectors should not be insulted if they are asked to sign a pledge of confidentiality.

## Storage

**Outdoor Storage.** The storage of materials outdoors usually is limited to those used in large quantities and those that are not susceptible to damage by weather. Storage practices should follow recommended safe practices.

All outdoor storage should be arranged so that it will not interfere with firefighting access to and around buildings and to the storage itself. If the stored materials are combustible, ignitable, or both, they should be far enough away from other buildings so that if on fire, one will not be an exposure hazard to another. There should be sufficient fire hydrants and hose houses with fire lanes to make outdoor combustible storage accessible on all sides. Areas must be free of vegetation and other loose combustibles.

**Indoor General Storage.** Preferably, storage areas should be in separate buildings or in cut-off sections of buildings used for no other purpose.

If storage is incidental to the main use of the building, inspectors should still follow the general rules for storage occupancies as much as possible, but they must also make additional judgments as to safe practices. Hazardous materials in relatively small amounts should be stored with due regard for their hazardous properties: flammable liquids should be stored inside cut-off storage rooms or cabinets; loose, highly

combustible fibers should be stored in metal or metal-lined bins with automatic closing covers; and pyroxylin plastics should be stored in vaults and tote boxes. Many of these materials have specific standards that address the proper storage applications.

You must be certain that piles are stable and separated by adequate aisles, that clearance to sprinklers is maintained, and that materials being stored are compatible. Stock piled over 12 ft (3.7 m) in height and rack storage of material require special considerations. See NFPA 13, *Standard for the Installation of Sprinkler Systems*, for proper methods of storage and protection.

Idle pallets awaiting reuse, repair, or disposal can be a constant problem. They should never be stored in unsprinklered areas. When they are stored in sprinklered areas, the piles should cover a small area and be less than 8 ft (2.4 m) high. They should preferably be stored outdoors, well away from buildings and other storage areas.

**Housekeeping and Maintenance.** Poor housekeeping and maintenance practices can be the most frustrating problem you will encounter and are probably the principal reasons for follow-up inspections. Improper housekeeping is not only a fire hazard, but it also indicates a lack of management commitment. Improper storage of materials and poor maintenance of pumps, piping, and exhaust systems can make floors slippery and atmospheres dusty and can interfere with the proper operation of fire protection equipment.

Industrial occupancies with good housekeeping and maintenance practices are relatively easy to inspect. As a general rule, where housekeeping and maintenance are a priority, most items of fire safety and protection will also be good, and less time will probably be needed to make a thorough inspection.

You should see that waste is removed properly and disposed of safely. Where waste has value as salvage, a safe collection area should be set apart and maintained in an orderly way. Chemical wastes must be disposed of in a manner that is safe for the environment and in accordance with state and federal regulations.

Control and mitigation of dust explosion hazards are also of concern in many types of industrial occupancies. Cutting, milling and processing operations can generate fine particulate materials that are prone to settle on equipment surfaces as well as on the buildings, structural and architectural components. Chapter 44 of this text covers the various environment and protection measures necessary to manage a range of operations that may cause a dust explosion hazard.

# FIRE PROTECTION

When inspecting industrial plants, you must be certain that existing fire protection systems and equipment are properly maintained and that portable fire extinguishers are properly located and are accessible. The locking pin should be in place and sealed, free from damage. There should be no foreign materials in hoses and nozzles that would interfere with their operation. Pressure gauges on extinguishers should indicate they are ready for use. Examine the tag for the last inspection and hydrostatic test dates. Extinguishers should be in cabinets or have covers when they are located in dusty or corrosive atmospheres. Their location should be clearly marked. The discussion on

automatic sprinkler and other water-based fire protection systems elsewhere in this text addresses the requirements for the inspection, testing, and maintenance of water-based fire protection systems such as automatic sprinklers.

## Water Supplies and Fire Pumps

Inspectors will have to rely on records and reports when inspecting water supplies, because much of the piping and valves is buried. Industrial occupancies often have more than one source of water supply (e.g., tanks, ponds, and city connections), and each one will need to be examined. Inspectors should check aboveground portions for proper maintenance. They should make sure that all supply valves are open, gravity tanks work, fire hydrants are maintained, and so on. They should review records of water-flow tests, pump tests, valve-operating records for underground valves, and hydrant inspection reports. Signs of neglected maintenance will usually be obvious.

You should check pump rooms to determine whether fire pumps and fire booster pumps are ready for operation if they are needed. The power should be on at the controller of electrically driven pumps, no trouble lights should be on, and the jockey pump should not run excessively or kick on too often. The fuel tanks of internal combustion drivers should be full or nearly so, and batteries should be fully charged with a trickle charger to keep them charged. Review records of pump testing and maintenance.

## Sprinkler Systems

If sprinkler systems are to perform as they were intended to, periodic inspection and maintenance are essential. Inspect them visually and witness periodic tests. In general, hands-on testing should be the responsibility of the building owner or an authorized maintenance company.

## Special Extinguishing Systems

Special extinguishing systems can consist of Halon 1301 (mostly on older systems), clean agent, carbon dioxide, dry chemical, and foam systems. Inspectors must have a good idea of how the various systems operate. The inspection must be visual; the valves should not be tested or manipulated. Inspectors should check that the extinguishing agent used is suitable for the hazard(s) being protected and that a reserve supply is available, if required. They should check that actuating devices and alarms are operational, see that nozzles are clear and free of foreign matter, and determine that nozzle caps, where used, are free. Nozzles should be properly aimed and protected from damage.

When systems are of the total flooding type, all openings required to be closed on system actuation should be checked for proper operation. It is important that the hazard enclosure be properly sealed before system discharge. Piping, cable assemblies, valves, and manifolds should be checked for damage. Records of inspection, testing, and recharging should be examined to determine whether maintenance has been proper. Specific information on these systems can be found in the appropriate standard or code in the *National Fire Codes®*.

## Standpipe Hose Systems

In industrial occupancies, standpipes and hose stations are more often supplied from the sprinkler system than from a separate system. Therefore, inspectors should inspect these systems as they would sprinkler systems. They should check that all valves on the water supply are open and that the fire department connection is accessible. Threads should not be damaged and should be properly capped. Swivels should work freely, and threads should be compatible with those of the local fire department.

Inspectors should check hose cabinets or reels for proper installation, location, and accessibility. They should check the hose for signs of deterioration or need for reracking, and they should be sure that the attached nozzle works freely. Hoses and outlets should have the same threads as those of the local fire department, or there should be an adapter in the cabinet or at the reel.

## Fire Alarm Systems

The inspection of an alarm system should be visual. Testing should be the responsibility of thoroughly trained employees or an outside alarm service company; however, you should review these test records as part of your inspection and should observe alarm-initiating devices for proper location, mechanical or electrical damage, painting, loading, or damage caused by a corrosive atmosphere. Wiring should be in good condition and securely fastened. Control panels should be in a safe location and readily accessible. The "power on" light should be lit, and all trouble lights and signals should be off. Service and test records should be in the panel enclosure. When emergency power is required, batteries should be fully charged. Equipment should be free from dirt or grit that can find its way into delicate parts and contacts.

Manual fire alarm stations should also be inspected for signs of any problems. Wiring should be secure and in good condition, and there should be no tape, wire, string, or other encumbrance to the effective use of the system. The stations should be located near the exits along natural egress paths.

You should check audible devices to see whether they have been tampered with, painted, or damaged and whether they can be heard above the ambient noise. Also check all records to determine that required servicing and testing have been done, and review records of all supervisory signal systems and alarm signal systems. Detection systems for actuating special extinguishing systems are usually serviced by an outside service company under contract.

# BIBLIOGRAPHY

Cote, A. E., *NFPA Fire Protection Handbook*, 20th ed., NFPA, Quincy, MA, 2008.

### NFPA Codes, Standards, and Recommended Practices

See the latest version of the NFPA Catalog for availability of current editions of the following documents.

NFPA 13, *Standard for the Installation of Sprinkler Systems*
NFPA 30, *Flammable and Combustible Liquids Code*

NFPA 30B, *Code for the Manufacture and Storage of Aerosol Products*
NFPA 32, *Standard for Drycleaning Plants*
NFPA 35, *Standard for the Manufacture of Organic Coatings*
NFPA 36, *Standard for Solvent Extraction Plants*
NFPA 61, *Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities*
NFPA 80, *Standard for Fire Doors and Other Opening Protectives*
NFPA 88B, *Standard for Repair Garages*
NFPA *101®*, *Life Safety Code®*
NFPA 120, *Standard for Coal Preparation Plants*
NFPA 400, *Hazardous Materials Code*
NFPA 484, Standard for Combustible Metals
NFPA 505, *Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Maintenance, and Operations*
NFPA 654, *Standard for the Prevention of Fire and Dust Explosions in the Chemical, Dye, Pharmaceutical, and Plastics Industries*
NFPA 664, *Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities*
NFPA 1124, *Code for the Manufacture, Transportation, and Storage of Fireworks*

CHAPTER

# 42

# STORAGE OCCUPANCIES

*Joseph Versteeg*

NFPA *101®*, *Life Safety Code*, defines storage occupancies as buildings or structures used to store or shelter goods, merchandise, products, vehicles, or animals. Examples are warehouses, freight terminals, parking garages, aircraft storage hangars, grain elevators, barns, and stables. These facilities may be separate and distinct facilities or part of a multiple-use occupancy. When storage is incidental to the main use of the structure, it should be classified as part of the main occupancy when determining life-safety requirements.

Considerable judgment must be exercised when determining whether storage is incidental to the main use of the building. One consideration is the hazard classification of the contents stored in the area. If they are classified as high hazard, the room or space must be separated from the rest of the occupancy by fire-resistive construction that meets the requirements of NFPA *101®*, the local building code, or fire prevention code. In cases where the hazard is severe, both fire-resistive construction and automatic fire suppression might be required.

You should be aware that storage occupancies or areas of storage occupancies that are used for packaging, labeling, sorting, special handling, or other operations that require an occupant load greater than that normally contemplated for storage must be classified as industrial occupancies when determining life-safety requirements.

Parking garages, whether closed or open, aboveground or below, must also be classified as industrial occupancies if they contain an area in which repair operations are conducted. If the parking and repair sections are separated by 2-hour fire-rated construction, they can be treated separately. Make sure you know the special requirements for underground and windowless structures, which are covered in Chapter 11 of NFPA *101®*.

## OCCUPANCY CHARACTERISTICS

Storage occupancies can be classified as low, ordinary, or high hazard or a combination of these where mixed commodities are stored together. Where different degrees of hazard exist in the same structure and cannot be separated effectively, the requirements

e most hazardous classification govern. The authority having jurisdiction must ıund judgment when applying this principle of hazard classification. NFPA *101*® :he ordinary hazard classification as the basis for general requirements. Most ge occupancies fall into this classification, although an increasing percentage are ; classified as high hazard because of the rapid fire and smoke development that ·e expected in some situations.

hen looking at the overall fire hazard, inspectors should also consider building truction. Combustible building materials can affect the spread and development ·e, especially if there are combustible concealed spaces. Combustible insulation is ·ticular problem in certain storage facilities and represents a serious fire problem. ectors must determine specifically the type of any insulation present.

lodern developments in materials handling have brought rapid changes to storage ıpancies, including high-rack storage areas that can reach heights of 50 to 100 ft (15 0 m). Computer-controlled stacker cranes and robot-controlled material handlers now being used to move materials. Regional distribution centers that cover several :s, which might contain two- or three-level mezzanines, are now being developed. ıistorage complexes that consist of rental spaces ranging from 40 to 400 ft² (3.71 to 2 m²) in size are also being developed. These complexes, which consist of as many 50 to many hundreds of rental spaces in one building, often contain varying types l amounts of hazardous storage in one or more of the rental areas and can be located multiple story buildings.

Storage occupancies can house raw materials, finished products, or goods in an ermediate stage of production, and these materials can be in bulk form, solid piles, lletized piles, or storage racks. Therefore, inspectors should remember that the ›rage arrangement can greatly affect fire behavior.

# NSPECTING THE PREMISES

## Contents

ı determining life-safety features and requirements in a storage occupancy, you must rst determine the hazard classification of the contents. Fire behavior will depend on he ease of ignition, rate of fire spread, and rate of heat release of the product itself. ›roducts, however, are often complex items whose fuel content, arrangement, shape, ınd form affect their performance in a fire. A packaged product must be considered ıs a whole, because that is the way it burns, so in classifying the contents, examine the ›roduct, product container, and packaging material used.

Increasing amounts of plastics are now being used as part of the product and as part of the packaging. Bicycles have traditionally been all metal except for the tires, but now the frame and wheels of a bicycle may contain 50% or more synthetic mate- rial. Electrical and plumbing supplies have traditionally been metal, but now many of these supplies, including pipe, conduit, fittings, and junction boxes, are made of plastic. Washing machines typically have a limited amount of combustible parts in the machine assembly; however, today's typical packaging arrangement, the machine

packed in a cardboard box surrounded with plastic foam, has made this commodity more hazardous even though the base commodity has not changed.

You should become familiar with National Fire Protection Association (NFPA) standards detailing requirements for the proper storage arrangement and level of protection for storage of specific items including flammable and combustible liquids, hanging garments, rolled paper, tires, and aerosol containers.

## Occupant Load

A small number of people in relation to the total floor area will usually be present in a storage occupancy at any one time. Work patterns usually require employees to move throughout the structure using industrial trucks to position the commodity. In totally computerized warehouses, even fewer occupants are present, which reduces the likelihood of early fire detection and the personnel available to begin first aid firefighting operations. Because of this, NFPA *101*® has no occupant load requirements for storage facilities. When establishing the occupant load for new and existing storage structures, the authority having jurisdiction will have to obtain in writing (from the building owner or occupant) the actual number of occupants expected in each occupied space, floor, or building. The authority having jurisdiction must then designate the number of occupants to be accommodated on every floor and in each room or space. Be aware of areas within the building having more concentrated occupant loads such as areas used for packaging, labeling, and sorting. Such areas, because of their small size and functions that support the primary storage function of the building, are considered an incidental industrial use area and now have a calculated occupant load based on 100 $ft^2$ (9.3 $m^2$) per person.

Special attention needs to be given to parking garages, which, at given times, could be occupied by many people, such as at the end of a workday or when an entertainment event is over. It should be noted that because of the typical low density of a storage occupancy, egress capacity is rarely a problem if the minimum number and size of exits along with maximum travel distance limitations are met.

# MEANS OF EGRESS

At least two separate means of egress, as remote from each other as possible, must be available from every floor in a storage structure. In smaller buildings, a single exit is permitted, as long as the common path of travel limitations is not exceeded. Inspect the exit access from within the building, the exit locations, and the arrangement of the exit discharge from the exit to a public way or street (see Chapter 22, Means of Egress).

Periodically, the storage arrangements in storage occupancies are modified to keep up with new technology and operations, and these modifications can significantly affect the components of the building's means of egress. Without proper planning, exits can become blocked by storage or rack systems, travel distances significantly increased, dead-end corridors or aisles created, and even exit discharge adversely affected by building additions, altered security measures, or changes to property lines.

## Exit Access and Travel Distances

All paths of travel from any part of the building must allow the occupants to travel safely, without obstructions, to the exits. The travel distances to the exit locations are shown in **TABLE 42-1**.

When repair operations are conducted within a parking garage, travel distances must meet the requirements for the industrial section (Chapter 40) of NFPA *101*®. If the repair operation area is separated by 2-hour fire-resistive construction, the industrial requirements will apply to only the part that is used for repair operations.

Any rearrangement of the storage aisles or additions or changes to the rack systems made since the occupancy's last inspection can greatly affect travel distances to exits. When new mezzanine levels are added for additional storage space, check that travel distances to exits are correct and that the appropriate number and arrangement of sprinklers have been added to the new area.

When determining exit access, look for areas where dead ends or common paths of travel are created by the storage arrangement. There is no limit to either in occupancies with a low-hazard classification. In new or existing storage occupancies with

**TABLE 42-1** Maximum Travel Distance to Exits

| Level of Protection | Low Hazard Storage Occupancy | Ordinary Hazard Storage Occupancy | | High Hazard Storage Occupancy | |
|---|---|---|---|---|---|
| | | ft | m | ft | m |
| Protected throughout by an approved, supervised automatic sprinkler system in accordance with 9.7.1.1(1) | NL | 400 | 122 | 100 | 30 |
| Not protected throughout by an approved, supervised automatic sprinkler system in accordance with 9.7.1.1(1) | NL | 200 | 61 | 75 | 23 |
| Flammable and combustible liquid products stored and protected in accordance with NFPA 30, *Flammable and Combustible Liquids Code* | NA | NA | NA | 150 | 46 |

NL: Not limited. NA: Not applicable.
Source: NFPA *101*®, 2012, Table 42.2.6.

an ordinary-hazard classification, a dead end or common path of travel of up to 50 ft (15 m) is allowed and up to 100 ft (30 m) is allowed if the building is protected by an automatic sprinkler system. No dead-end conditions are allowed in areas that are classified as high hazard except for very small spaces that:

- Are not over 200 ft$^2$ (18.6 m$^2$).
- Occupant load does not exceed 3 persons.
- The travel distance to the room door does not exceed 25 feet (7620 mm).

In parking garages, a dead end or common path of travel of up to 50 ft (15 m) is allowed.

## Exits and Locations

At least two means of egress are required from all floors and areas of the building in storage occupancies classified as ordinary and high hazard, and they must be located so that a person can reach an exit location within the allowable travel distances.

There are several exit requirements for any enclosed parking garage in which gasoline pumps are present. Travel away from the pumps in any direction should lead to an exit, and there must be no dead ends where people could be trapped by a fire originating at the pumps. The exits must lead to the outside of the building at the same level as the pumps or they must lead to stairs. Any story below the one housing the pumps must have exits directly to the outside by means of outside stairs or doors at ground level.

In aircraft storage and servicing areas, there must be exits at intervals of every 150 ft (45 m) on exterior walls of the hangar and every 100 ft (30 m) along interior fire walls when these walls serve as horizontal exits. The travel distance to reach the nearest exit from any point from a mezzanine floor located in an aircraft storage or servicing area must not exceed 75 ft (23 m). Such exits must lead directly to an enclosed stairwell discharging directly to the exterior, to a suitable cut-off area, or to outside stairs.

In grain or other bulk storage elevators, there should be two means of egress from all working levels of the head house. One must be stairs to the ground that are enclosed by a dust-resistant 1-hour fire-resistive enclosure. The second means of egress can be exterior stairs or a basket ladder-type fire escape that is accessible from all working levels of the head house and provides access either to ground level or to the top of an adjoining structure that provides a continuous path to another exterior stairway or basket ladder-type fire escape leading to the ground level. The underground spaces of an elevator must have at least two means of egress, one of which can be a ladder.

You should check all doors that serve as a required means of egress and are identified as exits for free and unobstructed operation to ensure that these doors are kept unlocked when the building is occupied. If locks requiring use of a key for operation from the inside of the building are used, make sure that a readily visible sign is posted

next to the door on the egress side of the door stating, "This door to remain unlocked when the building is occupied." The locking device should be readily distinguishable if locked.

Make sure that exit doors located in a high-hazard area swing in the direction of exit travel. In areas where flammable vapors or gases are present, or the possibility of an explosion exists, make sure that exit doors are equipped with panic hardware.

In ordinary and low-hazard areas that are protected throughout by an approved, supervised, automatic fire alarm or automatic sprinkler system, exit doors can be equipped with approved, listed, special locking devices that meet the requirements of Chapter 7 of NFPA *101*®.

NFPA *101*® permits horizontal sliding doors to be part of a means of egress. It also permits the use of a horizontal exit or smoke barrier. There are, however, special requirements in Chapter 7 of NFPA *101*®. It is quite common to find horizontal exits in storage occupancies due to the use of fire walls or barriers for compartmentation purposes. When the horizontal exit doorway is protected by a fire door on each side of the wall, one door must be swinging, and the other can be an automatic-sliding fire door complying with specific requirements involving fusible links (as detailed in Chapter 42 of NFPA *101*®) that must be kept open when the building is occupied.

In parking garages, the opening for the passage of automobiles can serve as an exit from the street floor, provided that no door or shutter is installed in the opening.

In storage areas that contain ordinary- or low-hazard contents and have an occupant load of not more than 10 people, exit doors that are not side-hinged swinging are permitted.

## Exit Discharge

You must determine that there is a continuous path of travel from the building exit to a public way and that there is nothing in front of the exit door that would prevent it from working. Also make sure the path of travel from exits opening into an alley leads to the public way, is well marked, and is illuminated.

## Identification of Exits

All required exits and paths of travel to an exit must be identified properly by signs that are readily visible from any direction of exit access. Where the exit or the way to reach it is not visible to the occupants, the path of travel should be marked so that no point in the route is more than 100 ft (30 m) from the nearest visible sign.

In large warehouses with high storage, exit identification can be a problem; therefore, you might want to suggest that exit signs be of sufficient size for visibility or that the travel paths to exits be painted on the floor.

Ensure that exit access routes are illuminated to allow the occupants to exit the building safely. If natural light is not available during the fire when the building is occupied, the illumination must be continuous when the building is occupied. Emergency lighting is required in storage occupancies that are occupied at night or that do not have exterior openings that would provide the required illumination during daylight hours. Check that emergency lighting operates when the normal lighting circuits for

the affected area are turned off. When a generator is used to power emergency lighting, the generator should transfer power and should operate emergency lighting within 10 seconds. Check the records and, if possible, be present for a generator test to be sure it runs properly. When checking battery-powered lighting units, look for acid corrosion and check the water level of wet-cell batteries and that the unit is fully charged and operational.

## Protection of Openings

You should check that fire doors operate properly, that they close tightly, and that the self-closing devices work. Assess the general condition of the doors for obvious damage. Nothing that would prevent counterbalance closing hardware from operating freely should be stored around the fire doors, and nothing should block the doors open. You should check that all door hardware and closing devices are lubricated and move freely, and examine all fusible links associated with the closing hardware to see that they are positioned properly and have not been painted or wired together.

It is important to carefully check materials-handling conveyor systems that pass through fire walls. Is there any air-handling ductwork passing through fire walls? NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems*, requires any ductwork passing through a 2-hour fire wall to be protected by fire dampers. Check that all openings through the walls made for electrical cables or conduits are tightly sealed with a material that affords the same fire-resistance rating as the fire barrier. Where storage buildings are susceptible to exterior exposure problems, you should check that fire shutters are operational and that wired-glass windows are properly placed. All wired glass that is missing or cracked should be replaced. Verify that installed roof vents are operating properly and that snow is not allowed to accumulate on the vent hatches during the winter.

# GENERAL STORAGE PRACTICES

## Indoor

NFPA 1, *Fire Code*, defines commodity storage as both pile and rack storage and describes four classes of ordinary commodities and three classes of plastics according to how easily automatic sprinklers will control a fire in them. Refer to this code to determine the proper storage arrangement in buildings protected by automatic sprinkler systems.

You should make sure that materials that could be hazardous in combination are stored so they cannot come in contact with each other, and verify that safe loads for floors and rack storage units are not exceeded. Floor loads for water-absorbent materials should be reduced to account for the added weight of water absorption during a fire. Check the clearance of stored material from sprinklers, heat ducts, unit heaters, duct furnaces, flues, radiant space heaters, and lighting fixtures. The wall aisle space should be at least 24 in. (61 cm) in storage areas where materials that will expand with absorption of water are stored. Verify that aisles are maintained to keep fire from spreading

from one pile to another and to permit access for firefighting, salvage, and removal or storage. Also verify that all automatic sprinkler control valves, hose stations, and portable fire extinguishers are accessible and that there is free access to all fire protection equipment. All unused wood or plastic pallets should be kept outside and stored in stacks no higher than 15 ft (4.6 m). Idle pallets are permitted to be stored inside the building when it is protected with an automatic sprinkler system. During the inspection, you should check to see whether exterior access doors and windows are being blocked with storage that would affect firefighting operations and prevent access into the building.

### Outdoor

Confirm that storage piles are not stacked too high and are in stable condition and that aisles are sufficiently maintained between individual piles, between piles and buildings, and between piles and boundary lines of the storage site. Also note whether the entire property is enclosed with a fence or some other means of keeping unauthorized persons from entering. There should be a gate to allow fire department apparatus to enter the area in the event of a fire. The storage yard should be free of unnecessary combustible materials, weeds, and grass, and any tarpaulins used to cover materials should be made of fire-retardant fabric.

## HAZARDOUS MATERIALS

Many different materials with different hazards can be stored in a storage occupancy, or the entire occupancy can be used to store a specific hazardous material. Special requirements for the storage of hazardous materials are found in several documents within the *National Fire Codes®*. You should be able to recognize out-of-the-ordinary storage and refer to the appropriate code or standard to determine special storage arrangements and protection requirements. Examples of hazardous materials include rubber tires, plastic products, combustible fibers, paper and paper products, hanging garments, carpeting, pesticides, flammable liquids and gases, reactive chemicals, and flammable aerosol containers. Storage of aerosol containers should meet the requirements of NFPA 30B, *Code for the Manufacture and Storage of Aerosol Products*. All storage occupancies should be properly identified on the outside of the building using NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*.

### Industrial Trucks

Determine that the industrial trucks being used are approved for use within the building for the hazard of the materials being stored. NFPA 505, *Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance, and Operations*, designates the types of trucks that can be used in hazardous areas. A fire extinguisher that can be used on flammable liquid and electrical fires should be mounted on each truck. Confirm that the trucks are being maintained, that all refueling operations are conducted outside the building, and that fuel for the trucks

is properly stored. Examine the area where batteries are recharged for electrical trucks. Areas used for the repair of trucks should be separated from the storage area.

## Hazardous Processes

You should assess the precautions management takes when a welding or cutting operation occurs in the storage area. In some cases, these operations should not be allowed at all until the hazardous materials are removed from the area. During welding operations, all combustible materials located below the operation should be removed or covered with a fire retardant cover. Portable fire extinguishers and small hose lines should be laid out ready for operation. A fire watch should be present at all times during the operation and for at least 30 minutes after the welding or cutting is completed.

If fuel pumps are located in a parking garage, you should check that the dispensing unit and nozzle are approved and that no ignition sources are located within 20 ft (6 m) of the dispensing area. When the dispensing units are located below grade inside the building, the entire dispensing area must be protected with approved automatic sprinkler systems. Make sure there is mechanical ventilation for the dispensing area to remove flammable vapors and that the mechanical ventilation system is electrically interlocked with the dispensing unit so that no dispensing can be conducted without the ventilation system being in operation.

# HOUSEKEEPING

Look for debris and trash accumulated in out-of-the-way places and neglected corners. The level of fire safety is greatly improved when areas are kept clean and neat. All waste generated daily should be removed from the building and disposed of in a safe manner outside the building. Check for the accumulation of dust and lint on sprinklers, on fire door self-closing hardware, and around electrical motors and compressors. All containers used for the disposal of waste material must be made of noncombustible materials and have lids.

In grain storage buildings, the single most important fire prevention practice is effective daily removal of dust, which will collect everywhere. Housekeeping in this type of occupancy should be done consistently and carefully. See Chapter 44 of this text for specific criteria concerning operations in dust-producing environments.

# FIRE PROTECTION

## Sprinkler Systems

A major factor in large fire losses in storage buildings has been the overtaxing of the automatic sprinkler system or associated water supply, which were improperly designed or became inappropriate for the type of material stored and the storage arrangement. Fire losses have also occurred because the sprinkler system water supply has been shut off. Sprinkler plans should be checked to determine the hazard that the system was designed to protect. During the inspection, check whether the material being stored or

the storage arrangement has changed in a way that would require redesign of the sprinkler system. Detailed inspection records should be kept indicating the type of material stored, pile arrangement, aisle width, storage methods, and height of storage materials. Pay special attention to buildings protected by older sprinkler systems designed for Class III or lower commodities that now store more hazardous materials or have more hazardous storage arrangements.

Verify that the sprinkler control valves are accessible, not blocked by storage, and in the open position. Also, confirm that the system has been maintained properly, is in working order, and that all alarms operate when tested, properly identifying the alarm/supervisory condition. The outside fire department sprinkler connection must not be blocked by storage. Look for any areas unprotected by sprinklers, such as small office enclosures with ceilings, mezzanines, or blind combustible spaces.

## Standpipe Hose Systems

Hose stations and standpipe connections must not be blocked by storage materials. There should be an adequate number of hose stations, so that all areas of the storage buildings can be reached by the hose stream. All hose stations should be identified properly. Assess the condition of the hose and nozzles and find out whether employees are expected to use this equipment and, if so, whether they are trained properly for using the standpipe hose system.

## Fire Extinguishers

You should determine that fire extinguishers are accessible, that they are the correct type for the hazard, and that their locations are identified. All extinguishers should be fully charged and inspected at least annually. Employees should be trained to use the extinguisher correctly.

## Fire Pumps

The fire pump should be examined to determine whether it is being properly inspected, tested and maintained and whether it is being run weekly and tested by a qualified contractor at least annually. Verify that all alarms operate when tested, and properly identify the alarm/supervisory condition. Determine whether the pump is set for automatic or manual operation and check that all controls are working. Also determine that proper documentation of testing and maintenance is being maintained. Chapter 17, Automatic Sprinkler and Other Water-Based Fire Protection Systems, addresses the requirements for the inspection, testing, and maintenance of water-based fire protection systems such as automatic sprinklers.

## Alarm System

Because storage buildings are usually large open-floor areas that are occupied by only a few employees who are working in many different parts of the building, these buildings should have a fire alarm system that, when operated, will sound an alarm at a

continuously attended location so that some type of emergency action can be initiated. If the occupancy has a trained industrial fire brigade or an emergency prefire plan, there should be a means of notifying people in all areas of the building so that the fire brigade or action plan can be initiated.

NFPA *101*® requires a fire alarm system in storage buildings when they contain either ordinary or high-hazard contents and have an aggregate floor area of more than 100,000 $ft^2$ (9300 $m^2$). This requirement would not apply if the occupancy is protected by an automatic extinguishing system.

A fire alarm system is also required in public parking garages, except when the parking structure is classified as an open-air structure. When inspecting this type of alarm system, make sure that the entire system and all functions are in operating order and that all initiating devices, such as manual fire alarm boxes, are identified and not blocked by storage. You should also ensure that the notification alarm or signal is adequate to notify all employees that are part of an industrial fire brigade or to activate the established, emergency prefire plan.

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**NFPA Codes, Standards, and Recommended Practices**

See the latest version of the NFPA Catalog for availability of current editions of the following documents.

NFPA 1, *Fire Code*
NFPA 13, *Standard for the Installation of Sprinkler Systems*
NFPA 30, *Flammable and Combustible Liquids Code*
NFPA 30B, *Code for the Manufacture and Storage of Aerosol Products*
NFPA 61, *Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities*
NFPA 88A, *Standard for Parking Structures*
NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems*
NFPA *101*®, *Life Safety Code*®
NFPA 220, *Standard on Types of Building Construction*
NFPA 400, *Hazardous Materials Code*
NFPA 484, *Standard for Combustible Metals*
NFPA 505, *Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance, and Operations*
NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*
NFPA 1124, *Code for the Manufacture, Transportation, and Storage of Fireworks and Pyrotechnic Articles*