Questions to Ask – Sprinkler Systems

- Must each floor be piped in independent zones?
- Are floors large enough to be further subdivided into zones?
- Are zones arranged with consideration of the fire service access levels?
- Are all sprinkler zones coordinated with the fire alarm design?
- Will hose connections remain in service if sprinklers are shut down?
- Are valves labeled to indicate their specific purpose or area covered?
- Are diagrams provided for floors with more than one sprinkler zone?
- Should valves be within reach from the floor below or positioned higher?
- Are valves located on the exterior where possible?
- Are exterior valves located away from doors, windows, and other openings?
- Are interior valves located in enclosed stairs where possible?
- Are valve rooms and valve access panels labeled?
- Are dual-feed systems provided with cross-reference signs?
- Is warning signage provided for partial systems?
- Are unsprinklered areas indicated on building plans and pre-incident plan documents?
- Have appropriate devices been incorporated to minimize unwanted alarms?

Resources

- IFC
- NFPA 1
- NFPA 13, *Standard for the Installation of Sprinkler Systems*
- 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*
- 13E, *Recommended Practice for Fire Department Operations in Properties Protected by Sprinkler and Standpipe Systems*
- 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies*
- NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*
- OSHA Standard *Automatic Sprinkler Systems*, 29 CFR 1910.159
- Fire Engineering, *Lessons Learned from Unsatisfactory Sprinkler Performance: An update on trends and a root cause discussion from the investigating engineer's perspective*, October 2010.

CHAPTER 9
STANDPIPE SYSTEMS

A fire standpipe system is a network of piping in tall or large structures that delivers water for manual firefighting. Water is fed into these systems either automatically through a water supply connection, manually through hose lines into a fire department connection (FDC), or both. The system piping delivers water to fire hose connections (FHCs) throughout the building, usually in enclosed or exterior stairs (figure 9.1). A properly designed, approved, and installed standpipe system precludes the need for long fire hose stretches.

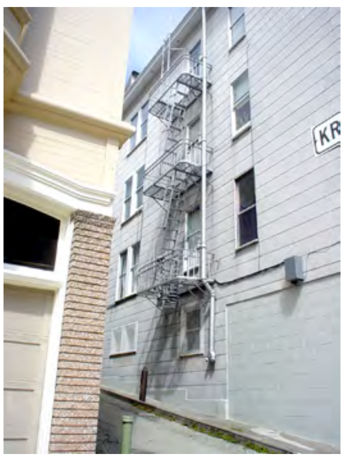

Photo: M. Chibbaro

Figure 9.1. *An exterior dry standpipe with an FDC on the bottom and a FHC at each fire escape platform.*

Firefighters can extend hose lines from FHCs for interior firefighting operations. To facilitate such operations, engine companies in jurisdictions with standpipe systems often carry bundles or packs of hose called standpipe packs (figure 9.2). In addition to hose, these standpipe packs may contain a nozzle, adapters, valve handles, a pressure gauge or piezometer, door chocks, and related equipment to allow connections to be made and to overcome problems such as vandalized systems. Some jurisdictions have required certain buildings to store caches of such equipment at strategic locations; however, other jurisdictions have found this approach to be less reliable than depending on their emergency responder's own equipment.

Photo: M. Chibbaro

Figure 9.2. *A training session showing firefighters connecting hose from a standpipe pack to a FHC.*

The vertical pipes that feed FHCs on multiple floors are called standpipes or risers. Pipes that feed two or more FHCs on a single floor are called horizontal standpipes. Vertical and horizontal standpipes are typically interconnected with feed main piping to form a single system (figure 9.3). This allows the FDC(s) to feed all FHCs concurrently, thereby simplifying emergency operations.

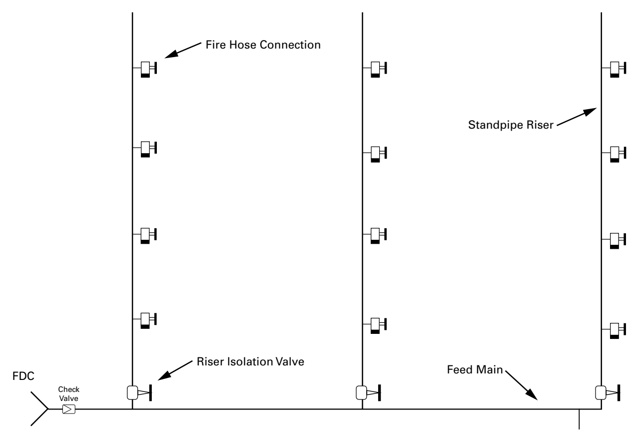

Figure 9.3. *A schematic diagram of a standpipe system.*

Standpipe systems are, in effect, a critical component in the supply of water to interior firefighting crews. Deficiencies can have disastrous consequences. For example, standpipe system inadequacies were reported as a factor in the 1991 Meridian Plaza high-rise fire in Philadelphia[8] (which killed three firefighters — figure 9.4) and the 2007 Deutsche Bank Building fire in New York City (which killed two firefighters).


Photo: FEMA

Figure 9.4. *The Meridian Plaza high-rise fire.*

Systems are classified according to usage: fire service use (Class I), occupant use (Class II), or combined fire service and occupant use (Class III). The considerations in this chapter apply to Class I systems and fire service portions of Class III systems. Occupant use systems may only be used where the occupants are properly trained and equipped; for this reason, their use has declined.

Building codes, fire codes, life safety codes, insurance carriers, and owner criteria specify when to provide standpipe systems. The code is usually a model code adopted by a jurisdiction, sometimes with local amendments. The trigger to require a standpipe system is usually building height or floor size. Typical applications include tall buildings, shopping malls, and other buildings with a large floor area.

In some cases code officials may allow a standpipe system to substitute for fire apparatus access. One example is a side of a building with a railroad spur and no apparatus access. FHCs could be located outside each fire service access door.

8. Federal Emergency Management Agency, "Building Fire One Meridian Plaza", USFA-TR-049, February 1991.

Another example is a pier that is structurally unable to support fire apparatus access.

Fire service hose connections are also installed in sprinkler systems in some warehouses and bulk merchandising spaces. These are intended for final extinguishment, or mop-up operations rather than fire attack. They do not constitute standpipe systems and do not provide the needed flow or pressure for effective fire attack.

The installation standard for standpipe systems is NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*. This standard allows options for FHCs, valves, and other design features. This chapter illustrates ways that designers can implement various options in different situations to assist the fire service.

Standpipe systems are often combined with sprinkler systems, which are covered in Chapter 8. Fire department connections are covered in Chapter 10. For systems to be effective, it is imperative that they be regularly inspected, tested and maintained. Impairment programs and maintenance are covered in Chapter 13.

System Design

Most new standpipe systems are designed by the hydraulic calculation method. This ensures that the water supply, pipe sizes used, and pumps (if needed) will provide the necessary flow and pressure at a specified number of FHCs in the system. Where FDCs supply all or part of the standpipe demand, designers and code officials must obtain from emergency responders the worst-case estimated water supply available from pumpers that are expected to respond and feed the FDC.

It is crucial that the proper range of pressure is provided at all FHCs. Firefighters may be able to compensate for improper pressure at an FHC by either boosting the system pressure with fire service pumpers through the FDC or by throttling down the control valve at the FHC. However, both of these approaches are last resorts and should only be needed if design or installation was inadequate or if a system deteriorated over time. Pumpers will be unable to boost pressure to compensate for any deficiencies in portions of tall standpipe systems that exceed their pumping capacity.

The selection of a minimum design pressure to be provided at FHCs must be based on accurate assumptions about the equipment used by the fire service. One common minimum design pressure is 65 psi. This is based on the friction loss through 100 ft. of 2½" hose and a smooth bore nozzle (figure 9.5) that requires a minimum pressure of 50 psi at the nozzle to be effective. Variation in equipment and procedures can render this pressure inadequate; for example, smaller diameter hose, fog or combination nozzles, and longer hose lines that are often needed to reach a fire location.

Photo: M. Chibbaro

Figure 9.5. *On the left is a smooth-bore nozzle that produces a solid stream. On the right is a combination nozzle that can be adjusted from a straight stream to a wide fog stream.*

Another common minimum pressure — in particular those designed since the mid-1990s — is 100 psi. Since some fog or combination nozzles require 100 psi at the discharge end of the standpipe hose line, providing 100 psi at the FHC may be inadequate regardless of hose size or length because additional pressure is needed to compensate for pressure loss through the hose line.

Remote portions of sprinklered floors may be up to 200 ft. from the closest FHC. Even longer hose lengths would be necessary where a fire must be fought from a more distant FHC due to conditions such as wind direction, ventilation paths, occupant location, and occupant egress routes.

Given these examples that illustrate how fire service equipment affects the pressure needed at FHCs, communication between designers, emergency responders, and code officials is critical. Designers and code officials should ensure that the minimum design pressure is based on a thorough understanding of fire service equipment — including hose size, hose lengths, and nozzle types. This will ensure the adequacy of fire streams for the safety of firefighters performing an interior fire attack.

In areas subject to freezing temperatures, dry type systems are used to keep water from freezing and rendering a system unusable. Heat tape and insulation of wet systems may be permissible for freeze protection; however, this option may be less effective because water is not normally flowing through the piping. Where freezing is not a concern, standpipe systems should be wet type so that water is immediately available at FHCs.

Large dry standpipe systems deserve special consideration. As the size of a dry system increases, the time required to deliver water to the remote FHC increases due to the larger pipe volume that must be filled when the system is activated. This can be mitigated by subdividing the system into smaller independent systems, or zones. However, this prevents them from being interconnected to be fed by the same FDC. See the Quantity section of Chapter 10 for specific considerations for signage to help alleviate potential confusion where systems are not interconnected.

Pressure-Regulating Devices

A maximum pressure limit of 175 psi is typical at FHCs on Class I and III standpipe systems. This is considered the maximum safe operating pressure of hose and devices used by firefighters. The maximum working pressure limit of many fire protection components is also 175 psi. Higher pressures will necessitate the use of pressure-regulating devices (PRDs) to restrict system pressures (figure 9.6).

Photo: M. Chibbaro

Figure 9.6. *An FHC equipped with a pressure-regulating device.*

Proper design, installation, acceptance testing, and maintenance of PRDs is imperative so that firefighters have adequate pressure for hose streams. Problems with PRDs have been cited as factors in several major high-rise fires.[9] For example, during the Meridian Plaza fire in Philadelphia mentioned above, failure to coordinate settings on these devices with fire service equipment resulted in inadequately low pressure for hose streams. Improper PRD settings during the 1988 First Interstate Bank building fire in Los Angeles resulted in excess pressure that made hose handling difficult and burst several hose lines.

PRDs fall into three categories: pressure-reducing valves (PRVs), pressure control valves, and pressure-restricting devices. Pressure-restricting devices do not limit pressure during static (non-flowing) conditions, nor do they maintain a constant discharge pressure. These devices incorporate orifice plates, mechanical pressure restrictors, or valve limiting stops. Pressure-restricting devices are not used for new Class I standpipe systems. However, designers may encounter these when redesigning existing systems — which would provide the opportunity to implement some or all of the considerations below.

PRVs and pressure control valves limit both static and residual (flowing) pressures. They are factory set to attain specific outlet pressures with specific inlet pressures. It is important for designers to specify the full range of possible inlet pressures at such valves, as well as the desired outlet pressure, so that they may be designed properly and then installed on the correct floors. Pressure fluctuations in the water supply as well as the greatest possible range of fire pump pressure capacity must be factored in.

PRVs and pressure control valves have other disadvantages. Their failure rate has been high, resulting in the addition of testing requirements (see NFPA 14 and NFPA 25). Also, many cannot be adjusted by firefighters during a fire, or they require special tools and knowledge.

One reliable means of limiting pressures in standpipe systems is to design them to eliminate the need for PRDs or limit the number of floors on which they will be needed. In shorter buildings, careful attention to the design of pumps and the maximum pressure supplied by incoming water mains can accomplish this. In taller buildings with multiple vertical standpipe zones, it may be possible to apply the same concept to the low zone. Another design option that can limit the need for PRDs is a variable-speed fire pump.

9. Federal Emergency Management Agency, "Special Report: Operational Considerations for Highrise Firefighting", USFA-TR-082, April 1996.

If the use of PRDs cannot be avoided, certain design features will help to balance their disadvantages. The easier the valves are to adjust in the field, the faster the fire service can overcome any unforeseen situation. However, this necessitates special training. Some jurisdictions may not want their firefighters to make such adjustments; others may prefer valves that can be easily adjusted and specify that adjustment tools and instructions be kept in a secure yet accessible location such as the fire command center or a locked cabinet near the fire alarm annunciator.

Firefighters are taught that a FHC can be used as an inlet if the FDC is not usable during an incident. This is not possible with PRDs, which permit water flow in a single direction. Standpipe systems with PRDs should incorporate a supplemental inlet at the level of fire service entry to serve as a backup to the FDC. This is especially important for systems with a single FDC. If the supplemental inlet is on the main feed piping upstream of riser isolation valves (see figure 9.3 above), it will feed all standpipe risers. Typically an extra FHC without a PRD will suffice as a supplemental inlet; however, it should be clearly marked for its purpose so that firefighters do not inadvertently use it as a hose outlet.

Fire Hose Connections

FHCs in Class I systems are typically 2½ inch threaded outlets (figure 9.7). As discussed in the Fire Hydrant Features section of Chapter 4, it is essential that hose connection type and size match those used by the fire service in the jurisdiction where the building is located. For example, incompatible hose threads were a factor in a 1992 Indianapolis, IN fire that killed two firefighters.[10]

Photo: M. Chibbaro

Figure 9.7*. A 2½" threaded FHC. The valve is opened and closed with the red hand wheel. The hose outlet has a 2½" by 1½" reducer to facilitate the use of different hose sizes. The 1½" cap is attached to the valve body by a chain.*

Location of Stair FHCs

Enclosed, fire-resistance rated stairs have traditionally been good locations for FHCs for the safety of firefighters. They can set up and begin their attack from within the protected stair enclosure. If a quick evacuation becomes necessary, the hose then functions as a lifeline, leading the firefighters back to the protection of the stairs. Disadvantages of hose lines keeping stair doors open are discussed in the following section.

Firefighters often stretch hose from a FHC below the fire floor for their protection. Below a fire is almost always a safer location than the same level or above. In stairs with intermediate landings between floors, some code officials or emergency responders may prefer that FHCs be located on the intermediate stair landings (figure 9.8). In this manner, firefighters can set up below the fire floor but need less hose compared to a FHC at the main landing a full story below the fire floor.

10. Federal Emergency Management Agency, "Indianapolis Athletic Club Fire", USFA-TR-063, February 1992.

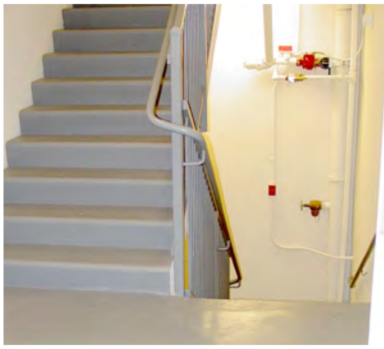

Figure 9.8. *A FHC on intermediate landing (lower right) as viewed from the main landing (foreground) where the stair entry door is located.*

If FHCs are located on main landings, consider their position in relation to doors. The FHCs should not be obstructed when the doors are open. Designers should position the outlet to permit the hose line to be stretched out the door without kinking and with as little obstruction as possible to the stair. Firefighters may use the door itself as a heat shield when initially opening it.

Location of Remote FHCs

Remote FHCs are sometimes needed outside of stairs (figure 9.9) if those located within stairs are beyond a given travel distance to the farthest points of a particular floor. Consider how firefighters will access and utilize remote FHCs during a fire incident rather than solely locating them to be code compliant. Remote FHCs within rooms, suites, or tenant spaces are not likely to be used for fire attack within the same spaces. In buildings with a corridor system, the corridor walls, ceilings, doors, and other openings may be rated for fire or smoke resistance. If so, they provide some degree of protection for firefighters, although it is usually less than that provided by a stair enclosure.

Figure 9.9. *A remote FHC in a cabinet in a corridor. The sign near the floor is intended to help locate the cabinet in light smoke conditions. Note that the hose outlet is angled to facilitate connection of hose.*

Remote FHCs can often be hard for firefighters to find. They should be placed as uniformly as possible on all floors to make them easier to find. Highly visible signs or other markings can assist firefighters in locating them quickly, along with notation of their locations on pre-incident plans. These may be tailored to décor or occupancy if acceptable to code officials and emergency responders. NFPA 170, *Standard for Fire Safety and Emergency Symbols*, contains symbols for marking standpipe outlets (another term for FHCs).

Location of Horizontal Exit FHCs

Horizontal exits are doors within fire-rated walls that substitute for exit stairs in some buildings. FHCs are typically placed on both sides of such doors (figure 9.10). Firefighters use these FHCs in the same manner as stair FHCs — to stretch hose lines from one side of the horizontal exit to attack a fire on the other side. The horizontal exit wall and door provide protection just as a stair would.

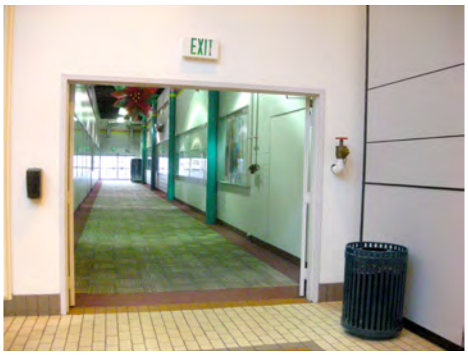

Photo: M. Chibbaro

Figure 9.10. *A double set of horizontal exit doors. One FHC is shown to the right of the doors; another is on the opposite side.*

Firefighters typically use a FHC on one side of a horizontal exit to attack a fire on the opposite side. The hose will then serve as a lifeline to the safe side of the wall as discussed above. For this reason, designers and code officials should remember to measure hose reach from remote locations to the FHCs on opposite sides of horizontal exit doors.

Location of Parking Garage FHCs

Parking garages deserve special consideration. Vehicle impact protection is important, especially for FHCs adjacent to drive aisles. Adequate access and marking should be provided (figure 9.11). This access path should be outside the designated parking spaces and clearly marked. If this access has the potential to be mistaken for a shopping cart storage area, consider a raised, curbed access path.

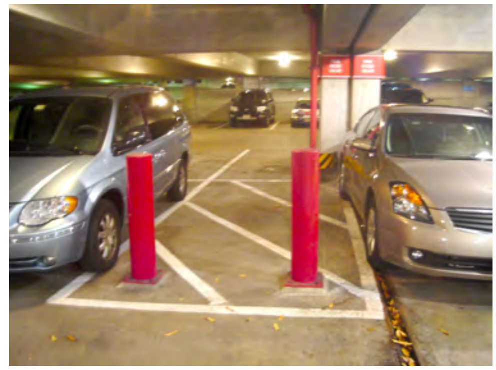

Photo: M. Chibbaro

Figure 9.11. *Floor striping indicates a FHC access path in a parking garage. Bollards provide vehicle impact protection. Bright signs at the top of the columns help firefighters locate the FHC.*

Exterior FHCs

Tenants or suites with exterior-only access pose yet another challenge for standpipe designers and code officials. Often they are beyond the hose reach limitation from the interior FHCs. Some jurisdictions allow this arrangement if apparatus access is nearby to permit attack hose lines to be stretched from pumpers. However, this is not an option for areas inaccessible to pumpers such as pedestrian promenades and boardwalks. In such situations, the solution for hose reach coverage is exterior FHCs (figure 9.12). In cold climates, a freeze-proof valve arrangement is necessary.

Photo: M. Chibbaro

Figure 9.12. *A pedestrian promenade serving ground-floor tenant spaces with no fire apparatus access. Below the red control valve is an exterior FHC.*

FHCs are also provided at access points to flat roofs in newer buildings. This allows firefighters to more easily stretch a hose line to fight a roof fire.

FHC Position

All FHCs should be positioned so that firefighters can connect hose to the outlet and operate the control valve handle while wearing heavy gloves (figure 9.13). A good height would be approximately adult waist or chest height. Emergency responders should be consulted for proper clearance from walls, cabinets, or other obstructions. Coordination is the key to preventing conflicts between features.

Photo: M. Chibbaro

Figure 9.13. *A FHC in a cabinet being checked by an inspector wearing a firefighting glove.*

Fire Attack from Stairs

Fire attack using hose lines from stair FHCs requires stair doors to be propped open (figure 9.14). This helps keep the hose from becoming pinched or kinked and thereby restricting water flow; however, this also allows smoke and heat to enter the stairs. Without careful coordination, occupants remaining above the level of the fire can be endangered and undesired ventilation flow paths can occur. This situation contributed to the deaths of six civilians in a stair during a 2003 fire in the Cook County Administration Building in Chicago.[11] Media accounts of a 2014 New York City fire that resulted in a civilian fatality in a stair also mention this coordination issue.[12,13]

Photo: M. Chibbaro

Figure 9.14. *A training session showing a firefighter chocking open a stair door to initiate a fire attack from a stair FHC.*

The conflicting needs to attack the fire and to protect remaining occupants can be challenging and difficult to manage under the best conditions. This can be complicated further by stair door locking arrangements, conflicting evacuation instructions, occupants not following evacuation instructions, the need for the fire service to operate from several stairs, or the need for total building evacuation during major incidents. Several alternative arrangements can help mitigate this dilemma.

One way of maintaining stair integrity during standpipe operations is to locate FHCs just outside stair doors instead of within stair enclosures. One disadvantage of this approach is that the fire attack must begin without the protection of the stair enclosure. Another disadvantage is a reduction in the lifeline concept described above. Some jurisdictions have allowed this arrangement if the FHCs are immediately adjacent to the stair (figure 9.15). If conditions warrant,

11. James Lee Witt Associates, Independent Review of Cook County Administration Building Fire, 2003.

12. http://www.nydailynews.com/new-york/high-rise-fire-killed-1-caused-overloaded-power-strip-article-1.1567795
13. http://newyork.cbslocal.com/2014/01/06/investigation-continues-into-deadly-manhattan-high-rise-fire

hose can still be stretched through the stair from a lower level. Disadvantages should be weighed against the possible advantages of maintaining the integrity of the stair enclosure — for both occupant and firefighter protection. This approach would require specific approval of code officials in addition to coordination with emergency responders.

Photo: M. Chibbaro

Figure 9.15*. A FHC on the corridor side of a stair door (on the left).*

A second alternative is to provide FHCs both inside and outside the stair doors (figure 9.16). Although this provides the greatest flexibility, it adds cost. Some jurisdictions have been successful in mandating this by code amendment.

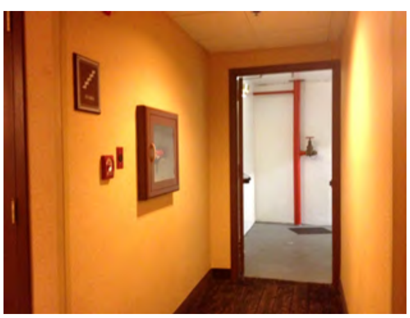

Photo: M. Chibbaro

Figure 9.16*. A standpipe riser and a 2½ in. FHC are located within the stair in the background. The FHC shown in the wall cabinet outside the stair is 1½ in. This was deemed adequate for many fire situations in this fully sprinklered building.*

A third approach to maintaining the integrity of stair enclosures during fire suppression operations is to place FHCs in a fire-rated vestibule between the stairs and the building interior. Although such vestibules require additional space, they may be provided anyway for refuge areas for individuals with mobility impairments or to create smokeproof stairs (figure 9.17). A potential disadvantage of using smokeproof stair vestibules is that the air flow path (and therefore the path of heat and smoke) may be towards these vestibules during a fire.

Photo: M. Chibbaro

Figure 9.17*. A standpipe riser and a FHC in a vestibule. The corridor door (foreground) can remain open for hose line use while the stair door (background) remains closed.*

Another type of smokeproof stair utilizes exterior balconies between the stair and the interior (figure 9.18). These balconies allow smoke to dissipate without entering the stair. Even if both doors are open for hose line use, smoke is not likely to enter the stair.

Photo: M. Chibbaro

Figure 9.18*. An exterior view of open air vestibules (arrow) between the stair and the interior of a building.*

The fire service elevator lobbies discussed in the Elevators section of Chapter 6 provide yet another option for location of FHCs. Much like the vestibules discussed above, if FHCs are located in the lobby instead of the stair, fire attack can proceed without opening the stair door.

Isolation Valves

Each standpipe riser is provided with its own isolation valve (figure 9.19) to permit shutting off one standpipe riser without interrupting the supply to other risers (see the diagram in figure 9.3 above). This allows firefighters to shut down a standpipe riser that has a problem such as a leak, a failure, or several open FHCs. They can then use the remaining standpipe(s). These problems often arise or occur during an emergency incident rather than in advance, making it important to locate the isolation valves quickly.

Photo: M. Chibbaro

Figure 9.19. *A standpipe isolation valve on a feed main (entering horizontally from the upper right) leading to a vertical standpipe riser (on the left). The valve is located within the stair enclosure to protect both the valve and the firefighters who may need to access it.*

Designers and code officials should ensure that each riser isolation valve controls one entire standpipe riser. Isolation valves in the feed main piping that can shut off more than one downstream standpipe riser would not permit the isolation of one riser at a time. Conversely, each standpipe should be provided with one single isolation valve rather than multiple valves for different sections.

Where possible, the isolation valves for standpipe risers in fire-rated stairs should be within the stair enclosure for protection as discussed in the Control Valves section of Chapter 8 (figure 9.19). They should also be located on a level as close as possible to the fire service entry level. This may take a bit more piping if the feed main is located on a different level. However, it can facilitate rapid access to the isolation valve.

Regardless of their location, it is important for isolation valves to remain open. Codes often require them to be supervised electrically by the fire alarm system (see Chapter 11) or another method. Electronic supervision can help ensure that valves are returned to the open position after repair or maintenance.

Questions to Ask – Standpipe Systems

- What equipment (hose length, size, and nozzles) does the fire service use for standpipe operations?
- Is the minimum pressure at FHCs coordinated with this equipment?
- Is the maximum pressure not exceeded at any FHC?
- Has the design minimized the need for PRDs?
- Are PRDs properly designed and installed on the correct levels?
- Will PRDs need to be field adjustable? Where must adjustment tools and instructions be stored?
- Are dry standpipe systems designed to mitigate long fill times?
- Do FHC threads match the fire service hose?
- Are FHCs positioned to allow hose connection and valve handle operation with a gloved hand?
- Must stair FHCs be on main landings or intermediate landings?
- Are remote FHCs outside stairs accessible and marked?
- Are garage FHCs accessible and protected from vehicle traffic?
- Will exterior FHCs be necessary for spaces without interior access?
- Can FHCs be located to allow fire attack without compromising the stair enclosure?
- Are standpipe isolation valves located for rapid access and protection of firefighters?
- Does each standpipe isolation valve feed only one entire standpipe?
- Have emergency responders been trained on system features and operations?

Resources

- IFC
- NFPA 1
- NFPA 13E, *Recommended Practice for Fire Department Operations in Properties Protected by Sprinkler and Standpipe Systems*
- NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*
- NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*
- NFPA 170, *Standard for Fire Safety and Emergency Symbols*
- FM Global Data Sheet 3-11, *Pressure Reducing Valves for Fire Protection Service*
- FM Global Data Sheet 3-11, *Standpipe and Hose Systems*
- OSHA Standard *Standpipe and hose systems*, 29 CFR 1910.158

CHAPTER 10
FIRE DEPARTMENT CONNECTIONS

A fire department connection (FDC) enables the fire service to connect hose lines from one or more pumpers and feed water into a system to augment its automatic water supply. Systems include sprinkler systems (see Chapter 8), standpipe systems (see Chapter 9), or other water-based suppression systems. Each FDC has one or more fire hose inlets (figure 10.1). In manual dry standpipe systems, FDCs are the only water supply.

Photo: M. Chibbaro

Figure 10.1. *Charged hose lines connected to a wall-mounted FDC with two inlets.*

The requirement to provide an FDC typically appears in the installation standard for the corresponding type of system. This chapter provides guidance on FDC quantity, number and type of inlets, location, position, marking, and signage. This guidance, together with the requirements and preferences of code officials and emergency responders, will facilitate rapid augmentation of the water supply to standpipe systems and other water-based systems.

In some cases, FDCs are not required because they would be of little or no value. Examples include very small buildings, remote buildings that are inaccessible to the fire service, and large open-sprinkler deluge systems that exceed the pumping capability of the fire service.

Impairment programs and maintenance are covered in Chapter 13.

Quantity

Often a single FDC such as the one in figure 10.1 will suffice. In some cases, multiple interconnected FDCs will be provided for redundancy. For example, high-rise fire experience has shown that broken glass and debris falling from a fire area can damage hose lines. Two FDCs are therefore typically provided for each zone in high-rise buildings; this will increase the dependability of the water supply as long they are located remotely from each other. Each FDC should also be sized to independently handle the full system demand.

Another reason for multiple FDCs would be for a system with a large demand. Multiple FDCs can supply a large flow of water to a single system. Examples of buildings or uses that may have large-flow-demand systems include aircraft hangers and warehouses with high-piled storage, high-rack storage, or highly flammable materials. A single FDC with additional inlets can handle a large flow but would not provide the redundancy of multiple FDCs in different locations.

Multiple FDCs can also supply separate systems within a single building. A separate FDC could feed each separate sprinkler system. In other cases, sprinkler and standpipe systems can have separate FDCs (figure 10.2). The separate FDC arrangement precludes the possibility of two or more FDCs being out of service due to a single pipe break, leak, or other problem. However, hose lines must be fed into each separate connection that needs its supply augmented.

Photo: M. Chibbaro

Figure 10.2. *Separate sprinkler and standpipe FDCs. To feed both systems, at least one hose line must be connected to at least one inlet on each of the two FDCs.*

Conversely, combined FDCs allow all interconnected systems to be fed from any FDC (figure 10.3). As complexes get larger with a multitude of systems, interconnecting FDCs greatly simplifies fire service support of such systems. The disadvantage is that a single-point failure of the interconnecting piping will preclude augmentation of any system. For these reasons, preferences for FDC interconnection will vary by jurisdiction.

Photo: M. Chibbaro

Figure 10.3. *A combined sprinkler and standpipe FDC.*

Manual dry standpipe systems (with no permanent water supply) cannot be interconnected with automatic sprinkler systems. As discussed in the System Design section of Chapter 9, individual manual dry standpipe systems may intentionally be left separate in order to keep their volume down and minimize fill time. Signage helps direct firefighters to the appropriate FDC (figure 10.4), along with proper pre-incident planning.

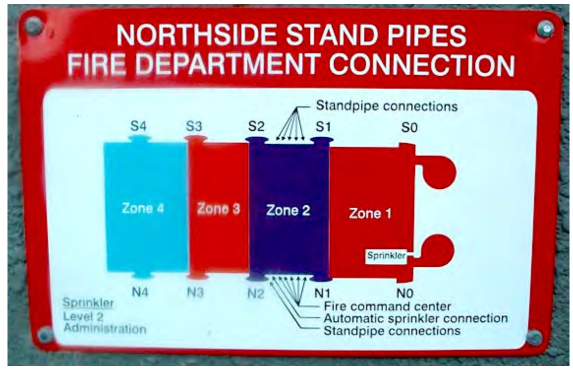

Photo: D. Banwarth

Figure 10.4. *A sign indicating the areas covered by separate manual dry standpipe systems. The colors and zone numbers correspond to zones with separate FDCs.*

Inlets

To permit the connection of hose lines, the inlet size and type must match the hose couplings used by the fire service. The type can be either threaded or quick-connect. Quick-connect hose inlets are usually 4 or 5 inches in size (figure 10.5) and one inlet usually suffices even for large flows.

Photo: M. Chibbaro

Figure 10.5. *A quick-connect type of FDC.*

In jurisdictions where the fire service uses threaded hose couplings, FDCs usually include one or more 2½-inch hose inlets. The thread type must match the hose used — usually NH Type (American National Fire Hose Connection Screw Thread). To facilitate the connection of the externally threaded (male) end of fire hose lines, threaded inlets should be the swiveling, internally threaded (female) type.

Many FDCs for threaded hose have two inlet connections (see figure 10.3 above); these are often referred to as siamese connections. A rule of thumb is to provide one inlet for each 250 gallons per minute (gpm) of system demand, rounded up to the next highest increment of 250 gpm. For example, if the system demand is 700 gpm, the designer would specify three inlets. Likewise, a system with a demand of 800 gpm would need four inlets.

When four inlets or more are needed, designers should consider placing multiple interconnected FDCs on different portions of the building. The latter scenario would provide the redundancy advantage discussed above, as well as facilitate separate pumpers feeding each FDC from different water supply points.

In areas where responding apparatus carry hose with different couplings, FDCs may be provided with both threaded and quick-connect couplings. This can be beneficial in areas with different fire service organizations providing mutual aid to each other.

Threaded hose inlets should have plugs (see figure 10.2 above) or caps (see figure 10.3 above) to help prevent damage, tampering, and infestation by animals and insects. However, plugs or caps are easy to remove and are often missing. Debris in an FDC can restrict the flow through it, cause delays while the debris is removed, or even clog the nozzle on a hose line being operated from a standpipe during a fire attack.

Lockable inlet plugs are available for increased security (figure 10.6). In some cases they will be required by code officials or emergency responders; if not, designers should find out if they are acceptable prior to specifying them. Master keys to the locks are often located in key boxes as discussed in Chapter 6. Building owners may be responsible for providing keys to the fire service.

Photo: M. Chibbaro

Figure 10.6*. An FDC with locked plugs. The key is in the key box below the inlets.*

In some areas, theft of brass inlets and entire connections is a problem. Designers of new systems and owners of existing systems should consult code officials to determine if additional security measures are appropriate and which measures to utilize.

Location

In general, FDCs should be easily accessible to fire service pumpers and located near an adequate water supply. This will facilitate rapid backup water supply to the systems. In some jurisdictions, emergency responders are specifically responsible to approve FDC locations. Here the communication with response personnel is not only desirable — it is required.

A commonly-specified location for FDCs is the street side of buildings. The intent is to make them immediately accessible to approaching fire service pumpers. The street side is obvious in urban settings where buildings front directly onto the streets. However, for buildings set back from the street, the street side may be subject to some interpretation. In these cases, the designer should consult code officials and emergency responders about apparatus approach direction and operational procedures.

Figure 10.7*. A fire hydrant in close proximity to an FDC (near the building entrance in the background). This allows the pumper to use its large-diameter intake hose to connect to the hydrant (foreground) and a pre-connected hose line to be stretched to the FDC (center of photo). Water will be supplied from the hydrant through the intake hose, through the pumper to boost pressure, and then through the hose line into the FDC.*

An important consideration is the location of FDCs in relation to nearby fire hydrants or other water supply sources, (such as ponds, lakes, or cisterns). Some jurisdictions require FDCs to be within a certain distance of the fire hydrant or other supply point. This allows a pumper to hook up directly to a hydrant with its intake hose and then use a short hose line (perhaps pre-connected) to quickly feed the FDC (figure 10.7). For example, if pumpers in a jurisdiction each carry a 150 ft.-long pre-connected hose line that can be used to supply FDCs, a maximum distance of 100 feet will enable firefighters to manually stretch this hose to the FDC regardless of the position of the pumper at the hydrant. If there are multiple FDCs, each should meet this distance requirement from separate hydrants to allow for redundant augmentation of system supply.

Some jurisdictions may prefer that FDCs be located near building entrances. This may depend upon their standard procedure and the number of responding engine companies.

Free-standing FDCs are available for situations where they are located away from buildings (figure 10.8). This option is helpful to get FDCs close to fire hydrants and other water supply sources. It also can help facilitate fire service apparatus positioning in several ways. One example would be to enable pumpers to leave the portions of fire lanes closest to buildings available for aerial apparatus. In advanced incidents, pumpers can remain at FDCs located outside of collapse zones.

Figure 10.8*. A free-standing FDC in a parking lot island near a fire hydrant.*

Free-standing FDCs have one drawback for buildings that have no below-grade levels in areas subject to freezing temperatures. The FDC feed pipe must be carefully designed for drainage into a pit with adequate capacity and acceptable maintenance access. In areas with extremely cold weather, this may not be an option acceptable to code officials.

Designers and code officials should consider site conditions leading to the FDC to make it easier for firefighters to stretch hose lines to it. Several steps, grassy areas, or low ground cover will not slow down this process. However, if a firefighter needs to negotiate walls, climb a ladder, maneuver around a fence or hedgerow, or remove an obstruction, the operation may be delayed. Designers should consider the growth potential of nearby landscaping so that the FDC remains accessible.

Fixed obstructions are easy to avoid with proper design coordination. These include walls, vegetation, planters, fences, pipes, poles, downspouts, and built-in or heavy furniture. FDCs can even be obstructions to each other if located too close to allow connection of hose lines without kinking.

Transient or temporary obstructions are trickier but can often be foreseen. Locations that are likely to be blocked should be avoided. For example, loading docks are subject to temporary storage and vehicular traffic (figure 10.9). Another poor location would be in front of a supermarket or store where stock or carts may block the FDC at any time. This may be a good reason to deviate from the street front location, or to locate the FDC in a column abutting the road. Designers and code officials should always keep in mind how buildings will be used when people, vehicles, and objects are introduced after occupancy.

Figure 10.9. *A loading dock with merchandise.*

Locate FDCs away from likely sources of fire that may make it difficult or impossible for a firefighter to stretch a hose line to it. These include fuel tanks, gas meters, and other hazardous materials and processes (figure 10.10). It is also good practice to locate FDCs away from windows, doors, or vents from which fire, heat, or smoke could be emitting. In areas subject to heavy snowfalls, FDCs should be positioned so that they are not subject to being buried under plowed snow.

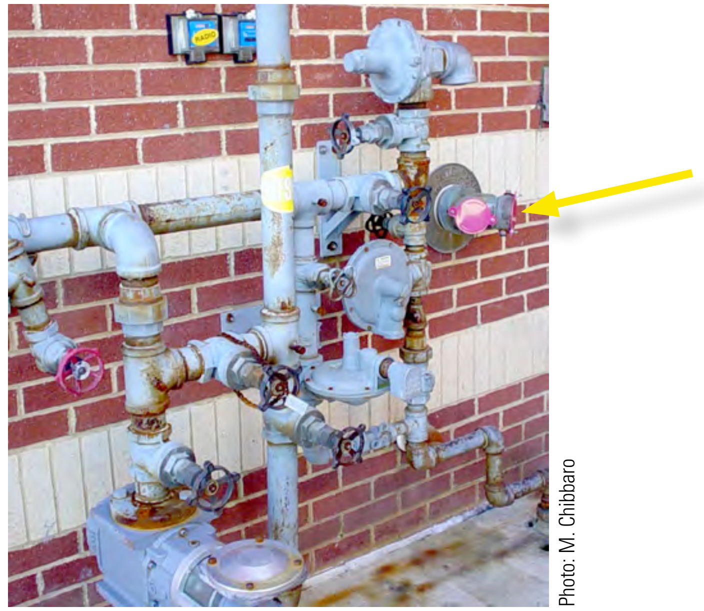

Figure 10.10. *An FDC (see arrow) located adjacent to gas service piping and a meter. The breakaway caps make it necessary for a firefighter to swing an axe or other tool to remove them. This is an accident waiting to happen that could be avoided through careful design coordination.*

Position

The height at which FDCs are mounted is important to enable a firefighter to easily connect hose lines. A good height range is approximately thigh to waist level for an adult. At this range, a firefighter can cradle the hose in one hand while turning the FDC inlet fitting with the other hand (figure 10.11). Sufficient clear area around the FDC will enable a firefighter to complete this operation efficiently.

Figure 10.11. *A firefighter connecting a hose line to an FDC inlet.*

If FDCs are located in landscaped areas, position the FDC based on the final grade. If the grade is built up in one area with a mound of soil or mulch to achieve the correct height, this can be inadvertently changed later by a landscaper. Or, if a platform is built to achieve the correct height, a fall hazard is created for firefighters who may be working in the dark and/or in smoky conditions (figure 10.12). These should not be considered as equivalent to positioning the FDC at a proper height above grade level.

Photo: M. Chibbaro

Figure 10.12. *A platform built up to reach an FDC. This creates an unnecessary fall hazard.*

Consider the locations of entrances and exits when locating FDCs. A charged hose line is very rigid and will block an outward-swinging door or pose a trip hazard. Avoid locating FDCs with their inlets pointed in the direction of doors, so that firefighter access and occupant egress is not impeded.

FDCs subject to vehicle damage should be protected by barricades such as the bollards often used near fire hydrants (see the Fire Hydrant Placement section of Chapter 4). Alternatives to protect wall-mounted FDCs include recessing them (figure 10.13) or providing a guard.

Photo: M. Chibbaro

Figure 10.13. *An FDC recessed into a wall. Note the notch on left prevents hose lines from kinking.*

Marking and Signage

Marking and signage for FDCs serve several purposes. These include helping firefighters to find the FDC and providing information about the system it feeds (type, coverage, and design). Pre-incident plans should also indicate the location of all FDCs.

Prominent marking will allow arriving firefighters to quickly locate FDCs. One example of signage can be found in NFPA 170, *Standard for Fire Safety and Emergency Symbols* (figure 10.14). Prominent signs can help greatly where the FDC is on a building set back from the street.

Photo: M. Chibbaro

Figure 10.14. *An FDC sign with the NFPA 170 symbols for both sprinkler and standpipe systems.*

Some jurisdictions require a light at FDCs to help firefighters identify their locations. These are particularly beneficial in the dark. Other jurisdictions, especially those prone to foggy conditions, require a strobe near the FDC that flashes upon sprinkler activation.

FDCs themselves should indicate whether the connection feeds sprinklers, standpipes, or both. The system type is usually cast with raised lettering into the plate surrounding the inlets. Color-coding is employed in some jurisdictions to differentiate system type.

Pumper operators are normally trained to supply a certain amount of water pressure to the FDC to augment the system. For example, standard procedure could be to pump sprinkler systems at 125 psi, and standpipe systems at 150 psi. This is adjusted as necessary for other floor levels or to account for different hose line configurations on standpipe systems. System demand signs can eliminate some of this estimating for pump operators and signs for special systems can also indicate tactical considerations (figure 10.15). Any additional wording to assist pumper operators can help supplement the basic standard procedures with the specific needs of each building.

Photo: G. Jakubowski

Figure 10.15. *A foam-water sprinkler system FDC sign with a cautionary statement regarding the use of water.*

Additional FDC signage is warranted for underground buildings such as transit system facilities. This is because the visual cues that a pump operator typically has on aboveground buildings (such as size or height), are absent. Also, smoke or fire venting provides no indication about the subsurface level where the fire is located. In these cases, a sign indicating the maximum depth and longest horizontal run of pipe gives a pump operator an idea of the pressure needed to reach the most remote areas of the system.

In some circumstances, an FDC will feed a system covering only a portion of a building. Signage at the FDC indicating such partial protection alerts responding firefighters to this, so they may factor it into their risk analysis (figure 10.16). Signage should provide enough detail so that firefighters connecting the hose lines can identify the proper connection and extent of coverage.

Photo: M. Chibbaro

Figure 10.16. *An FDC sign showing partial system coverage.*

Signage is also warranted for systems that are not interconnected — to clearly indicate which FDC feeds which system(s). This can occur for the reasons discussed in this chapter's Quantity section above or where high-rise buildings are tall enough to need separate vertical zones. The latter should indicate the specific floors covered rather than simply indicating "high" or "low" zones.

Signage assists firefighters when it is unclear which FDC corresponds to which building. This can occur when free-standing FDCs are located far from the buildings they feed. Signage also helps when FDCs feed a building with several addresses.

Questions to Ask – Fire Department Connections

- How many FDCs should be provided?
- Should multiple FDCs be interconnected?
- Should multiple FDCs be located remotely from one another?
- What type of inlet connection and thread type will match the fire service hose?
- How many inlets are needed for each FDC, based on the system demand?
- Are inlet caps or plugs provided? Must they be lockable?
- Where should FDCs be located for quick access by the fire service?
- How close must FDCs be to a fire hydrant or other water supply?
- Have fixed, temporary, and transient obstructions been considered?
- Are FDCs located away from wall openings or hazardous materials/processes?
- At what height above finished grade should FDCs be mounted?
- Will charged hose lines feeding FDCs not block exits or entrances?
- Are FDCs positioned or protected to avoid vehicle damage?
- Are FDC locations clearly marked with signs and/or lights?
- Does each FDC clearly show the type of system it feeds?
- Will signage be needed for design details? Partial coverage? Underground facilities? To indicate building(s) covered?

Resources

- IFC
- NFPA 1
- NFPA 13, *Standard for the Installation of Sprinkler Systems*
- NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*
- NFPA 13E, *Recommended Practice for Fire Department Operations in Properties Protected by Sprinkler and Standpipe Systems*
- NFPA 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies*
- NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*
- OSHA Standard *Automatic Sprinkler Systems*, 29 CFR 1910.159
- NFPA 170, *Standard for Fire Safety and Emergency Symbols*
- NFPA 1963, *Standard for Fire Hose Connections*

CHAPTER 11
FIRE ALARM AND COMMUNICATION SYSTEMS

Fire alarm systems have traditionally been used in buildings to alert occupants. Modern systems are able to perform this alerting function and much more. Properly designed, approved, and installed fire alarm systems may accomplish one or more of the following:

- Warn or inform building occupants of abnormal or harmful conditions (after which they should take appropriate action — which may be sheltering in place, relocating to a refuge area, or evacuating)
- Summon assistance from appropriate entities (such as the fire service, building fire wardens, staff responders, maintenance personnel, etc.)
- Control auxiliary building fire safety devices and other systems to enhance life safety (related to elevators, air handling units, egress door locks, fire doors, fire dampers, etc.)
- Provide intelligence to responding firefighters regarding the occupants, the fire location, smoke movement, and the status of the installed fire protection systems and devices.

All the above functions are related to fire service operations during emergency incidents. Firefighters can operate more efficiently and safely when occupants are given clear direction, the correct location of the emergency is reported, staff take proper actions, the building and its components react properly, and firefighters are given clear and concise information.

To accomplish its function(s), fire alarm systems monitor alarm-initiating devices such as manual pull stations, automatic detectors, or water flow indicators. Systems can also monitor non-emergency supervisory conditions such as wiring integrity, control valve position, fire pump status, low water level in tanks, and improper air pressure on dry suppression systems. When an input signal is received from an initiating device, the control components (figure 11.1) will trigger pre-determined outputs.

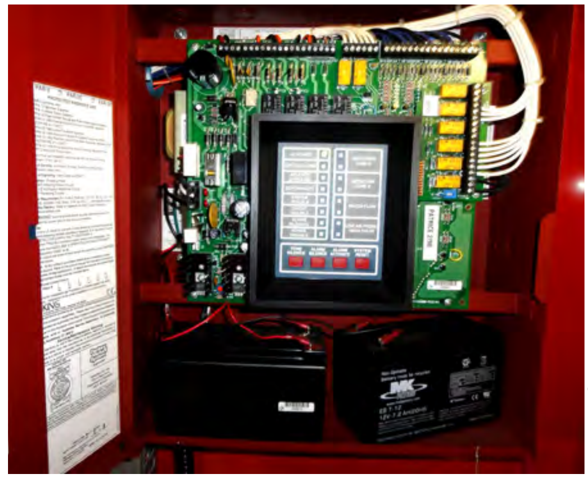
Photo: M. Smith

Figure 11.1. *A basic fire alarm control panel with its door open, showing the wiring and the batteries for backup power. The controls and indicator lights in the center are visible when the panel door is closed and locked.*

Output functions include activating audible and visual occupant notification devices sending a signal to the fire service or other authorities, displaying the location and type of the alarm or supervisory signal, and performing auxiliary building fire safety functions. Examples of auxiliary functions are elevator recall, ventilation system shutdown, smoke control activation, fire door or damper closure, and stair door unlocking. Outputs also include trouble or supervisory signals that typically notify maintenance personnel or others responsible for correcting abnormal conditions.

Before any signals are received, fire alarm systems should be in an operationally-ready mode known as normal status. Upon receipt of a signal, the system condition will change to one of the following status conditions:

- Alarm: An emergency condition that usually results in the activation of occupant notification devices and can also notify the fire service.

- Supervisory: A non-emergency condition that indicates a device or feature is not in an operationally-ready mode.
- Trouble: A non-emergency condition that indicates a device or feature has a fault that may prevent one or more of the system's intended functions.

Systems vary widely in complexity. A basic, fundamental system consists of a control panel, initiating devices, and notification devices that transmit a general alarm throughout a building. On the other end of the spectrum are complex selective or phased voice evacuation systems with integrated fire department communications systems.

Fire alarm technology has evolved, and will likely continue to evolve, at a rapid pace. However, many systems continue to function with older technology. As a result, designers, code officials, and emergency responders have to be familiar with various generations of technology — including systems that are hard-wired, multiplex, addressable, and wireless.

Building codes, fire codes, life safety codes, and owner criteria specify when to provide fire alarm systems. The code is usually a model code adopted by a jurisdiction, sometimes with local amendments. The trigger to require a fire alarm system is usually building size, occupancy type, and/or occupant load. In addition, certain OSHA standards mandate employee alarm systems.

The installation standard for fire alarm systems is NFPA 72, *National Fire Alarm Code*. This code, along with the fire alarm wiring portion of NFPA 70, the *National Electrical Code*, contains comprehensive requirements for design, installation, and maintenance of fire alarm and detection systems. OSHA's Employee Alarm System standard and Fire Detection Systems standard address several specific aspects of these systems. The *Americans with Disabilities Act* (1990, amended 2009) prompted changes to fire alarm systems such as the addition of visual notification devices for the visually-impaired and lower mounting height of manual stations for the mobility-impaired.

This chapter covers fire service interaction with fire alarm systems and provides guidance to facilitate firefighters' operational efficiency. It is critical for fire alarm designers to confer with sprinkler and standpipe system designers; these systems are covered in Chapters 8 and 9, respectively. Elevator and smoke control systems, which are often interfaced with fire alarm systems, are addressed in Chapters 6 and 12, respectively. For systems to be effective they should be regularly inspected, tested, and maintained; impairment programs and maintenance are covered in Chapter 13.

Zoning and Annunciation

An annunciator panel — also called a zoning indicator panel — displays information about the location and type of alarm. This assists firefighters with their initial response and may help them track the spread of smoke or heat. The annunciated information can be displayed on the alarm system control panel for basic systems; otherwise a separate annunciator panel is provided (figure 11.2).

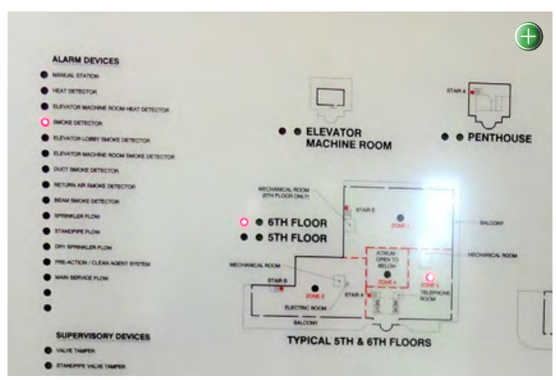

Photo: M. Smith

Figure 11.2. *A close-up photo of a portion of an annunciator panel. The red lights indicate a smoke detector is in alarm mode in zone 3 on the 6th floor.*

A building may have multiple annunciators to serve multiple entrances. Or, there may be different annunciators for different users —

such as the fire service, the security force, and building management. This manual focuses on annunciator features applicable to fire service use. Designers and code officials should always consult fire service response personnel on the design and location of these panels.

The location of an annunciator is critical to enable emergency responders to quickly determine the origin of the alarm and the status of related equipment. Typically, the best location is at the entrance where the fire service plans to initially respond. Keep in mind that this primary fire service entrance may not be the primary occupant or visitor entrance. Consultation with emergency responders is the only way to obtain this important piece of information.

In some large buildings, it may be beneficial to have duplicate annunciators at different locations. In buildings with a fire command center, an annunciator would be located within this room. However, depending on the room's accessibility, an additional annunciator may be appropriate at another entrance.

Each building should have its own annunciator, even if a single fire alarm control system serves multiple buildings. Fire service operations would be delayed if it were necessary for the initially-responding unit to report to a given building to check the annunciator, then relocate (or direct another unit) to investigate origination of the alarm. In large complexes, an additional master annunciator could assist the fire service in locating the building where an alarm originates.

Annunciators display information about signals in different ways:

- Directory — lamps or LEDs that are labeled with a description (figure 11.2)
- Textual (also called liquid crystal display (LCD) or alphanumeric) — static or running display that describes the signal (figure 11.3)
- Graphic — diagram showing floor layout(s), alarm information, and building information
- Computer workstation — with graphic floor plan software package

Photo: M. Smith

Figure 11.3 *A textual-style annunciator panel with a touch-screen display.*

Directory and textual annunciators are often supplemented with graphic diagrams. These diagrams and graphic annunciators are discussed in the following section. In simple systems where the control panel serves as the annunciator, its location and features should meet all annunciator requirements.

In buildings without a fire command center, the annunciator panel may store schematic building plans (see the Fire Command Centers section of this chapter and the Interior Access section of Chapter 6) to make them easily accessible to firefighters. Advance planning would ensure that the size of the panel accommodates this. A note outside the panel can indicate that it contains building plans or diagrams.

All annunciators show at least the type of alarm initiating device and the floor level where the alarm signal originated. Floor level designations must be consistent with stairs, elevators, and building directories to avoid confusion.

The larger a floor is, the longer time it will take firefighters to search for the alarm origination. Extended search times may translate into delayed fire suppression and longer times that the affected building will be evacuated or non-functional. Accordingly, large floors are typically split into two or more zones. These zones are normally limited to a maximum area as well as a maximum linear dimension.

Zone descriptors, whether they are labels next to lights or textual displays, should provide pertinent information to fire service personnel. Descriptors should be intuitive and rapidly decipherable to anyone unfamiliar with the building. For example, "pull station, dining exit" may be less intuitive than "pull station, northwest exit", depending on the level of detail on the graphic diagram (see following section). Coded descriptors, such as WE-776, are meaningless to emergency responders. As the building, layout, tenants, or room names change, descriptors must be updated.

Flow switches or pressure switches indicate water flow. To direct firefighters to the appropriate area, it is important that the flow zone descriptor show the area covered by the sprinkler system because that is where firefighters will find the flowing sprinkler(s). The location of the switch itself is not important during an emergency incident.

Alarm devices indicate a situation requiring emergency action and normally activate evacuation signals. Examples include:

- Manual pull stations (also called pull stations or pull boxes)
- Sprinkler flow detectors
- Smoke detector (spot type or air-sampling type)
- Heat detectors
- Flame detectors
- Optical detectors
- Carbon monoxide detectors
- Dry chemical extinguishing systems
- Wet chemical extinguishing systems (typically protecting cooking equipment)
- Clean agent systems
- Carbon dioxide or other gaseous systems
    - Note: where zone sprinkler flow devices are provided to activate an alarm signal, any main or standpipe water flow indicators may be arranged to sound a supervisory signal, since they are effectively only monitoring the main feed or standpipe piping for breakage.

Smoke and heat detectors should be further identified on the annunciator by mounting location:

- Open area (ceiling)
- Underfloor
- Duct
- Air plenum
- Elevator lobby
- Elevator machine room or machinery space
- Elevator hoistway
- Stair shaft

Supervisory devices indicate abnormal conditions. They signal a need for non-emergency action, such as maintenance or repair, and they should not cause an evacuation alarm or notify the fire service. Examples include:

- Valve tamper switch (closed or partially closed water supply control valve)
- Dry sprinkler high or low air pressure switch
- Pre-action sprinkler low air pressure switch
- Water tank low temperature or low water level indicator
- Valve room low air temperature indicator

Some devices control certain building features, such as elevators, fans, doors, or dampers. They may be shown as alarm or supervisory, depending on the preference of the code official or emergency responders. Examples include:

- Duct smoke detectors
- Air plenum smoke detectors
- Underfloor detectors
- Door closure smoke detectors
- Elevator hoistway smoke or heat detectors
- Elevator machine room or machinery space smoke or heat detectors
- Stair smoke detectors
    - Note: devices subject to frequent unwanted alarms (primarily smoke detectors in air ducts, air plenums, and elevator hoistways) are often arranged to activate a supervisory signal, since their main purpose is mechanical control rather than initiating occupant evacuation.

Status indicators give information about the condition of devices external to the alarm system. Examples include:

- Main system power on
- Main system trouble
- Fire pump running
- Fire pump fault
- Fire pump phase reversal
- Generator run
- Generator fault
- Stair doors unlocked
- Smoke control system in operation
- Elevator floor status

Controls and monitors for ancillary functions are routinely included on alarm panels or annunciators. These include:

- Fire pump start switches and indicators
- Generator start switches and indicators
- Egress or stair door unlocking switches
- Smoke control or smoke ventilation switches

Graphic Displays

Simple annunciators for small buildings will typically show alarm location in terms of floor levels only. If more specific location-related information is indicated, a graphic diagram will enable firefighters to quickly find the source of the alarm. Examples of this type of information are zone boundaries, room names, and room numbers. When an alarm originates from locations with designations such as "Zone 2 East," "Suite 121," or "Main Electric Room", a diagram will help pinpoint those areas or their boundary.

The graphic display may be a separate, printed diagram mounted on the wall adjacent to the annunciator (figure 11.4). The diagram may be integrated with the annunciator, in which case it is called a "graphic annunciator" (figure 11.5). Some jurisdictions may require annunciators to be graphic type in certain situations.

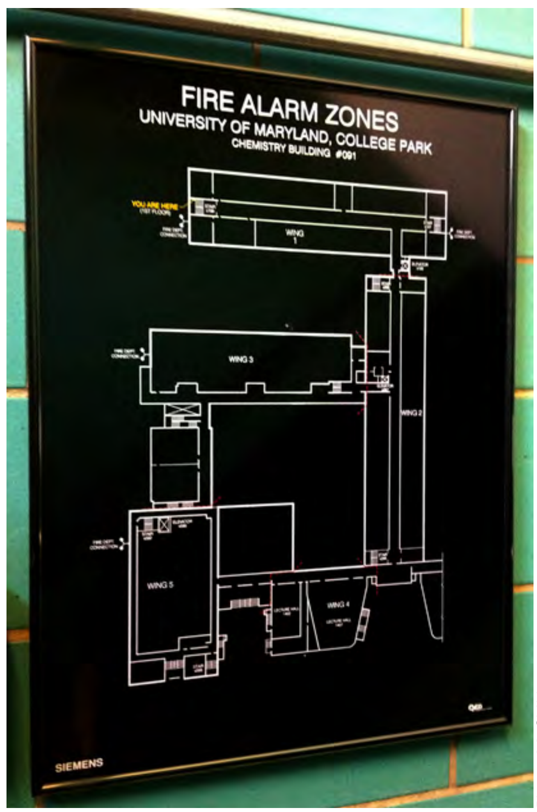

Photo: M. Chibbaro

Figure 11.4. *A graphic diagram in a frame.*

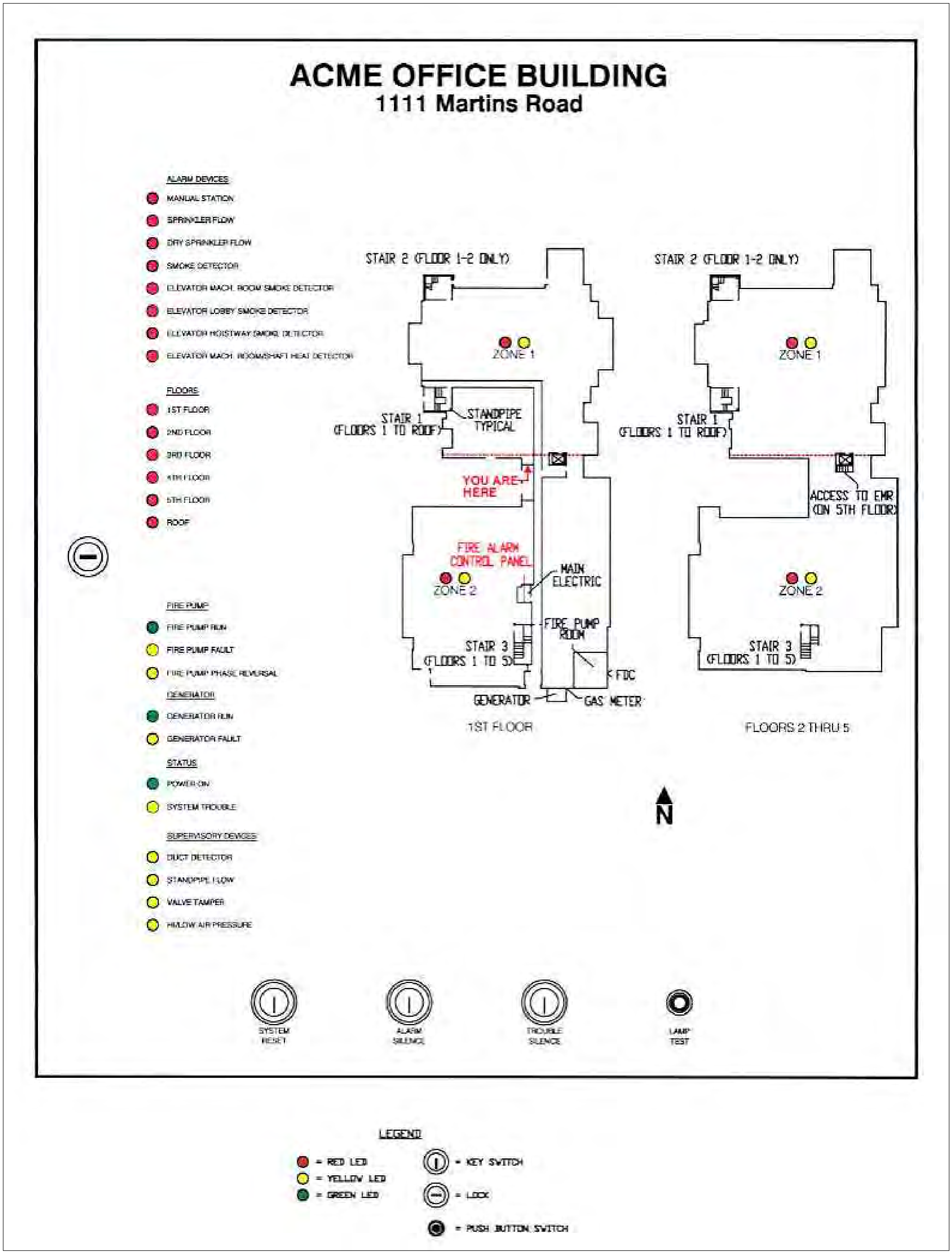

Diagram courtesy of Alarm Tech Solutions, LLC

Figure 11.5. *A diagram of a well-designed graphic annunciator, with clearly organized and labeled lamps, as well as building features to assist the fire service.*

The design of the diagram is very important to enable firefighters to rapidly obtain needed information. Fire services may have regulations or policies outlining their requirements or preferences. Some code officials or emergency responders require annunciators throughout their jurisdiction to have standardized features.

Proper orientation of the floor plans on the diagram will help firefighters to visually process the information it contains. When viewing the annunciator, the farthest point of the building beyond the annunciator's location should be at the top of the diagram. A "You Are Here" indicator on the floor plan shows the viewers where they are in the building.

Within the building's outline, zones are identified by the boundary lines between them. Likewise, for alarms designated by room, suite, or tenant, these specific locations are shown.

Often, sprinkler zones are allowed to be larger than zones for other alarm-initiating devices. This is because a flowing sprinkler is much easier to find than an activated heat or smoke detector. Careful coordination is important in this scenario to avoid confusion. If the sprinkler zone boundaries do not track along the other alarm zone boundaries, separate diagrams would be necessary for each.

In addition to information about floors, zones, and devices, many features of the building could be shown on the diagram. These include fire protection systems, building areas, and site features that the fire service needs to be aware of, including the following:

- Building address
- North direction arrow
- "You Are Here" indicator
- Nearby streets, especially if the building abuts more than one street
- Adjacent buildings
- Private fire apparatus access lanes
- Stairs, their identification, and the floors they serve
- Elevators, their identification, and the floors they serve
- Elevator machine rooms
- Exterior entrances
- Security, management, and maintenance offices
- Standpipe locations
- Standpipe riser isolation valves
- Sprinkler zone control valves
- Main water and sprinkler control valves
- Location of utility controls (electric, gas, fuel)
- Fire alarm control panel
- Standby generator
- Fire pumps
- Fire department connections
- Laundry rooms
- Trash or linen chutes
- Swimming pools

Designers and code officials should remember that modifications to the building or its layout may require changes to the graphic diagram. An annunciator with inaccurate information could be worse than no annunciator at all.

Engraved type graphic annunciators can be expensive to keep updated. Depending on the expected changes in a given building, it may be more appropriate and cost-effective to use an electronic annunciator that is much easier to revise. Technology is available to enable electronic annunciators to transmit their information directly to fire service apparatus via wireless communication.

Fire Service Notification

Building or fire codes may require fire alarm systems to automatically alert the responsible fire department, fire brigade, or other emergency response agency. Often an alarm service or off-site location will receive the alarm signal and then retransmit it to the response agency. Whether required or optional, automatic fire service notification often results in the fastest response and therefore the best opportunity to affect rescues and limit property damage.

Reporting of the proper location is vital for responders. Fire alarm designers and code officials should consult emergency response personnel to determine how automatic alarms are to be reported. Considerations may include pre-incident plans, familiarity with the site, likely response direction, and location of hazardous materials.

It is crucial that the address reported to the fire service match the address where the alarm originated. If a building has multiple addresses, the one with the fire alarm annunciator or fire command center should be reported. If a building includes separate, independent annunciators, coordinate the remote signal with the correct annunciator location.

Larger buildings with multiple entrances for different sections, wings, or tenants can be confusing. If possible, remote fire service notification should include information on the section, wing, or tenant from which the alarm originates. This will help initially responding units to position properly. If the reporting system does not have this capability, another approach could be strobe lights at entrances corresponding to the alarm origination (figure 11.6).

Photo: M. Chibbaro

Figure 11.6. *This building has multiple tenants with different addresses fronting on two streets. Strobes outside each exterior tenant entry door indicate the tenant where an alarm originates.*

Another feature to assist firefighters in multi-tenant buildings is supplemental tenant information signs (figure 11.7). These show a diagram of the overall building, the specific tenant location, a "You Are Here" indicator, and the location of other features such as the exterior entrances, the fire alarm control panel, the annunciator, and the fire department connection.

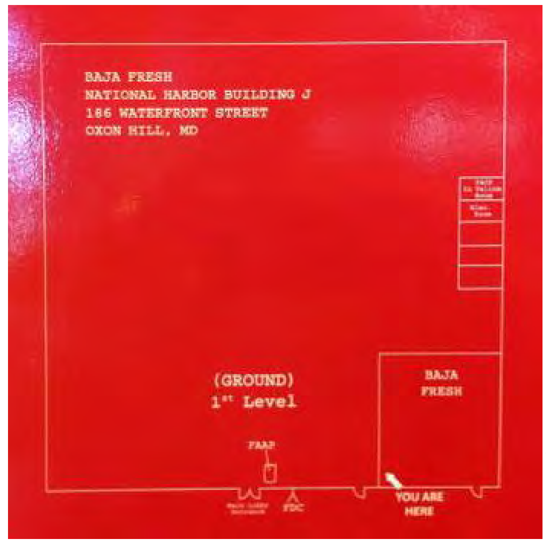

Photo: M. Chibbaro

Figure 11.7. *A supplemental tenant fire alarm information sign.*

Unwanted Alarms

An unwanted alarm is an alarm condition that does not result from a hazardous or emergency condition. These cause the fire service to respond unnecessarily and desensitize occupants to alarm signals. Malicious alarms result from intentional acts. Unintentional (often called "good intent") alarms occur when a person mistakenly believes a hazardous or emergency condition exists. Nuisance alarms are system responses to conditions that are not hazardous or emergency in nature. Unwanted alarms can also result from unknown or unidentified conditions. All efforts designers and code officials make to prevent any type of unwanted alarms will keep fire service responses to a minimum, thereby decreasing hazards to firefighters and keeping them available for actual emergency incidents.

Locating manual pull stations at the high point of the allowable height range will help keep small children away from them. Covers are also available (figure 11.8) that will sound a local alarm when raised to activate the pull station. These should reduce malicious alarms and are often used in schools, stores, and malls.

Photo: M. Chibbaro

Figure 11.8. *A manual pull station cover.*

Improperly located smoke detectors and smoke alarms will be subject to nuisance alarms. Locations likely to cause problems include those close to kitchens, air diffusers, and fans, as well as within elevator hoistways. Also, these devices are not designed for exterior use (figure 11.9). In such locations where automatic detection is required, heat detectors are often substituted.

Photo: M. Chibbaro

Figure 11.9. *A smoke detector mounted in an outdoor location (an open parking garage).*

Some smoke detectors have an adjustable sensitivity feature that can help prevent unwanted alarms. Sensitivity should be set very low for areas such as mechanical spaces and low for corridors and elevator lobbies. Sensitivity can be set high in rooms where the climate is highly controlled, especially if they contain high-value contents such as computer rooms.

Security alarm systems that emit smoke to confuse criminals can present a dangerous situation for firefighters. They can prompt false calls to the fire service, followed by the possibility of firefighters encountering criminal activity. Fire codes typically prohibit such systems. Where allowed, careful coordination with emergency responders would be important for their safety.

Many unwanted alarms can be traced to inadequate alarm system maintenance. Some jurisdictions assess fines for multiple responses to unwanted alarms. See Chapter 13 for system maintenance and impairment programs.

Occupant Notification

The main purpose of notifying occupants of a fire or other emergency is to facilitate their appropriate reaction. The notification is often both audible and visual — the latter for occupants with hearing impairments. To successfully mitigate an incident, responding firefighters must coordinate their strategy with the actions of the occupants, provide them clear direction, and update them as the incident progresses.

Firefighters may need quick access to a fire alarm panel — to either activate or silence the occupant notification signals. Rooms or closets containing fire alarm panels should be provided with signage (figure 11.10). Directional signs could also be provided to show the direction to such rooms from the entry point.

Photo: M. Chibbaro

Figure 11.10 *A sign on a door to a room containing fire alarm control panels (FACP).*

Voice type alarm systems can greatly assist in the important communication between responders and occupants, but only if they are arranged to provide clear direction based on the desired egress scenario. Possible scenarios include full evacuation, partial evacuation, sheltering in place, relocation to refuge areas, or a combination of these. Occupant notification and the egress scenarios must also be coordinated with the door locking scheme, especially those doors in stairs.

Voice alarm systems automatically send a voice evacuation message to speakers — often only in selected areas of large or tall buildings. This selective evacuation is typical where general (total) evacuation is impractical, at least initially. Examples of such buildings are high-rises, hospitals, and large assembly occupancies. The voice messages can be pre-recorded or live (by properly-trained building staff).

A typical high-rise selective evacuation scenario would automatically send a pre-recorded message to the floor where the alarm originates and the adjacent floors above and below it. Another high-rise scenario could direct occupants to move to a designated refuge area or to another floor several floors below the incident.

Arriving firefighters can evacuate additional areas in a phased manner by manually activating one, several, or all floors with the manual-select switches in the command center. They can also override the pre-recorded message and broadcast live voice announcements to any or all evacuation zones with a microphone at the command center. Visual indicators typically show which evacuation zones are activated at any given time (figure 11.11).

Photo: M. Smith

Figure 11.11. *A voice alarm system panel with the door open. The microphone for live voice announcements is to the right of the red handset. The manual select switches and indicators for the different evacuation zones are shown. The red telephone handset is for the fire department communication system (see the following section) that is integrated with this panel.*

The arrangement of selective evacuation notification zones depends upon the design of the building, its egress scenario, and its evacuation plan. Each floor level is typically one notification zone when the floors provide a complete fire-rated barrier. Each floor space divided by fire or smoke barriers to enable occupants to take refuge on either side would be provided with multiple notification zones. Boundaries of those zones within a given floor must coincide with those barriers.

Conversely, floors that are physically open to one another should be arranged as a single notification zone. Occupants of these floors can be exposed to the same heat and smoke conditions. Also, the single notification zone avoids the confusion possible when occupants in portions of the space hear an evacuation signal, but cannot clearly decipher it. A common example of this situation is a series of parking garage levels connected by open ramps (figure 11.12). Such interconnected levels are often arranged as a single notification zone for the "floor, floor above, and floor below" selective evacuation scenario.

Figure 11.12. *This high-rise building has three garage levels interconnected by open vehicle ramps. Those three levels have a single occupant notification zone.*

Speakers are often omitted from stairs, exit passageways, and elevator cabs because occupants either spend little time in these areas, are already exiting, or will encounter others exiting. Speakers in such areas can also cause confusion because they may be heard in many other areas, including those where occupants should be remaining in place. A third issue with any alarm notification device in stairs is the negative impact on communication among firefighters using the stair for entry and staging.

However, in some special circumstances, such as very tall buildings where occupants may be in exit stairs or exit passageways for extended time frames, speakers may be provided in such areas. Speakers in each such area should be arranged as a single notification zone with manual-only selection capability for the responders staffing the fire command center.

For similar reasons, atriums and other large open spaces spanning multiple floors are challenging in buildings with selective evacuation. Again, coordination with the building's egress scenario and evacuation plan is important. The entire atrium will likely comprise one occupant notification zone. It may be desirable to activate only the atrium zone upon receipt of an alarm signal from within the atrium, and not from alarm signals in other areas. Designers should consider the audibility and legibility of signals in areas adjacent to the atrium to minimize occupant confusion.

Fire Department Communication Systems

Fire department communication systems are two-way telephone systems typically found in high-rise buildings. The system's control unit has a main handset for use by the fire service commanders (figure 11.13) and is usually located in the fire command center (see the following section). Either handsets or jacks for handsets (figure 11.14) are then placed in areas of the building for firefighters to communicate with the command center.

Figure 11.13. *A fire officer speaking into the main handset at the control panel for a fire department communication system. This panel also houses the portable handsets used by firefighters at remote jacks.*

Figure 11.14. *A firefighter training to use a handset in a remote jack located inside a stair.*

If the system uses jacks, a number of portable handsets with plugs are provided in the command center for distribution to firefighters. If handsets are provided at all remote locations, portable handsets are not necessary.

Designers and code officials should plan for handsets or jacks in locations where firefighters are likely to be operating. Typical locations include each level within exit stairs, elevator cabs, elevator lobbies, elevator machine rooms or machinery spaces, fire pump rooms, emergency or standby power rooms, and areas of refuge.

In some jurisdictions, particularly for new buildings, fire service radio signal enhancement systems (see Chapter 12) may be preferred over, or allowed instead of, fire department communication systems. Firefighters are often much more comfortable using the radios they regularly use rather than a separate system they may not be familiar with or confident using. Where radio signal enhancement systems are not required, code officials may consider an equivalency or modification to allow them to substitute for the fire department communication systems discussed in this section.

Fire Command Centers

High-rise buildings often have a dedicated room or other location containing fire alarm and related fire protection and utility control equipment. Building and fire codes mandate these for newer high-rises. NFPA 72 refers to them as Fire Command Centers; other terms used include Central Control Station, Emergency Command Center, and Fire Control Room. Fire command centers provide a single location for all equipment that incident commanders would need during an emergency incident.

Items in a fire command center vary by the code(s) in effect. Equipment related to the alarm, detection, water flow, annunciation, smoke control, and communication systems are included, as are related functions and controls such as stair unlocking, air handling systems, and emergency or standby power. Other helpful features are an outside phone line, area of refuge emergency communication equipment, video monitoring equipment, elevator emergency communication equipment, elevator status indicators, building information cards (see the Building Information section of Chapter 7), hazardous materials information, emergency contacts, schematic building plans, and a work table to facilitate referencing these materials. Furthermore, code officials or emergency responders may have requirements or preferences regarding how the various panels are arranged within the center (figure 11.15).

Photo: M. Smith

Figure 11.15. *The inside of a fire command center.*

The schematic building plans in the fire command center should not be detailed construction plans; rather, they should be simple firefighter-friendly plans showing features that will help firefighters determine their strategy and tactics. These features include the floor layouts, fire- and smoke-rated walls, egress and access, fire service elevator lobbies, and fire protection equipment. These same plans should also be provided to emergency responders for pre-incident planning.

Fire command centers are usually separated from other building areas by fire-rated construction. Many jurisdictions desire fire command centers to have an exterior entrance (figure 11.16). Others permit the fire command centers to be within entrance lobbies or other approved locations. Some jurisdictions may even require underground tunnel access for protection from falling glass and debris. Regardless of location, they should be prominently marked. The center's walls and doors should have no ordinary glass windows — both for security and for protection from severe weather.

Photo: M. Chibbaro

Figure 11.16. *A fire command center (right) with an outside entrance next to main building entrance (left). Note the proximity of a key box (on a pedestal) and the fire department connection.*

Fire command centers must be locked for security but should not be located where they are difficult for emergency responders to access or could become inaccessible during foreseeable emergencies (figure 11.17). If a key box is provided, it should contain a control room key. It may also be desirable to arrange the fire alarm system to automatically unlock the fire control room door and any intervening doors or gates leading to the fire service access point. These unlocking features must be balanced with security concerns.

Photo: M. Chibbaro

Figure 11.17. *A fire command center (behind the red door) in a parking garage. To access this room, firefighters must make entry through a steel vehicle entry gate; however, it opens automatically upon fire alarm activation. A nearby car fire could render this room inaccessible even though its walls and door are fire-rated.*

If a building has multiple fire command centers, visual indicators outside the rooms should show, at a glance, which center is active at any given time. Each fire command center should also have a visual indicator inside to show that another command center is active.

Another important consideration is the size of the room. Space is needed accommodate a table and to access all the equipment in the room. The table is intended to help incident commanders consult plans for the building and fire protection systems. If the center is used for other purposes (such as security), additional space should be provided beyond that required or needed for the fire protection features.

Questions to Ask – Fire Alarm and Communication Systems

- Is a fire alarm annunciator needed?
- Where must the annunciator be located?
- What information must the alarm annunciator show?
- Are floor level designations coordinated with elevators and stairs?
- Must large floors be split into multiple alarm zones?
- Do sprinkler zones indicate area covered rather than location of flow indicator devices?
- What control features must be included on the annunciator?
- Must devices subject to unwanted alarms be arranged to sound supervisory signals?
- Must a graphic diagram be on or adjacent to the annunciator?
- What features must be shown on the graphic diagram?
- Is the orientation of the graphic diagram coordinated with its location in the building?
- Are separate sprinkler graphic diagrams necessary?
- Does the alarm system remotely report the correct address, location, wing, or tenant?
- Does the remote reporting direct firefighters to the entrance with the alarm annunciator or fire command center?
- Have systems been designed, and devices been located, to minimize unwanted alarms?
- Are voice alarm systems coordinated with the building egress scenario and the door locking scheme?
- Are selective evacuation zone boundaries coordinated with fire or smoke barriers?
- Should areas or floors open to one another have a single selective evacuation zone?
- How should selective evacuation notification devices be handled for elevators, stairs, and open areas such as atriums?
- Can a radio signal enhancement system substitute for a 2-way fire department communication system?
- Where must jacks or handsets be located for a fire department communication system?
- Must the fire command center be in a dedicated room? Must it have an outside entrance? How is it protected from fire and other hazards?
- What fire protection equipment must be in the fire command center?
- What supporting equipment must be in the fire command center?
- Are there preferences for how the various panels must be arranged in the fire command center?
- How large must the fire command center be?
- What visual indicators should be provided for multiple command centers?
- Have emergency responders been trained on system features and operations?

Resources

- IFC
- NFPA 1
- NFPA 70, *National Electrical Code*
- NFPA 72, *National Fire Alarm and Signaling Code*
- NFPA 170, *Standard for Fire Safety and Emergency Symbols*
- FM Global Data Sheet 5-40, *Fire Alarm Systems*
- OSHA Standard *Fire detection systems*, 29 CFR 1910.164
- OSHA Standard *Employee alarm systems*, 29 CFR 1910.165

CHAPTER 12
OTHER SYSTEMS

This chapter addresses several protection systems not covered in previous chapters. Chapter 13 covers impairment programs and the maintenance of all systems discussed in this chapter. Emergency responders would also benefit from system installers providing them training on the operation of protection systems with which they will interact. This is discussed in more detail in Chapter 13.

Firefighter Radio Signal Enhancement Systems

Communication is vital during an emergency incident. Mobile radios (those mounted in vehicles) and portable radios (hand-held — figure 12.1) are used by firefighters and fire officers to transmit and receive important information such as the location of occupants or fire advancement reports. In some cases, emergency transmissions can be crucial to firefighter safety — for example, evacuation orders or mayday calls.

***Figure 12.1.** A fire officer transmitting on a portable radio from an exterior balcony.*

Radio signals are frequently unreliable inside buildings and other structures such as tunnels. Construction materials, earth, and changes in the radio frequency environment can greatly reduce the strength of radio signals. Window coverings, reflective film, photovoltaic coverings, and insulation systems can affect radio signal strength.

A firefighter who is inside and unable to transmit must relocate closer to an exterior opening (figure 12.1), move to a different floor, use an alternate means of communication, resort to runners, or relocate to enable direct voice communication. Numerous NIOSH firefighter fatality investigation reports cite inadequate communication as a factor in the outcome.[14]

For many years the fire service has struggled with radio communication problems in the built environment. The communication problems encountered by the Fire Department of New York at the World Trade Center on September 11, 2001 are well documented by NIST.[15] The NIST report brought to the forefront several communication issues at this large scale incident. For example, after the collapse of the South Tower, many firefighters in the North Tower were unable to receive evacuation messages.

Unfortunately, alternate means of communication cannot always be relied upon. Cell phone signals are affected by the same factors as radio signals. Land line phones can allow firefighters to communicate with dispatchers, but not with other units. In addition, land line phone systems may be affected by the incident occurring in the building.

The Fire Department Communication Systems described in Chapter 11 are intended to provide a means of communication within buildings where radio transmissions are difficult. However, they are limited by the locations of phone jacks or handsets. Messages must often be relayed between the communication systems and fire service radios. Also, the maintenance of these systems is not under the control of emergency responders.

14. NIOSH Firefighter Fatality Investigation program, http://www.cdc.gov/niosh/fire
15. NIST World Trade Center Disaster Study, http://www.nist.gov/el/disasterstudies/wtc

All of these factors may delay operations, create greater challenges for firefighters, and even place firefighters in danger. Communication technology is available to improve signal transmission within buildings and allow emergency responders to use their ordinary portable radios rather than alternative communication means. Compliance could involve an installed communications infrastructure (figure 12.2).

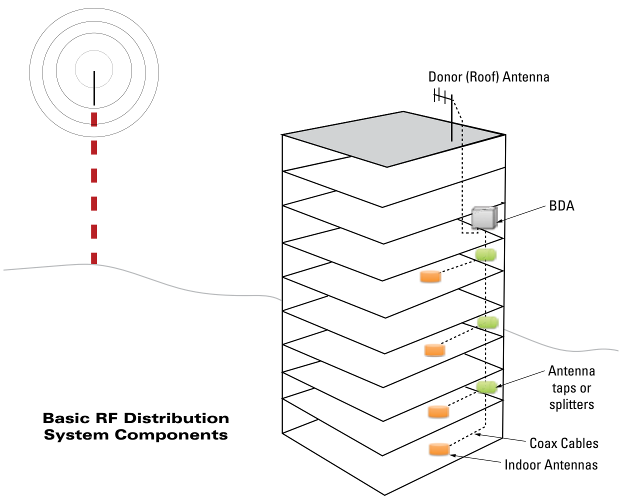

Figure 12.2. *A schematic showing communication infrastructure within a building.*

Passive communication infrastructure functions as a conduit that assists in the transmission of signals. For example, a passive antenna system includes both an internal and an external antenna, connected with a coaxial cable. A radiating cable, also known as leaky coax, is a network of coaxial cables with slots in the outer conductor that create a continuous antenna effect.

Active communication infrastructure involves powered signal boosters to amplify and retransmit signals. One type of signal booster is known as a bi-directional amplifier, or simply BDA. These devices amplify signals passing through the passive infrastructure. Active infrastructure can be particularly beneficial in larger, diverse areas that need a radio coverage solution.

Some fire service organizations use mobile signal boosters or repeaters. These are carried by fire service units to an incident scene. Some emergency responders and code officials prefer mobile boosters rather than the fixed signal boosters installed within buildings.

Fire codes may specify required levels of radio coverage for emergency responders — in some cases even for existing buildings. Local laws in several U.S. cities contain specific requirements for passive and/or active communication infrastructure. Any building or structure, except very small ones, can be candidates for this. High-rise buildings, large floors, and underground levels can particularly benefit from this technology. Codes or code officials may allow proof of adequate radio coverage to substitute for Fire Department Communication Systems as discussed in Chapter 11.

Proper system performance must be specified to help ensure proper effectiveness. Considerations include signal strength, area coverage, reliability, secondary power supply, and interference filters. Acceptance testing (upon completion) and periodic testing (ongoing) are important for reliability.

Firefighter Air Replenishment Systems

Firefighters use self-contained breathing apparatus (SCBA) for interior firefighting and other dangerous environments. SCBA air is contained in pressurized cylinders that have a limited capacity. When depleted, these air cylinders need to be refilled or replaced with full ones (figure 12.3). Some fire service organizations have specialized vehicles that contain air compressors or air refill systems known as cascade systems that refill breathing air cylinders at fire scenes.

Photo: David Purcell, Post Road Photos

Figure 12.3. *An SCBA cylinder being replaced at a fire scene.*

Traditionally, breathing air cylinder replacement in a tall building consists of a shuttle system. Firefighters carry full air cylinders to a staging area, where they are swapped for empty ones. Other firefighters must transport empty cylinders back to a replenishment location outside. Every firefighter performing such operations is unavailable for firefighting, rescue, and other activities.

An example of the logistical challenge is the 1988 First Interstate Bank Building high-rise fire (figure 12.4), during which 600 air cylinders were used in the hours-long firefighting operation.[16] During the 1991 One Meridian Plaza high-rise fire, 100 firefighters were needed to perform support operations such as air cylinder replenishment. Three firefighters died when they ran out of air several floors above the fire. Eight additional firefighters from a search team also ran out of air but were rescued by helicopter from the roof.[17]

Photo: USFA

Figure 12.4. *An SCBA staging area during the First Interstate Bank Building fire.*

16. Fire Engineering, "The Case for Interior High-Rise Breathing Air Systems."
17. Ibid.

A firefighter air replenishment system (FARS) is a system of piping within a tall building or a large structure that enables firefighters to refill their breathing apparatus cylinders at remote interior locations. These systems are essentially air standpipe systems that substitute for the cylinder shuttle operation described above. This makes emergency operations more efficient by reducing the time and personnel needed for logistical support. Several jurisdictions require FARS for high-rise buildings or long underground tunnels. Proper function depends upon careful design, installation, and maintenance.

A FARS consists of a piping distribution system that runs from a supply point to interior fill stations or fill panels. Fill panels contain short sections of hose with connections that fit firefighter's air cylinders (figure 12.5). Fill stations are larger rooms or closets in which cylinders are replenished. Both fill panels and stations have the necessary valves, gauges, regulators, and locks to prevent tampering. The mounting height of air hoses should facilitate easy connection of cylinders.

Photo: S. Stookey

Figure 12.5. *A breathing air fill panel with its door open showing air hoses.*

Typical locations for fill panels or stations are in or near stairs on every second or third floor. Emergency responders or code officials may prefer they be located just outside enclosed, fire-rated stairs. This enables firefighters to set up a replenishment operation in safe proximity below the fire but away from the traffic within the stairs (whether firefighters or occupants). Signage within the stair enclosure can indicate the location of fill panels or stations — for example, "Breathing Air Fill Panel, Through Door and 10 Feet to the Right". Some code officials and emergency responders may prefer that fill stations be located inside stair enclosures. This necessitates careful consideration and coordination with the emergency response procedures. Additional space may need to be allocated within stairs for refilling operations to prevent impediments to occupant egress and firefighter entry (figure 12.6).

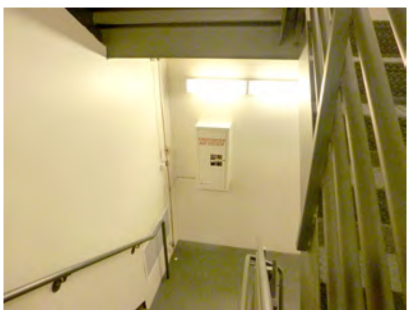
Photo: S. Stookey

Figure 12.6. *A breathing air fill panel and piping in a stair. Conducting replenishment operations within a stair may cause a traffic bottleneck.*

For tunnels, designers should locate fill points a reasonable spacing apart; for example, one at each standpipe outlet or at each exit.

Two supply options are available for FARS. Where the fire service has one or more mobile air supply units, an exterior fire department connection panel (FDCP) can be provided (figure 12.7). The other option is a fixed air storage system within the building. For large buildings such as high-rises, multiple FDCPs may be provided. Some responders or code officials may desire or require both a fixed air supply and an FDCP.


Photo: S. Stookey

Figure 12.7. *An exterior FDCP being supplied by a fire service mobile air unit.*

All FDCPs should be in locked, weather-resistant enclosures marked to indicate their use. Many of the design considerations in Chapter 10 apply to FDCPs. All of the apparatus access considerations in Chapter 3 also apply. The clear height and width would need to accommodate only the air supply unit if access is not needed for larger fire apparatus.

Reliability features are very important for FARS. The piping should stay pressurized and the system should include a low air pressure monitoring device. Continuous monitoring of critical attributes (such as oxygen content, contaminant gases, and moisture) is preferred and may be required. For adequate protection throughout an incident, all components of the system should be separated from other portions of the structure by fire-rated construction — perhaps a rating equivalent to that required for stair enclosures. All panels must be lockable, and the emergency responders should dictate key locations. Isolation valves may be needed — both for air piping risers (see the Isolation Valves section of Chapter 9) and for individual fill panels and stations. All system components, panels, and piping should be clearly marked as firefighter breathing air systems.

The performance of the entire FARS should be clearly specified. This may include the number of air cylinders to be filled simultaneously at remote locations, the fill pressure, and the fill time. This will dictate design details such as the distribution piping size and air storage cylinder capacity. All components should be specified for use with breathing air and marked to indicate their use.

Proper design, approval, installation, testing, and maintenance are crucial for FARS. An acceptance test after installation, including air quality analyses, would serve to verify system design and installation. Ongoing periodic testing after acceptance will help ensure continued reliability.

Backup Power Systems

Building codes, fire codes, and life safety codes specify systems to provide backup power for various building features when normal utility power is out of service. Applicable consensus standards include NFPA 70, *National Electrical Code* and NFPA 110, *Standard for Emergency and Standby Power Systems*. OSHA addresses electrical systems in Subpart S of the General Industry standards. Several categories exist for different levels of backup power.

One category of backup system is emergency power systems. These provide backup power to systems or features that protect occupants while evacuating a building. Examples include illuminated exit signs, emergency lighting, fire alarm and detection systems, occupant-egress elevators, and electric fire pumps. Such systems and features are the first to be switched over automatically to backup power.

Many systems or features provided with emergency power have secondary roles that provide protection to emergency responders. Emergency lighting aids entering firefighters as well as exiting occupants. Fire alarm system annunciators provide critical information to firefighters. Fire pumps often feed standpipe systems as well as sprinkler systems.

A second category of backup system is legally required standby systems. These typically provide backup power to systems or features that assist emergency responders. Examples include firefighter access elevators, lighting for fire command centers, equipment supporting smokeproof enclosures, and fixed radio signal enhancement systems. Such systems and features also automatically switch to standby power, but typically after emergency power systems are switched over.

Firefighters are particularly dependent upon systems or features classified as standby systems in high-rise buildings, as discussed in the Challenges section of Chapter 2. Loss of emergency power was cited as a factor in the 1991 One Meridian Plaza high-rise fire that killed three firefighters.[18]

A third category of backup power is optional standby systems, which provides backup power to systems and features that are important for operation of the facility but generally do not affect the safety of occupants or emergency responders. Examples include HVAC, data processing, and industrial process equipment. Such systems are typically switched to backup power manually rather than automatically.

Generators are often located outside, giving firefighters easy access while protecting the generator from a fire or other emergency within the building. If a generator must be located within a building, consider how firefighters will access it and how it will be protected from fires, flooding, and other hazards.

Generators are monitored for several conditions. Remote indications of these conditions and control features are often incorporated into fire alarm annunciators or fire command centers (see Chapter 11). These enable the fire service to quickly identify the generator's status or start the generator if not running.

18. Federal Emergency Management Agency, "Special Report: Operational Considerations for Highrise Firefighting", USFA-TR-082, April 1996.

Firefighter Emergency Power Outlet Systems

Firefighters regularly use electric power for lights, ventilation fans, and other tools. In large or tall buildings they must run extensive lengths of electric cords to feed equipment in remote areas of the building. A fixed, emergency power outlet system built into the building can substitute for these long cable runs, and save time and effort. This is analogous to standpipe systems substituting for long hose lays. One approach is to require an emergency power outlet system whenever standpipes are required (figure 12.8).

Photo: M. Chibbaro

Figure 12.8. *A firefighter emergency power outlet next to a standpipe fire hose connection.*

One or more dedicated electric circuits feed a series of emergency power outlets. Electricity is fed to these circuits in one of two ways. The first arrangement is from the building's electric supply on an emergency circuit ahead of the main power shutoff. The outlets should be fed by backup power systems in buildings so equipped. The second arrangement is to provide an electrical inlet connection that would be fed by the generators on responding fire apparatus.

The plug type the fire service uses for its electrical equipment determines the outlet and inlet type (figure 12.9). The wiring methods and overcurrent protection must meet applicable standards, which may include Subpart S of OSHA's General Industry standards and any other local or state electrical codes in effect.

Photo: M. Chibbaro

Figure 12.9. *A weather-resistant outlet cover opened, showing a twist-lock type of outlet.*

Typical outlet locations include every level in or near each enclosed stair, or next to each standpipe fire hose connection. Mark receptacles so that firefighters can spot them easily. For example, the designer could specify that each be painted red and labeled "For Fire Service Use Only."

Smoke Control and Ventilation Systems

Smoke control systems are mechanical systems that control the movement of smoke during a fire. System types include smoke exhaust systems (figure 12.10) and stair pressurization systems (figures 12.11 and 12.12). Other buildings may be equipped with zoned smoke control systems where zones or floors are either pressurized or exhausted to keep smoke from spreading. Building codes specify when to provide which systems. NFPA has developed three installation standards that cover various types of smoke control systems.

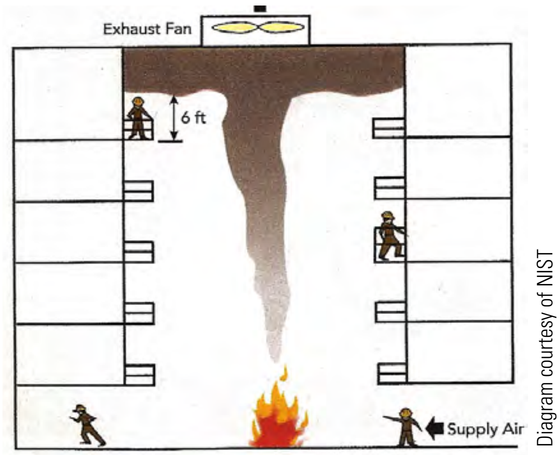

Figure 12.10. *A diagram of an atrium smoke exhaust system.*

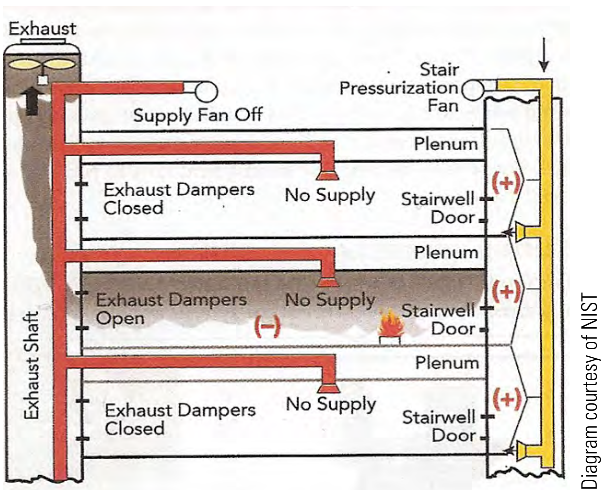

Figure 12.11. *A diagram of an exhaust system (left) and a stair pressurization system (right).*

Figure 12.12. *A stair pressurization fan.*

The primary purpose of most smoke control systems is to protect occupants while they are evacuating or remain in a refuge area. These systems are usually activated automatically (by detectors or suppression systems). Systems that are not zone-dependent (such as stair pressurization systems) can also be activated by manual pull stations.

The forces exerted by air movement when smoke control systems operate can result in egress doors becoming hard to open. This can be a life safety issue for both occupants and firefighters. Conversely, air flow can cause fire-rated doors to remain open when they should self-close, thereby compromising the integrity of fire barriers. Careful design must consider egress door opening force limits and fire door integrity during all system operating modes. Thorough testing should follow — to verify both proper smoke control activation and compliance with egress and fire-rating requirements.

Firefighters have some level of manual control over smoke control systems during an incident. These manual controls should be designed as preferred by emergency responders. When firefighters arrive, they can assess whether the automatic modes are functioning as intended. Incident commanders may then use the manual controls to select a different mode or turn any given zone off. It is imperative that these fire service controls override any other automatic or manual controls at any other location. Also, similar to fire alarm annunciators, the fire service may have specific requirements or recommendations, and may prefer uniformity of panels within their jurisdiction.

An easy-to-understand smoke control panel will assist a firefighter who may be trying to decipher the controls after awakening in the middle of the night. A simple, straightforward panel layout might feature a single switch for each system or zone (figure 12.13). Each different position of the switch places the system in a specific mode; the corresponding activation or setting of the individual fans, dampers, etc. would be configured behind the scenes. For example, a stair pressurization system might contain a three-position switch for each of three modes: automatic, pressurize and off.

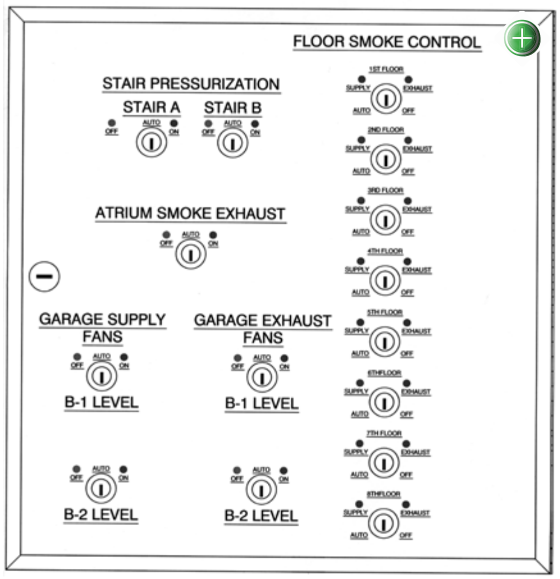

Diagram courtesy of Alarm Tech Solutions, LLC

Figure 12.13. *An easy-to-understand diagram of a panel for several types of smoke control systems. Each system and zone has a single, clearly labeled switch to select each mode.*

Some jurisdictions may desire that smoke control panels provide visual verification that individual system components have activated. For example, indicator lights could be provided to show that each fan has activated and each damper has opened or closed, according to the system design (figure 12.14).

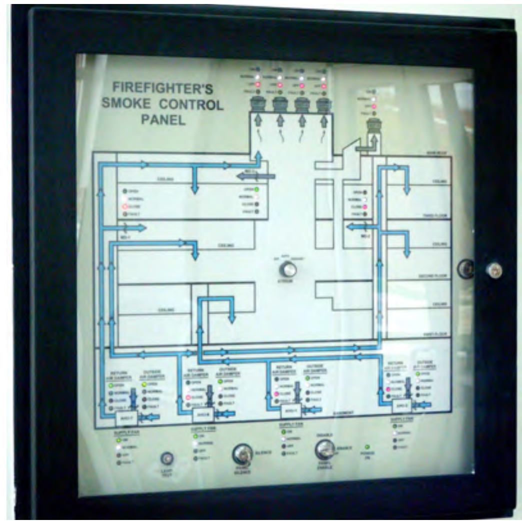

Photo: G. Havel

Figure 12.14. *A panel for a smoke exhaust system in an atrium. The switch in the center allows simple control. The lights provide positive indication of the operation of individual fans and dampers.*

Other jurisdictions may prefer that smoke control panels provide individual control over system devices such as fans and dampers. This level of sophistication should be accompanied by a corresponding level of training for all emergency responders who would need to use the system control panels.

Zoned smoke control systems are often arranged with each floor as a separate zone. In other cases, a floor may be split into multiple zones. These should be indicated on a graphic display, either on or adjacent to the smoke control panel. See the Graphic Displays section of Chapter 11 for additional guidance.

Smoke removal systems assist firefighters in the removal of smoke after a fire is extinguished. These are mechanical systems designed for a certain capacity without recirculating air back into the building. They are often arranged to be activated manually.

Other smoke removal features include operable windows or smoke vents (figure 12.15) distributed along walls or roofs. Windows are intended to be opened manually by firefighters. Smoke vents can be arranged to activate either manually or automatically, depending on the overall fire safety design approach in the building.

Photo: M. Chibbaro

Figure 12.15. *A smoke vent at the top of a stair.*

Questions to Ask - Firefighter Radio Signal Enhancement Systems

- Is fixed communications infrastructure needed?
- What is the radio system coverage of the responding fire service?
- What design and reliability criteria must be specified?

Resource

- IFC

Questions to Ask - Firefighter Air Replenishment Systems

- Will a firefighter air replenishment system be needed?
- Are fill stations or fill panels preferred? On which floors? At what locations?
- What signage is desired to indicate locations of fill stations or fill panels?
- Will fire department connection panels be needed? How many? At what locations?
- Will a fixed air supply be necessary?
- What design and reliability criteria must be specified?
- Are all panels and rooms with breathing air equipment lockable?
- Are all panels and piping marked?
- What criteria will constitute an acceptable acceptance test?
- Have emergency responders been trained on system features and operations?

Resources

- IFC
- International Association of Plumbing and Mechanical Officials, Uniform Plumbing Code, Appendix F, *Firefighter Breathing Air Replenishment Systems*

Questions to Ask – Smoke Control and Ventilation Systems

- Are smoke control switches designed for simple, straightforward operation?
- Are smoke control zones coordinated with fire/smoke barriers and other fire protection systems? The verification code for this document is 526887
- Should smoke vents be provided?
- Must vents be manually or automatically operated?
- Where should manual vent controls be located?
- Which devices should activate automatic vents?
- Have emergency responders been trained on system features and operations?

Resources

- NFPA 92, *Standard for Smoke Control Systems*
- NFPA 92A, *Standard for Smoke Control Systems Utilizing Barriers and Pressure Differences*
- NFPA 92B, *Standard for Smoke Management Systems in Malls, Atria, and Large Spaces*
- NFPA 204, *Standard for Smoke and Heat Venting*
- OSHA *Electrical Standard*, 29 CFR 1910 Subpart S

Questions to Ask – Emergency Power Systems and Firefighter Emergency Power Outlets

- Which systems must be provided with emergency power?
- Which systems must be provided with standby power?
- Is a firefighter emergency power outlet system required?
- Will the power outlet system be fed from the building's electrical system or through a fire service inlet?
- How should the outlets be wired for reliability during an emergency?
- What plug type is used by the fire service?
- Where must outlets be located? How should they be marked?
- Have emergency responders been trained on system features and operations?

Resources

- NFPA 70, *National Electrical Code*
- NFPA 110, *Standard for Emergency and Standby Power Systems*
- OSHA *Electrical Standard*, 29 CFR Part 1910, Subpart S

CHAPTER 13
BUILDING PHASES

Fire service needs span the entire lifetime of a building. Consideration begins as early as the concept and design phase and continues through construction, when a building is occupied, and during demolition. Communication among all stakeholders is important during each phase. Stakeholders include code officials, emergency responders, design professionals (architects, engineers, planners, and design technicians), construction professionals (contractors, subcontractors, and construction managers), building owners and developers, and security professionals.

There are two general considerations for everyone involved to remember. First is the integration, throughout all building phases, of the appropriate features covered in other chapters of this manual that facilitate fire service operations. This chapter addresses how these features can be applied effectively during various phases of a building's life.

Secondly, any features that help protect workers or occupants will also reduce the frequency or severity of incidents to which the fire service must respond (figure 13.1). Accordingly, the safety and health of workers should remain a high priority for both the sake of workers and the safety of emergency responders who are called upon when an emergency occurs, whether fire-related or otherwise.

Photo: M. Chibbaro

Figure 13.1. *Fire service crews clearing the scene of a construction site rescue.*

Concept and Design

Communication

The concept phase is the time period before any design work has begun. During this phase, a general idea of the building size and occupancy type(s) are developed. Only rather general planning of fire service features is possible. However, this is where communications among the stakeholders must begin.

Early and regular contact between designers and code authorities can establish communication that is vital to efficient incorporation of code requirements — both those that address construction hazards as well as those that apply to the finished building. Jurisdictions frequently issue amendments to the national model codes. Both the basic codes and amendments leave room for interpretation to accommodate the wide array of sites and structures. The earlier the code officials' interpretations and expectations are understood, the more efficiently the design and construction phases can proceed. This, in turn, translates into time and cost savings for the owner or developer, as well as facilitating timely incorporation of fire service features.

Designers and code officials are also encouraged to obtain emergency responders' views as early as possible. In some cases the code officials are able to speak for responders, but do not assume that is always the case. Try to learn about everyone's responsibility and authority during this phase to avoid surprises later. This will increase the chances of projects proceeding smoothly, on-time, and within budget.

Advance Planning

The subsequent construction phase will likely proceed more efficiently if designers and code officials give advance thought to how construction and occupancy will progress. Addressing these issues clearly on design and permit documents can help avoid conflicts.

Coordination in advance will help to maintain the features discussed below. These features include fire apparatus access, water supply, firefighter access, temporary standpipes, staging for combustible materials, proper locations for hazardous materials, and egress/access for partially occupied areas. Design documents should mandate proper phasing and code officials should follow up with effective enforcement. For long-term or unusual projects, a formal phasing plan may be beneficial.

Buildings or complexes that are to be initially occupied in stages will also proceed more smoothly with proper advance planning. Speculative spaces are those intended to be subdivided into separate tenants (figure 13.2). Examples include shopping centers, office buildings, or industrial complexes. Individual tenant occupancy will usually occur in stages.

Photo: M. Chibbaro

Figure 13.2. *A new, partially-occupied, speculative office building.*

Code officials will often mandate that means of egress and protection systems be in service for occupied portions of a building. Designers can facilitate this by planning ahead. For example, a shopping center must have its water supply in place before any individual tenant can be sprinklered. This is complicated further when a single water supply or fire pump feeds several buildings. The Occupancy section below discusses partial occupancy in greater detail.

Subsequent sections of this chapter suggest areas where advance planning during design (and on the design and permit documents) can be beneficial. These areas include pre-incident planning, system impairment programs, and temporary features (during both construction and demolition).

Permit Process

The design phase includes the site, the building itself, utilities that serve it, features built into the building, and systems installed in it. Site plans, construction plans, and system shop drawings are developed. This phase provides the opportunity to plan for all the appropriate fire service features before construction begins. Changes made on paper are always less costly than changes only recognized as needed after construction begins.

With the exception of minor work, the design process involves a variety of professionals developing material for submission to the appropriate code officials to obtain required permits. The material (often called submittals) can include plans, specifications, and calculations. Depending on the jurisdiction, permit types may include site, building, utility, and fire protection systems. Utilities typically include gas, plumbing, electric, water, and sewer. Fire protection systems include fire alarm, detection, standpipe, sprinkler, and other suppression systems. In some cases, code officials at multiple levels (state, county, and/or city) will be involved.

Municipalities are usually responsible for utilities and systems on the public side of the property line. The design team takes responsibility for the private side of the property line. However, designers often need to know municipal capabilities; for example, the water supply available to feed a building's sprinkler or standpipe system.

In some jurisdictions, emergency responders are a mandatory part of the permit process for certain features. One common example is the location of features used by the fire service such as fire hydrants, fire alarm annunciators, fire control rooms, standpipe FHCs, or FDCs. Codes generally require coordination with emergency responders for many of the features listed in the table in Annex A, below.

Application for permits usually involves submitting material to the appropriate code official. Various code officials have different responsibilities such as building, fire, electrical, etc. This permit work must often be done sequentially. For example, a sprinkler system permit will usually not be issued until after a building permit is obtained because the building permit establishes the occupancies or uses, from which the sprinkler design criteria will be derived.

The code officials will review the materials submitted and determine if they are in compliance with applicable codes and standards. Sometimes revised submissions are requested. Once the submissions are acceptable, they are approved and a permit is issued to allow the construction or system installation to begin. This approval is often subject to the completion of changes or additions that are included on the plans or otherwise transmitted to the entity that applied for the permit. These conditional comments must be addressed during construction or installation if projects are to proceed efficiently.

Construction

OSHA's construction safety and health standards apply during this phase. Local and state buildings codes usually mandate basic safety during this phase. Comprehensive guidance is contained in NFPA 241, *Standard for Safeguarding Construction, Alteration, and Demolition Operations.*

Soon after contractors are selected be sure to include them in communications with design professionals, responders, and code officials. Early involvement minimizes surprises for all parties concerned. An on-site pre-construction meeting including these stakeholders should be conducted before construction of the building begins. Such a meeting is required in some jurisdictions. Whether required or voluntary, it allows the contractors to find out what will be expected of them by the code officials and responders as the construction proceeds. Fire codes may also require that an on-site fire prevention coordinator be designated.

Hazards

Buildings under construction or renovation likely contain a high concentration of combustible material, a wide variety of ignition sources, and an array of worker safety hazards (figure 13.3). These can result in responses to construction sites by the fire service for falls, spills, fire suppression, rescue, etc. Furthermore, the risks to firefighters during construction are greater than those in a finished building due to incomplete fire protection features and constantly changing site conditions.

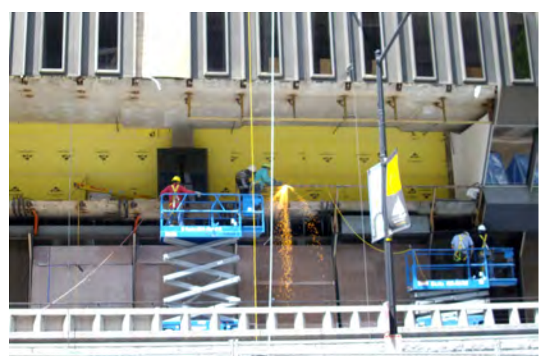

Photo: M. Chibbaro

Figure 13.3*. Workers on an aerial lift performing welding tasks.*

Many hazardous processes and materials are introduced to the job site early in the construction phase. These may include welding, open flames, flammable liquids and gases, explosives, other hazardous materials, rubbish piles, temporary heating or electrical equipment, and temporary enclosures for heating or health hazard containment. Where possible, label all hazardous materials.

Prior to their introduction, some materials or processes may require a permit and/or notification of emergency responders. These issues emerged as significant in a 1988 incident in Missouri when a construction trailer containing explosive material detonated, killing six firefighters who were not fully informed of the material's presence.[19] The potentially conflicting security concerns involving the labeling of the locations of extremely hazardous materials can be addressed by early communication between security and safety stakeholders.

Pre-Incident Planning

Pre-incident planning is the process during which the fire service learns important information about facilities in advance of an emergency. This allows them to operate more efficiently and safely when an incident does occur. Pre-incident planning begins at the construction stage. Planning is developed in cooperation with the fire service and construction professionals as the building is constructed, altered, or demolished. It is vital for building designers and developers to communicate their design intentions and building operational features to emergency responders so that they understand how the building should function and react during an emergency situation. Code officials may be in a good position to facilitate this communication.

Knowledge of the site as construction proceeds (figure 13.4) will be helpful during emergency incidents at the construction site. The fire service can learn about hazards and temporary protection features. Furthermore, seeing how a building is built provides valuable knowledge on construction and protective features that can help when a fire or other emergency occurs in a building after completion. The fire service and construction personnel should work together to facilitate site visits during various phases of construction. Remember to accommodate different shifts for career firefighters and convenient times for volunteer firefighters who often have other employment obligations.

Photo: M. Chibbaro

Figure 13.4. *Firefighters can obtain valuable insight about construction materials and methods as a building is being built.*

A convenient location on the construction site should contain items that may be needed during emergencies. These items include keys, plans, permits (hot work, HAZMAT, etc.), emergency information, spill containment kits, and other equipment for use or reference by emergency responders. The location should be readily accessible by emergency responders.

Temporary Features

During the construction phase, temporary protective features often compensate for the lack of permanent features or their incomplete nature. Access for fire apparatus and firefighters should be in place from the beginning of construction (figure 13.5). A permanent or temporary water supply is needed when the first combustible construction materials are on site.

Photo: M. Chibbaro

Figure 13.5. *Temporary fire apparatus access.*

19. Federal Emergency Management Agency, "Six Firefighter Fatalities in Construction Site Explosion", USFA-TR-024, November 1988, http://www.usfa.fema.gov/downloads/pdf/publications/tr-024.pdf

Several features should progress as the building rises in height. A temporary or permanent standpipe is usually installed in tall buildings as they near a height beyond the reach of fire service ladders (figure 13.6). At least one stair should be provided as the building rises. When the building's exterior walls are in place, smoke and heat from a fire will be confined; at this time the stair should be enclosed to maintain its integrity.

Photo: M. Chibbaro

Figure 13.6. *A temporary FDC (see arrow) feeding a standpipe being installed as this building rises.*

Temporary hoists are often used to bring workers and materials to upper floors. Temporary trash chutes may be in place to facilitate material removal, especially during renovation or demolition work. Responders need to be aware of both features before emergencies occur.

Inspection and Testing

As construction progresses, various inspections will occur at different times. Inspectors will be checking compliance with the codes in effect and the various permits issued. The approved documents for all permits must always be available on site. All appropriate contractors and subcontractors must be aware of each condition imposed by code officials. This includes any conditional comments on permits or approved plans. When neglected, these conditional comments can cause delays.

Toward the end of the construction phase, acceptance testing of systems is conducted. These tests can be performed individually or as part of full building commissioning. Continue to involve the fire service to educate them about the systems with which they will interact (especially fire alarm, communication, and standpipe systems). Code officials can invite emergency responders to witness acceptance testing. Demonstration of systems can also be arranged as soon as possible after acceptance testing (figure 13.7). Design documents should identify the need for these important interactions with emergency responders.

Photo: M. Chibbaro

Figure 13.7. *Building maintenance staff familiarizing firefighters with a fire alarm system in a new building.*

As construction or renovation nears completion, identify features that have not been coordinated — especially those installed late in construction. One example is security bollards that are not coordinated with fire hydrant locations. Another is fixed planters or furniture obstructing FDCs. With a large number of possible features needing coordination, all stakeholders should remain vigilant.

Information Exchange

When construction is nearing completion, as-built plans can be provided to the fire service for their use in continued pre-incident planning. These plans should include construction plans, fire protection system shop drawings, and site diagrams showing fire apparatus and firefighter access routes. Emergency responders may prefer schematic rather than detailed plans. Also check to see if responders prefer electronic or hard copies of plans.

Code officials are also in a good position to share with emergency responders a summary of important building information gleaned from the permit process (figure 13.8). This may include information on the building, its construction, its occupancy, utilities serving it, protection features and systems, and hazardous materials and processes.

P&CA PLANNING AND CODE ADMINISTRATION Gaithersburg

City of Gaithersburg • 31 South Summit Avenue • Gaithersburg, Maryland 20877 • Telephone: (301) 258-6330 • Fax: (301) 258-6336

- NEW BUILDING CONSTRUCTION -

- FIRE and RESCUE SERVICES INFORMATION SHEET -

Project: Courtyard at Washingtonian

Addresses: 204 Boardwalk Place

Location Description: Project to be located adjacent to the existing Rio Mall (just to the North) and Rio Lake in the Washingtonian Waterfront.

First Due: Station 31

Occupancy Type: Mixed use [Mercantile (Retail), Assembly and Hotel]

Construction Type (Per 2000 IBC): I-A (protected noncombustible)

Number of Stories: 9

Building Height: approx. 100 feet

Floor Area: 129,907 square feet total

First Floor	=	20,876 sq. ft.
Second Floor	=	14,727 sq. ft.
Floors 3 – 9	=	13,472 sq. ft./floor

Fire Hydrant Locations: New hydrants will be located across Boardwalk Place from the building near the A/D corner, and diagonally across the intersection near the A/B corner.

General Notes: This building will be fully sprinklered and will have a Fire Alarm system. In addition, and although not required, the building will also have a Smoke Control System. The fire department connection for the Standpipe/Sprinkler system will be located on Side A near the A/D corner of the building. The main Electric room and the Fire Pump room will be accessible via exterior doors on Side C near the Side C/D corner. The gas meter will be located on Side D near the A/D corner of the building.

Ivan J. Humberson, P.E., Fire Marshal June 11, 2004

Diagram: Gaithersburg City Fire Marshal, MD

Figure 13.8. *A sample of a new building information sheet prepared by a code official for transmittal to emergency responders.*

Occupancy

The occupancy phase begins when code officials determine that the building is either fully code-compliant or when a portion becomes safe enough to permit occupants to move in. In reality, occupancy is often allowed pending the completion of minor punch-list items that remain to be done. In the interim, additional features may be provided or restrictions imposed to ensure a sufficient level of safety. Examples include a limitation on the occupant load or a restriction on the occupancy type (such as storage or merchandise stocking only).

Partial occupancy occurs frequently in building addition/renovation projects. Remember that speculative spaces are often initially occupied in stages (as discussed in the Concept and Design section above) and then partially occupied during periodic renovations of tenant spaces or common areas (figure 13.9).

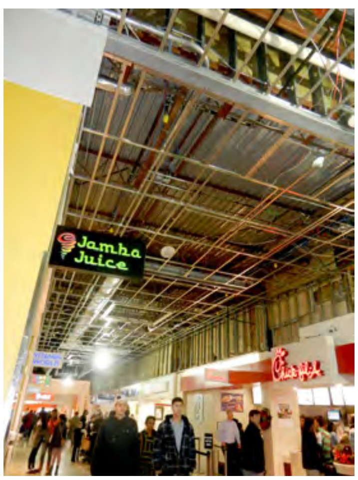

Photo: M. Chibbaro

Figure 13.9*. An occupied area of an existing shopping mall being renovated. Apparent deficiencies include a suspended ceiling grid without ceiling tiles, detectors and sprinklers at the future ceiling level, and protective caps on sprinkler heads.*

Careful planning and attention is necessary in partial occupancy scenarios to minimize hazards to occupants, workers, and emergency responders. Considerations include fire barriers separating occupied and unoccupied areas, completeness of the fire suppression and fire alarm systems, and all means of egress clear of any obstructions or combustible material (figure 13.10).


Photo: N. Hobbs

Figure 13.10*. An exit discharge area from an occupied building. The path to safety was demolished during adjacent construction.*

Often occupant egress routes and fire service access routes will be modified during construction or renovation projects. Signs will be helpful (figure 13.11) as long as they are updated for accuracy as the projects progress.

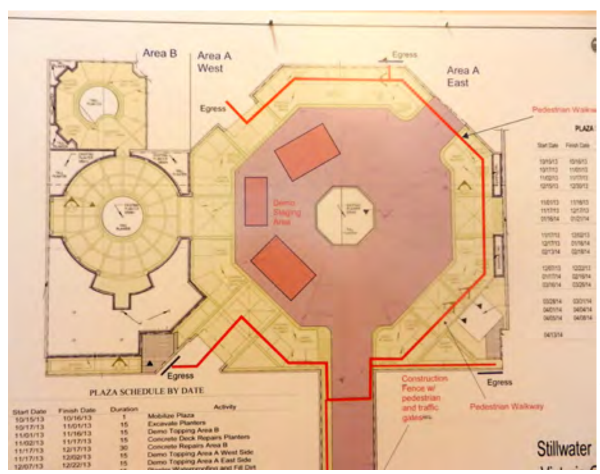

Photo: M. Chibbaro

Figure 13.11*. A diagram showing temporary egress and access routes during a renovation project for a plaza between two buildings.*

Temporary walkway roofs are usually provided over pedestrian areas adjacent to construction sites. When such areas also serve as means of egress from occupied buildings or areas, consider the width needed to maintain egress capacity (figure 13.12). Egress discharges also serve as firefighter access points.

Photo: M. Chibbaro

Figure 13.12. *A typical 4 ft.-wide temporary walkway (painted white) over a sidewalk adjacent to a construction site. The wide span between posts accommodates the double exit doors (shown in the center), which serve an occupied cinema.*

Maintenance and Use

Pre-incident planning must continue during a building's lifetime. Conditions, features, and systems can change over time. Firefighters are regularly hired, reassigned, promoted, and retired. Accordingly, building owners, operators, and tenants should continue to facilitate regular visits by the fire service — both to help with fire service pre-incident planning and to coordinate that effort with companies' emergency preparedness.

Most fire safety features installed in buildings for the protection of occupants also serve to protect firefighters during an emergency (for example, fire barriers and suppression systems). Others are intended primarily for the use and protection of firefighters (including standpipe systems, fire alarm annunciators, and elevator emergency power). Several administrative programs will increase the chances that protective features are available when an emergency occurs.

Preventive System Maintenance

Routine preventive maintenance of fire protection systems is one such program. Effective and ongoing maintenance will verify that systems remain in service and are capable of functioning properly. Deficiencies can be found and repaired before an emergency occurs (figure 13.13). Budget constraints may target maintenance first; therefore, code officials and emergency responders should remain vigilant.

Photo: M. Chibbaro

Figure 13.13. *An FDC with a glass bottle jammed into one inlet.*

Maintenance of Built-in Features

A process with effective checks and balances can help ensure that work performed in a building will not negatively impact important building features. A propped-open fire door will render a fire barrier ineffective. Utility work can result in unsealed penetrations of fire barriers (figure 13.14). Even the simple act of removing one or more tiles from a suspended ceiling can reduce the effectiveness of a fire-rated floor/ceiling assembly.

Photo: N. Hobbs

Figure 13.14. *A "Do Not Penetrate" sign stenciled on a fire barrier wall above a suspended ceiling. The sign is intended to warn workers modifying the utilities located in the space above the ceiling.*

Routine inspection of features by responsible parties (owners and occupants) can uncover deficiencies such as breaches of fire-rated barriers or damage to protective systems. Codes may place this responsibility on owners, who may contract with a third party to perform this service.

Impairment Programs

Impairments of fire protection systems or features can occur during maintenance and rehabilitation work, or when systems are installed on a phased basis. Regardless of the reason that a system is out of service, emergency responders should be notified when they are placed out of service and again when they are returned to service. Inoperable fire hydrants, annunciators, standpipes, etc., can cause delays in emergency operations. The fire service can compensate, at least somewhat, if they are made aware in advance. For example, rather than wasting time committing to a nearby out-of-service hydrant, firefighters can establish a water supply from a more distant in-service hydrant.

In some cases, temporary measures can be taken during impairment periods. Examples include a fire watch during a fire alarm outage and a temporary hose supply though an FDC during a water service outage.

Design documents could require notification of any impairment to the emergency responders and coordination with the code officials about any temporary protection during the time of impairment. Warning signage should be provided for systems or features that are inoperable or disabled (figure 13.15) at a location visible to responders. Impairment systems are equally as important after building occupancy.

Photo: M. Chibbaro

Figure 13.15. *A sign next to an FDC indicating that the system valve is shut off.*

Rehabilitation Work

Rehabilitation work, including renovations, alterations, and additions, can introduce hazards and create access issues (figure 13.16). Emergency responders must be aware of such work to factor it into their decisions and strategy during emergencies. Code officials should notify responders when a permit is issued for rehabilitation work.

Photo: M. Chibbaro

Figure 13.16. *A temporary barrier covering an entire building.*

Designers should remember that modifications to a building or its layout may necessitate changes to graphic diagrams, graphic annunciators, and building information diagrams. Inaccurate information can lead to poor decision-making, delays, and even strategic errors during an emergency incident.

Deteriorated Structures

Emergency responders should be notified when buildings deteriorate to the point where they are unsafe to enter (figure 13.17). Code officials can play an important part in this notification process. Warning signs as discussed in the Building Information section of Chapter 7 are also important.

Photo: M. Chibbaro

Figure 13.17. *A building deteriorated to the point that trees are growing in it and major cracks are apparent.*

Vacant or abandoned buildings pose severe dangers to firefighters. For example, after two Philadelphia, PA firefighters were killed in the 2012 collapse of such a structure, the dilapidated condition of the building was cited as a contributing factor.

Buildings condemned by code officials are usually posted with signs. Such signs should be prominently displayed. See the Building Information section of Chapter 7 for a discussion of marking dangerous buildings. Code officials should ensure that signs remain in place; vagrants have been known to remove signs to avoid detection.

Condemned buildings should be slated for demolition or repair as soon as possible. In the interim, they should be secured to preclude entry.

Demolition

Considerations during demolition are similar to those during the construction phase, but generally in the reverse order. Firefighters may still be called to mitigate emergencies during this phase. Two firefighters were killed at a 2007 fire during the demolition of the Deutsche Bank Building in New York City (figure 13.18). Factors cited included an inoperative standpipe system and maze-like conditions caused by asbestos abatement containment partitions.

Photo: NIOSH

Figure 13.18. *The fatal 2007 fire at New York City's Deutsche Bank Building.*

Depending on the structural condition, firefighters may enter a partially demolished building to mitigate an emergency. Standpipes and stairs should be maintained as the building is brought down; codes typically dictate how far below the uppermost accessible floor these features must be maintained. Fire protection systems and fire barriers should remain in place and in service as long as possible. Unprotected openings in floors are an extreme hazard for firefighters who may be working in darkness or smoky conditions. Gas and electric service should be terminated where possible, and labeled where they remain in service.

Questions to Ask – Building Phases

- Has communication with jurisdictional representatives begun as early as possible?
- Are both code officials and emergency responders in the communication loop?
- Should security professionals be consulted?
- Are fire service features accommodated during all phases of a building's life?
- Will a pre-construction meeting be held?
- Must an on-site fire prevention coordinator be designated?
- Are temporary fire service features maintained during construction and demolition?
- Are emergency responders informed about expected hazardous materials and processes?
- Are proper worker safety precautions taken during construction and demolition?
- Has the fire service been invited to conduct pre-incident planning during all phases?
- Has the fire service been invited to fire protection system acceptance testing or demonstrations?
- Are accurate as-built plans transmitted to emergency responders?
- Are accurate as-built plans maintained at the facility after occupancy?
- Have facility emergency liaisons or contacts been selected? Is this information available to emergency responders?
- Have partial occupancy precautions been taken?
- Is a program in place for inspecting building features?
- Is a preventive maintenance program in place for fire protection systems and features?
- Is an impairment program in place for fire protection systems?
- Are deteriorated and vacant buildings properly marked and secured?
- Are deteriorated buildings slated for repair or demolition as soon as possible?

Resources

- IBC
- NFPA 5000
- NFPA 241, *Standard for Safeguarding Construction, Alteration, and Demolition Operations*
- NFPA 3, *Recommended Practice on Commissioning and Integrated Testing of Fire Protection and Life Safety Systems*
- NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*
- NFPA 1620, *Standard for Pre-Incident Planning*
- NFPA Handbook, chapter entitled *Pre-Incident Planning for Industrial and Municipal Emergency Response*
- OSHA Construction Standards, 29 CFR Part 1926
- FM Global Data Sheet 1-0, *Safeguards During Construction, Alteration and Demolition*
- FM Global Data Sheet 2-81, *Fire Protection System Inspection, Testing and Maintenance*

ANNEX A
COORDINATION CHECKLIST

The following checklist is a multidisciplinary list of items that would benefit from coordination between the following three stakeholders — designers, code officials and emergency responders (figure A.1). As discussed in Chapter 1, a particular code official may or may not be able to speak for the needs of emergency responders. The coordination should occur before a building is designed or prior to a major renovation.

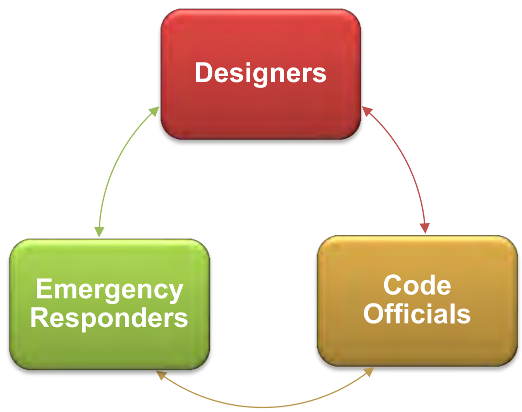

Figure A.1. *Stakeholder communication*

This list is not a substitute for the more specific questions that appear at the end of each chapter, which are referenced in the table. Rather, it is an overview of fire service needs in the built environment — particularly those needing coordination with emergency responders. Design professionals of various disciplines can also see where coordination among them would be beneficial. Building and fire codes include mandates for designers to coordinate some of the following items with fire service responders.

	Feature	**Chapter**
	Fire apparatus access — number, dimensions, proximity, material, security	3
	Water supply adequacy — total fire flow, flow testing for systems, permits needed	4
	Fire pump room — location, access, protection, remote alarms, signage	4
	Fire hydrants — outlet type, spacing, location, position, marking, access, security, vehicle impact protection, fire department connection proximity	4, 10
	Premises ID — addresses, signage	5
	Key boxes — location, keys contained	6
	Door locking arrangements — stair re-entry, access control, delayed egress	6
	Identification and signage — stairs, elevators, utilities, fire protection systems	6
	Designation of levels — coordination with stairs, elevators, building ID signs, annunciators	6, 11
	Designation of room or suite numbers	6

	Feature	Chapter
	Entry doors — signage at rear doors, blocked doors, utility rooms, fire protection system rooms	6, 8, 9, 11
	Features required or desired to be at main fire service entrance	4, 6, 10, 11
	Building plans and information — signs, cards, cabinets, command centers	7, 11
	Hazardous materials — signage, manifests, permits needed	7
	Underground or aboveground tanks (liquid or gas) — permits needed	7
	Lightweight construction marking, shaftway marking, skylight guarding	7
	Photovoltaic systems — signage, marking, access, ventilation	7
	Rooftop gardens — access, maintenance, ventilation	7
	Sprinkler systems — zoning, valve locations, signage, prevention of unwanted alarms, permits needed	8, 11
	Standpipe systems — design pressure at fire hose connections, pumper flow and pressure available at FDC, control valve locations, hose connection locations, permits needed	9
	Fire department connections — quantity, location, position, marking, access, signage, and proximity to water supply	4, 10
	Fire alarm — zoning, remote reporting, automatic door unlocking, prevention of unwanted alarms, permits needed	8, 11
	Fire alarm annunciator — location, orientation, content	11
	Voice fire alarms — pre-recorded message details, coordination with building egress scheme, coordination with stair locking/re-entry scheme	11
	Fire command center — location, protection, access, size, equipment arrangement, panel function, signage	11
	Firefighter radio enhancement systems vs. two-way communication systems	11, 12
	Special systems — firefighter air replenishment, backup power, smoke control, ventilation, permits needed	12
	Generator room — location, access, protection, remote alarms, and signage	12
	Permits needed for construction or system installation	13
	Pre-construction or pre-demolition meeting with all stakeholders	13
	Temporary features during construction — access, water supply, stair, standpipe, FDC	13
	Fire service pre-incident planning for both the construction phase and the occupied phase — site visits, construction plans, impairments	13
	Post-construction preventive maintenance and impairment programs	13

WORKERS' RIGHTS

Workers have the right to:

- Working conditions that do not pose a risk of serious harm.
- Receive information and training (in a language and vocabulary the worker understands) about workplace hazards, methods to prevent them, and the OSHA standards that apply to their workplace.
- Review records of work-related injuries and illnesses.
- File a complaint asking OSHA to inspect their workplace if they believe there is a serious hazard or that their employer is not following OSHA's rules. OSHA will keep all identities confidential.
- Exercise their rights under the law without retaliation, including reporting an injury or raising health and safety concerns with their employer or OSHA. If a worker has been retaliated against for using their rights, they must file a complaint with OSHA as soon as possible, but no later than 30 days.

For more information, see OSHA's Workers page.

OSHA ASSISTANCE, SERVICES AND PROGRAMS

OSHA has a great deal of information to assist employers in complying with their responsibilities under OSHA law. Several OSHA programs and services can help employers identify and correct job hazards, as well as improve their injury and illness prevention program.

Establishing an Injury and Illness Prevention Program

The key to a safe and healthful work environment is a comprehensive injury and illness prevention program.

Injury and illness prevention programs are systems that can substantially reduce the number and severity of workplace injuries and illnesses, while reducing costs to employers. Thousands of employers across the United States already manage safety using injury and illness prevention programs, and OSHA believes that all employers can and should do the same. Thirty-four states have requirements or voluntary guidelines for workplace injury and illness prevention programs. Most successful injury and illness prevention programs are based on a common set of key elements. These include management leadership, worker participation, hazard identification, hazard prevention and control, education and training, and program evaluation and improvement. Visit OSHA's Injury and Illness Prevention Program web page at www.osha.gov/dsg/topics/safetyhealth for more information.

Compliance Assistance Specialists

OSHA has compliance assistance specialists throughout the nation located in most OSHA offices. Compliance assistance specialists can provide information to employers and workers about OSHA standards, short educational programs on specific hazards or OSHA rights and responsibilities, and information on additional compliance assistance resources. For more details, visit www.osha.gov/dcsp/compliance_assistance/cas.html or call 1-800-321-OSHA (6742) to contact your local OSHA office.

Free On-site Safety and Health Consultation Services for Small Business

OSHA's On-site Consultation Program offers free and confidential advice to small and medium-sized businesses in all states across the country, with priority given to high-hazard worksites. Each year, responding to requests from small employers looking to create or improve their safety and health management programs, OSHA's On-site Consultation Program conducts over 29,000 visits to small business worksites covering over 1.5 million workers across the nation.

On-site consultation services are separate from enforcement and do not result in penalties or citations. Consultants from state agencies or universities work with employers to identify workplace hazards, provide advice on compliance with OSHA standards, and assist in establishing safety and health management programs.

For more information, to find the local On-site Consultation office in your state, or to request a brochure on Consultation Services, visit www.osha.gov/consultation, or call 1-800-321-OSHA (6742).

Under the consultation program, certain exemplary employers may request participation in OSHA's **Safety and Health Achievement Recognition Program (SHARP)**. Eligibility for participation includes, but is not limited to, receiving a full-service, comprehensive consultation visit, correcting all identified hazards and developing an effective safety and health management program. Worksites that receive SHARP recognition are exempt from programmed inspections during the period that the SHARP certification is valid.

Cooperative Programs

OSHA offers cooperative programs under which businesses, labor groups and other organizations can work cooperatively with OSHA. To find out more about any of the following programs, visit www.osha.gov/cooperativeprograms.

Strategic Partnerships and Alliances

The OSHA Strategic Partnerships (OSP) provide the opportunity for OSHA to partner with employers, workers, professional or trade associations, labor organizations, and/or other interested stakeholders. OSHA Partnerships are formalized through unique agreements designed to encourage, assist, and recognize partner efforts to eliminate serious hazards and achieve model workplace safety and health practices. Through the Alliance Program, OSHA works with groups committed to worker safety and health to prevent workplace fatalities, injuries and illnesses by developing compliance assistance tools and resources to share with workers and employers, and educate workers and employers about their rights and responsibilities.

Voluntary Protection Programs (VPP)

The VPP recognize employers and workers in private industry and federal agencies who have implemented effective safety and health management programs and maintain injury and illness rates below the national average for their respective industries. In VPP, management, labor, and OSHA work cooperatively and proactively to prevent fatalities, injuries, and illnesses through a system focused on: hazard prevention and control, worksite analysis, training, and management commitment and worker involvement.

Occupational Safety and Health Training

The OSHA Training Institute in Arlington Heights, Illinois, provides basic and advanced training and education in safety and health for federal and state compliance officers, state consultants, other federal agency personnel and private sector employers, workers, and their representatives. In addition, 27 OSHA Training Institute Education Centers at 42 locations throughout the United States deliver courses on OSHA standards and occupational safety and health issues to thousands of students a year.

For more information on training, contact the OSHA Directorate of Training and Education, 2020 Arlington Heights Road, Arlington Heights, IL 60005; call 1-847-297-4810; or visit www.osha.gov/otiec.

OSHA Educational Materials

OSHA has many types of educational materials in English, Spanish, Vietnamese and other languages available in print or online. These include:

- Brochures/booklets;
- Fact Sheets;
- Guidance documents that provide detailed examinations of specific safety and health issues;
- Online Safety and Health Topics pages;
- Posters;
- Small, laminated QuickCards™ that provide brief safety and health information; and
- *QuickTakes*, OSHA's free, twice-monthly online newsletter with the latest news about OSHA initiatives and products to assist employers and workers in finding and preventing workplace hazards. To sign up for *QuickTakes* visit www.osha.gov/quicktakes.

To view materials available online or for a listing of free publications, visit www.osha.gov/publications. You can also call 1-800-321-OSHA (6742) to order publications.

Select OSHA publications are available in e-Book format. OSHA e-Books are designed to increase readability on smartphones, tablets and other mobile devices. For access, go to www.osha.gov/ebooks.

OSHA's web site also has information on job hazards and injury and illness prevention for employers and workers. To learn more about OSHA's safety and health resources online, visit www.osha.gov or www.osha.gov/html/a-z-index.html.

NIOSH HEALTH HAZARD EVALUATION PROGRAM

Getting Help with Health Hazards

The National Institute for Occupational Safety and Health (NIOSH) is a federal agency that conducts scientific and medical research on workers' safety and health. At no cost to employers or workers, NIOSH can help identify health hazards and recommend ways to reduce or eliminate those hazards in the workplace through its Health Hazard Evaluation (HHE) Program.

Workers, union representatives and employers can request a NIOSH HHE. An HHE is often requested when there is a higher than expected rate of a disease or injury in a group of workers. These situations may be the result of an unknown cause, a new hazard, or a mixture of sources. To request a NIOSH Health Hazard Evaluation go to www.cdc.gov/niosh/hhe/request.html. To find out more, in English or Spanish, about the Health Hazard Evaluation Program:

E-mail HHERequestHelp@cdc.gov or call 800-CDC-INFO (800-232-4636).

OSHA REGIONAL OFFICES

Region I
Boston Regional Office
(CT*, ME*, MA, NH, RI, VT*)
JFK Federal Building, Room E340
Boston, MA 02203
(617) 565-9860 (617) 565-9827 Fax

Region II
New York Regional Office
(NJ*, NY*, PR*, VI*)
201 Varick Street, Room 670
New York, NY 10014
(212) 337-2378 (212) 337-2371 Fax

Region III
Philadelphia Regional Office
(DE, DC, MD*, PA, VA*, WV)
The Curtis Center
170 S. Independence Mall West
Suite 740 West
Philadelphia, PA 19106-3309
(215) 861-4900 (215) 861-4904 Fax

Region IV
Atlanta Regional Office
(AL, FL, GA, KY*, MS, NC*, SC*, TN*)
61 Forsyth Street, SW, Room 6T50
Atlanta, GA 30303
(678) 237-0400 (678) 237-0447 Fax

Region V
Chicago Regional Office
(IL*, IN*, MI*, MN*, OH, WI)
230 South Dearborn Street
Room 3244
Chicago, IL 60604
(312) 353-2220 (312) 353-7774 Fax

Region VI
Dallas Regional Office
(AR, LA, NM*, OK, TX)
525 Griffin Street, Room 602
Dallas, TX 75202
(972) 850-4145 (972) 850-4149 Fax
(972) 850-4150 FSO Fax

Region VII
Kansas City Regional Office
(IA*, KS, MO, NE)
Two Pershing Square Building
2300 Main Street, Suite 1010
Kansas City, MO 64108-2416
(816) 283-8745 (816) 283-0547 Fax

Region VIII
Denver Regional Office
(CO, MT, ND, SD, UT*, WY*)
Cesar Chavez Memorial Building
1244 Speer Boulevard, Suite 551
Denver, CO 80204
(720) 264-6550 (720) 264-6585 Fax

Region IX
San Francisco Regional Office
(AZ*, CA*, HI*, NV*, and American Samoa, Guam and the Northern Mariana Islands)
90 7th Street, Suite 18100
San Francisco, CA 94103
(415) 625-2547 (415) 625-2534 Fax

Region X
Seattle Regional Office
(AK*, ID, OR*, WA*)
300 Fifth Avenue, Suite 1280
Seattle, WA 98104
(206) 757-6700 (206) 757-6705 Fax

*These states and territories operate their own OSHA-approved job safety and health plans and cover state and local government employees as well as private sector employees. The Connecticut, Illinois, Maine, New Jersey, New York and Virgin Islands programs cover public employees only. (Private sector workers in these states are covered by Federal OSHA). States with approved programs must have standards that are identical to, or at least as effective as, the Federal OSHA standards.

Note: To get contact information for OSHA area offices, OSHA-approved state plans and OSHA consultation projects, please visit us online at www.osha.gov or call us at 1-800-321-OSHA (6742).

HOW TO CONTACT OSHA

For questions or to get information or advice, to report an emergency, fatality, inpatient hospitalization, amputation, or loss of an eye, or to file a confidential complaint, contact your nearest OSHA office, visit www.osha.gov or call OSHA at 1-800-321-OSHA (6742), TTY 1-877-889-5627.

For assistance, contact us.
We are OSHA. We can help.

OSHA®
www.osha.gov

U.S. Department of Labor

For more information:

Occupational Safety and Health Administration

www.osha.gov (800) 321-OSHA (6742)