Occupational Safety and Health Administration

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# Fire Service Features
## of Buildings and Fire Protection Systems

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***Cover photo:*** *Vito Maggiolo*

# Fire Service Features

## of Buildings and Fire Protection Systems

**Occupational Safety and Health Administration**
**U.S. Department of Labor**

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This manual is advisory in nature and informational in content. It is not a standard or a regulation, and it neither creates new legal obligations nor alters existing obligations created by OSHA standards or the *Occupational Safety and Health Act* (OSH Act).

Employers are required to comply with hazard-specific safety and health standards as issued and enforced either by the Occupational Safety and Health Administration (OSHA) or by one of the 27 OSHA-approved State Plans. State Plans have and enforce their own occupational safety and health standards that are required to be at least as effective as OSHA's, but may have different or additional requirements. A list of the State Plans and more information is available at: www.osha.gov/dcsp/osp.

In addition, Section 5(a)(1) of the OSH Act, the General Duty Clause, requires employers to provide their employees with a workplace free from recognized hazards likely to cause death or serious physical harm. Employers can be cited for violating the General Duty Clause if there is such a recognized hazard, and they do not take reasonable steps to prevent or abate the hazard. However, the failure to implement any of the recommendations in this manual is not, in itself, a violation of the General Duty Clause. Citations can only be based on standards, regulations, or the General Duty Clause.

This manual does not supersede or substitute for any local or state laws, codes, ordinances, regulations, or amendments thereto. This document shall only be used as a nonbinding supplement to a jurisdiction's requirements.

# CHAPTER 1
# INTRODUCTION

## Purpose

The purpose of this manual is to increase the safety of emergency responders and building occupants by providing information about how firefighters typically interact with building features and fire protection systems during fires (figure 1.1) and similar emergencies. By better understanding the needs of the fire service, designers and code officials can work together to streamline fire service emergency operations within the built environment.


Photo: G. Ellman

***Figure 1.1*** *Firefighters attacking a building fire.*

Originally published in 2006, this manual cited specific criteria for many of the building features discussed and code references. This document avoids such specifics and instead provides a general discussion of each feature, followed by a series of questions to ask and a list of resources to help users answer them. Editions are not listed for the resources such as codes and standards that are regularly updated. Two new chapters have been added on water supply and building phases and topics on energy conservation, emergency power, and room and floor numbering are now included.

The combined efforts of designers, code officials, and related stakeholders can result in safer workplaces for firefighters. When designs are tailored to better meet emergency service operational needs, the time and complexity needed to mitigate an incident is often reduced. Designers in this manual can include architects, engineers, planners, and design technicians. Code officials can include fire marshals, fire inspectors, fire prevention officers, building inspectors, and plan reviewers. Other stakeholders include building owners and developers, security professionals, and construction professionals.

The faster the fire service can respond, enter, locate the emergency incident, and safely operate in or near a building, the sooner they can usually resolve the incident in a safe manner. This, in turn, will likely increase the safety of building occupants (workers, residents, and visitors), reduce property damage, and limit related indirect losses. Therefore, both building occupants as well as fire service employees will realize the benefits of this document in terms of reasonably safe working conditions as intended by the *Occupational Safety and Health Act of 1970*.

The model building codes used in the United States — The *International Building Code* and the National Fire Protection Association's (NFPA) 5000 — include firefighter safety within their scope. Designers and code officials therefore bear some responsibility for the safety of firefighters dealing with emergencies in buildings that these specialists design or approve, respectively. Users of NFPA's *Life Safety Code* should note that firefighter safety is not specifically stated as part of its scope, which is one reason it would not substitute for a building code.

The building code responsibility for firefighter protection applies equally to prescriptive and performance-based design. However, a higher level of knowledge regarding fire service operations would likely be needed to meet this responsibility in a performance-based design scenario. Only with a thorough understanding of how the fire service interacts with all building features and systems during an emergency can a designer evaluate and ensure the safety of firefighters.

Many portions of the prescriptive codes and standards governing buildings and fire protection systems allow for design variations. The resulting flexibility permits the selection of a variety of design options. This manual discusses how the fire service interacts with different building features to help designers select options that may streamline fire service operations.

Designers routinely consider the needs and comfort of their clients when arranging a building's layout and systems. Within the framework of codes and standards, design options may be developed to benefit a particular owner, occupant, or user. For example, a building code would typically dictate the minimum number of lavatories and water fountains. However, the location, distribution, and types of such facilities are left up to the designer in consultation with the client.

The application of fire protection features in buildings is similar. For instance, a code may require the installation of a fire department connection for a sprinkler system or an annunciator for a fire alarm system. However, there may be little or no guidance as to the location, position, features, or marking of such devices. This manual discusses such features, lists questions to ask, and provides resources to help answer these questions. Primarily, these questions will be addressed by local and state fire codes, the code officials administering these codes, and emergency response personnel in the affected jurisdiction. Designers should consider code officials and emergency responders as stakeholders — just as they would building owners or occupants.

## Scope

This publication is to be used voluntarily, as a companion to mandatory and advisory provisions in fire codes, building codes, life safety codes, safety regulations, and standards for fire protection systems. The material contained in this document focuses on ways that stakeholders listed above can contribute to the efficiency of operations during emergency incidents in both new and existing structures. Proper design and approval should be followed by suitable installation, inspection, testing, and maintenance.

The material in this document is applicable to all types of fire service organizations, including fire brigades and fire departments, and will help emergency responders at incidents other than fires — hazardous materials releases, emergency medical care, explosions, collapses, and entrapments.

Users of this manual must understand its limitations. It is intended to supplement rather than substitute for codes and standards. For example, there are entire standards and books written about sprinkler, standpipe, and fire alarm design. However, this document covers only the portions of those systems with which the fire service interacts and suggests design choices that will help streamline and support fire service operations.

The concepts discussed here will apply to most facilities but do not cover every possible type of building, facility, or hazard. Therefore, designers and code officials should seek additional specific guidance from code officials and emergency responders regarding specialized facilities such as tunnels, transit systems, underground structures, and about the handling of highly hazardous chemicals.

## Manual Organization and Use

Chapter 2 of this manual presents an introduction to the fire service which is important for all users of this publication. The remaining chapters include a narrative describing specific building features and how the fire service uses or interacts with them. Depending on a designer's field of practice, one or more of these chapters may be applicable.  Boxes at the end of each chapter list specific questions that designers and code officials should consider for each topic, followed by resources that may help answer those questions. The Annex section contains a checklist to facilitate coordination with emergency responders on the topics addressed in this document.

Readers should recognize that this manual was developed during 2013–2015. Its contents reflect the state of the art at that time. It is possible — in fact, likely — that building features, materials, systems, and methods to assist the fire service will continue to change in the future. Technology will continue to evolve. Material in this publication is not intended to discourage the use of the latest technology, provided that adequate data demonstrates that it provides equivalent or superior protection for firefighters.

Along with the general considerations contained in this manual, designers and code officials should seek out and follow the specific advice of emergency responders. In some cases, the fire service will have statutory code enforcement authority to take part in the plan review, permit process, and inspections of these facilities or to approve some features of the building or site. Whether or not the fire service is involved in the code enforcement process, designers and code officials can only obtain all pertinent information if they consult appropriate response personnel. Consultation among appropriate stakeholders should begin at an early stage in the design process when changes are easier to make and are less costly.

There are several ways for code officials and emergency responders to disseminate or incorporate the information in this manual. Simply sharing the general information is a great start. Developing a handout or doing a presentation based on this document that is specific to a particular jurisdiction, with specific dimensions and other criteria, is a more effective strategy. The recommendations can also serve as a basis for local code amendments which carry the force of law, in which case the provisions would need to be revised from advisory language to enforceable mandatory language.

Codes and standards typically include an equivalency clause that permits code officials to allow alternatives to strict compliance, as long as the prescribed level of safety is not diminished. In some cases, a higher level of safety for firefighters can be achieved through this process, and perhaps even at a lower cost. For example, when fire service radio signals are inadequate within an existing building, it may be determined that portable signal enhancement devices carried by fire service vehicles are both more effective and less costly than enhancing the building's radio signal infrastructure. Equivalent alternatives and their justification should be documented so that this key information needed for safe and effective response is maintained for the life of the building.

## Terminology

The terminology used in this manual is as generic as possible, based primarily on the codes and standards of the National Fire Protection Association (NFPA) and the International Code Council (ICC). For example, the term code official is used to mean any of the following: authority having jurisdiction (an NFPA term), building code official, or fire code official (both ICC terms).

Fire service terms vary depending on where you are in the U.S.  For example, this document uses the term aerial apparatus to describe a fire service vehicle with an extendable ladder or articulating boom mounted on top. Common terms for this same type of vehicle include truck, ladder, aerial, ladder truck, tower, or tower ladder. Some of these terms indicate specific types of aerial fire apparatus. In some regions, the term truck refers only to aerial apparatus, while in other areas this term could also include pumper apparatus. The term tanker means a road vehicle in some areas and a water-dropping aircraft in others.

In another example of potentially confusing terminology, fire apparatus drivers in different regions may be referred to as driver/operators, chauffeurs, or engineers. To those in the building design community, the term engineer means a person who does building design.  Understanding local terminology variations is important to avoid misunderstandings.

## Glossary of Acronyms and Terms

The following terms are used in multiple chapters of this manual.

| | |
|---|---|
| **Apparatus:** *fire service vehicle.* | **High-rise building:** *qualitatively used in this manual as a building with one or more floors above the reach of fire service ladders. Many codes and standards use a more quantitative definition.* |
| **Apparatus, aerial:** *vehicle that carries a fixed extendable ladder and portable ladders.* | **Hose line, pre-connected:** *a hose of fixed length with a nozzle attached and connected to a discharge outlet on a pumper.* |
| **Apparatus, pumper:** *vehicle that carries hose, a pump, and a water tank.* | **IBC:** *International Building Code.* |
| **Code Official:** *a person legally designated to enforce a building code, a fire code, or a life safety code in a particular jurisdiction.* | **ICC:** *International Code Council.* |
| **Designer:** *a person involved in one or more facets of creating the built environment, including architects, engineers, planners, and design technicians.* | **IFC:** *International Fire Code.* |
| **Emergency responder:** *a person designated to respond to mitigate structural fires or similar emergencies, including firefighters, HAZMAT technicians, and rescue technicians.* | **Ladder company:** *aerial apparatus and personnel.* |
| **Engine company:** *pumper apparatus and personnel.* | **NFPA:** *National Fire Protection Association.* |
| **First due unit:** *engine company or truck company designated to respond first to an incident at a given location.* | **NFPA 1:** *Fire Code.* |
| **HAZMAT:** *Hazardous materials.* | **NFPA 101:** *Life Safety Code.* |
| | **NFPA 5000:** *Building Construction and Safety Code.* |
| | **Pre-incident plan:** *a compilation of information and diagrams on a specific facility to facilitate emergency operations.* |
| | **Truck company:** *aerial apparatus and personnel.* |

# CHAPTER 2
# FIRE SERVICE PRIMER

## Challenges

Fire service operations take place in dangerous, time-sensitive environments (figure 2.1). A slight delay in operations, especially when the first fire apparatus are arriving and positioning, can adversely affect subsequent operations and the outcome of the incident. Delays caused by poorly located fire hydrants, confusing fire alarm system information, ineffective communication systems, or inaccessible equipment can have a ripple effect on other aspects of the operation. During these delays, the fire will likely grow exponentially, expanding the hazard for both occupants and firefighters.

Photo: M. Carroll and G. Shaner, Clayton Fire Company #1, DE, and Odessa Fire Company, DE

***Figure 2.1.*** *Trapped firefighters being rescued from a building.*

Fire service operations are performed at all times of the day or night, in any weather conditions, and frequently in unfamiliar environments. The work is mentally stressful, and physically exhausting. Crew variations (due to time off, transfers, replacements, other emergency responses, etc.) introduce additional challenges.

Firefighters' workplaces are the buildings and areas in which they deal with emergency incidents. So, they have an unlimited variety of workplaces. Without knowing the location or circumstances of the next incident, traditional risk assessments for worker safety cannot be effectively undertaken.

Risk assessment must be done in a dynamic manner. The need to carry out inherently risky fire suppression and rescue tasks must be balanced with the need to maintain firefighters' safety. In these situations, pertinent information, building protective features, and protection systems help make for a more favorable work environment for firefighters, along with proper strategy, tactics, and protective equipment.

Information is frequently limited during emergency operations. This can impact initial decisions, which in turn can affect the incident duration and outcome (figure 2.2). However, decisions must be made very quickly, despite the unknown factors at an emergency scene. These factors, many of which can be critical, include the incident origin location(s), what materials are involved or exposed, how long the incident has progressed, what directions the hazard is spreading, where the occupants are located, building construction features, and installed protection systems.

Firefighters arriving at an incident scene often see no exterior indications of fire or smoke. This occurs more frequently in newer structures that are tightly encapsulated due to modern construction techniques, stricter energy codes, and environmental features (improved weatherproofing, inoperable windows, etc.).

Photo: David Purcell, Post Road Photos

***Figure 2.2.*** *The initial hose line placement can determine the course of an incident.*

Even when smoke and fire is showing from the exterior, little is immediately known about the occupants or interior conditions. Emergency scenes are often chaotic. Information given to firefighters is frequently limited, erroneous, or conflicting.  Firefighters are trained to act quickly to save lives and property that are in imminent danger. Furthermore, conditions can change drastically during the time it takes firefighters to set up their equipment to attack the fire. The abilities to adapt, improvise, and foresee fire progress are key skills for successful firefighters and fire officers.

All of these challenges are magnified in high-rises, underground structures, and other large or complex buildings (figure 2.3). Many portions of these buildings are beyond the reach of ladders, making exterior access impossible and limiting firefighting and rescue operations to the interior. Firefighter escape options are also limited to internal routes. Greater time, resources, physical endurance, and dependence on elevators are required. Several crews are often needed to accomplish tasks that normally could be accomplished by one or a few firefighters — for example, an air bottle exchange and replenishment operation. A great deal of support may be necessary for basic tasks such as setting up a hose line or rescuing a trapped victim.

Trends in building construction material and contents have changed working conditions for firefighters. The Federal Emergency Management Agency (FEMA) has identified the following trends that have increased the complexity and uncertainty of fighting fires. Chapter 7 contains a detailed discussion of several of these features.

- Lightweight construction
- Synthetic furnishings
- Residential transformations including reduced lot sizes, open floor plans, and larger concealed spaces
- Energy conservation measures including insulation, windows, doors, and rooftop gardens
- Alternative energy technology including photovoltaic systems, electric vehicles, battery storage, fuel cells, wind turbines, and smart grids

All of the above challenges may further jeopardize the safety of firefighters. Simplifying the firefighter's job in small ways will increase the level of safety for them, and for building occupants. Design features that save time or personnel can help firefighters operate in a safer manner and mitigate incidents more quickly. Any feature that provides additional information regarding the fire, the building, or its occupants can assist firefighters, as would any ways to speed the delivery of this information.


***Figure 2.3.*** *Firefighters entering an occupied residential high-rise building to perform an interior attack (smoke and fire is showing from an upper floor window). In addition to heavy protective gear and breathing apparatus, they are carrying hose, extra air tanks, and other equipment.*

## Organization

Fire service organizations can be classified as career, volunteer, or a combination of both. Career personnel are paid for their work, while volunteer members are either unpaid or compensated in non-monetary ways. Combination organizations have both career and volunteer staff. Career organizations typically serve larger, more urban, or industrial settings, although many smaller cities or towns have a full or partial career staff. Volunteer organizations are usually found in more suburban or rural settings, although some serve densely populated areas and have very high emergency response rates. Some areas utilize call firefighters, who are paid per response or hourly.

Perhaps a more important way to categorize fire service organizations is by whether fire stations are staffed with personnel ready to respond. Most career personnel remain in their station while on duty. Call firefighters do not remain in their station awaiting emergency calls. Most volunteers respond from home or work when they are alerted to an emergency. However, some organizations have volunteer personnel staffing their stations on shifts or living in the stations. The types of firefighters and mechanism of response are often driven by the community's call volume, budget, and the dedication and determination of its fire service members.

Another type of fire service organization is the industrial fire brigade. This is an organized group of employees trained and equipped to provide emergency services for one or several specific employers. A fire brigade can provide a full range of services (similar to a municipal fire department) or specific services such as initial fire suppression, hazardous materials mitigation, or emergency medical care. Members may be dedicated full-time to emergency operations or emergency response may be a part-time, collateral duty. The part-time members leave their primary jobs to respond.

## Apparatus

The fire service response to a structure fire would normally involve a number of different units, also called companies. Fire service vehicles are called apparatus; one vehicle is sometimes referred to as a piece of apparatus. They come in a wide variety of types for specialized uses. A basic understanding of the main types of apparatus will help designers understand some of the considerations for access and other features.

A pumper type of apparatus carries hose, a pump, and a water tank. Together with its personnel, this is called an engine company. Their main responsibility is to deliver water to the fire. Initially, the engine company may operate using the water available in their tank; however, any incidents other than small exterior fires will typically require a continuous water supply. This is done when hose lines carry water from a source of supply (fire hydrant, lake, pond, temporary basin) to the on-board pump, which then boosts the pressure to hose lines or other devices attacking the fire. Pumpers are typically equipped with a large-capacity nozzle, commonly referred to as a master stream device or deck gun, that can flow a large amount of water and is mounted on the top of the apparatus. Additionally, pumpers usually carry one or two short portable ladders.

Fire hoses are manufactured in various lengths (typically 50, 75, or 100 ft.) which must be coupled together to form hose lines. Pumpers carry hose lines of various diameter and lengths (formed with several sections). Some are used to supply water to the pumper from a water source as discussed in Chapter 4. Other hose lines are used to attack fires (figure 2.4) and are usually smaller in diameter than supply hose lines.

Photo: M. Chibbaro

***Figure 2.4.*** *A pumper operating at an incident. The red hose is supplying water from a fire hydrant to the pumper. The white hose is a fire attack line.*

Many pumpers have one or more preconnected hose lines comprised of a nozzle and several hose sections that remain coupled to each other and connected to a pump discharge (figure 2.5). Firefighters can quickly deploy preconnects, which are generally between 100 and 400 feet in length. They can be extended with additional hose, but this takes time — especially if the preconnect is already charged with water.

Photo: M. Chibbaro

***Figure 2.5.*** *A preconnected hose line in the front bumper of a pumper. The hose is connected to the red pump discharge outlet on the right and a nozzle is connected to the other end of the hose.*

An aerial apparatus (figure 2.6) is typically equipped with a long ladder or elevating platform on top, an assortment of portable ladders (extension, roof, or folding types), and many power and hand tools. The aerial ladder/platform can extend, articulate, or both. Aerial apparatus can be straight-frame or articulating; the latter can make sharper turns but requires a tiller driver to steer the rear wheels.

An aerial apparatus along with its personnel is often called a truck (or ladder) company. They are primarily responsible for support functions, including forcible entry, search, rescue, laddering, ventilation, and utility control. If an aerial apparatus is not available, these functions must be performed by another unit. All aerial apparatus are equipped with outriggers (also called stabilizers) to provide support when the aerial ladder is extended.

A multipurpose apparatus, also called a quint, is equipped to function as a pumper or an aerial apparatus. If provided with adequate staffing and positioned properly at a fire scene, a quint can perform both functions.

Other more specialized vehicles are used by the fire service. These include rescue units, hazardous materials units, air supply units, lighting units, ambulances, and water tenders. Access for pumpers will suffice for these special units with the possible exception of large or unusual facilities. For instance, a sports arena may be designed for ambulances to enter but not fire apparatus. Where arenas are designed for large trucks to access and set up concerts, the opportunity exists for all fire apparatus to access the venue.

Photo: David Purcell, Post Road Photos

***Figure 2.6.*** *Two types of fire service aerial apparatus — one with a straight ladder (left) and the other with an elevating platform (right). The latter type of aerial apparatus is often referred to as a "tower", "tower truck", or "tower ladder".*

## Emergency Operations

A typical emergency begins with the discovery and reporting of an incident. The time span of this phase can vary greatly, and the fire service has no control over it. After the report is received, the information is processed and the appropriate units are alerted. Those firefighters not staffing the station (whether volunteer, paid on-call, or collateral-duty fire brigade members) must travel to the fire station. Firefighters then don their protective equipment, board the vehicles, and the response phase begins. In some organizations or scenarios, members not staffing the station may go directly to the incident scene. If the emergency is a fire, the scene is usually referred to as a fireground.

Stages of a fire emergency:

- Fire discovery
- Fire reported
- Dispatch
- Response
- Arrival and setup
- Rescue and fire attack
- Fire containment and control
- Extinguishment
- Overhaul and salvage
- Investigation

Photo: M. Chibbaro

***Figure 2.7.*** *During initial operation at this structure, the first arriving engine crew is already using a fire lane, a fire hydrant, the fire department connection, and the key box. Interior operation will soon involve the alarm system, stairs, standpipe system, and other building features.*

Upon arrival at an incident scene, firefighters must handle many tasks. Standard operating procedures enable firefighters to quickly assess the situation, and go into operation (figure 2.7). Rescuing occupants is the first priority, followed by confining and extinguishing the fire. In some cases, firefighters must attack the fire in order to attempt rescues.

Engine companies, which are usually first to arrive at an incident scene, deliver water for fire extinguishment. This involves establishing a water supply from a reliable source and attacking the fire with hose lines (figures 2.2 and 2.4) or other devices.

Truck or ladder companies perform the support functions discussed above, including forcible entry and ventilation (figure 2.8). In areas without truck companies, support functions are handled by engine companies or other units such as rescue squads.

Photo: David Purcell, Post Road Photos

***Figure 2.8.*** *Firefighters perform vertical ventilation on a roof, relieving heat and smoke to assist interior firefighting crews. Horizontal ventilation relieves heat and smoke through windows, doors, or other wall openings.*

Many fire service organizations have standard operating procedures that assign different responsibilities to different units depending on their order of arrival. Units that are expected to arrive at an emergency scene first are called first due units. Responsibilities may need to be reprioritized when one or more occupants are in need of immediate rescue. While often immediate rescue may seem to be the most critical task, attacking the fire might be a better tactic to protect trapped or incapacitated occupants.

The management of all objectives, activities and resources needed to successfully mitigate an emergency is called incident command. This begins when the first arriving officer rapidly gathers information, which is called size-up or scene size-up. Incident command expands as additional units and chief officers arrive. Commanders base their strategy on the best information available at any given time regarding the fire, the building, and the occupants. Commanders also take into consideration the emergency resources and staffing available.

As they receive additional information, commanders may revise their strategies, including calling for additional resources. Units responding from another jurisdiction or district are referred to as mutual aid units. Units that are dispatched without being requested — usually based on inter-agency agreements — are called automatic mutual aid units. Mutual aid units will normally have longer response times than first due units.

Perhaps the most significant of the many decisions that must be made at a fire scene is whether to attack a fire from the interior (figure 1.1) or defensively from the exterior. Firefighters will often mount an interior attack to protect any remaining building occupants from the advancing fire. However, this often places the firefighters in a dangerous situation. Incident commanders and safety officers must evaluate this risk to make proper attack mode decisions, both initially and on an ongoing basis.

In other cases, due to fire advancement or building conditions, a fire must be attacked from the outside (figure 2.9). This is a critical decision, so the more accurate information firefighters have on the fire, the building, its contents, and the occupants, the more likely they are to make sound decisions on the initial fire attack mode and when to transition to another mode.

OSHA's Respiratory Protection standard contains provisions that address interior firefighting. One of these is known as the "Two In – Two Out" rule; it mandates that at least two firefighters work together (partner) to conduct interior firefighting while at least two others remain at a safe location outside to assist or rescue the interior crew. This helps to ensure the safety of the interior firefighting team.

Photo: John Guyton

***Figure 2.9****. An exterior fire attack.*

As operations expand, one or more larger rescue team(s) will normally stand by outside or at a staging area in a high-rise building. These are known as rapid intervention teams or rapid intervention crews. Such teams are a last resort and never a substitute for safe operations or proper building design.

As the fire incident is brought under control, several activities take place. Property that can be saved is salvaged. The structure is overhauled to find and extinguish any remaining hot spots. This may include removing building materials and opening wall cavities. An investigation is likely conducted to determine the fire's origin and cause. These activities, although dangerous and important, are less time-sensitive. As a result, they are less of a consideration for building and fire protection system designers.

## How Stakeholders Can Help

Designers and code officials can provide assistance by opening the lines of communication as early as possible and continuing communication through design and construction. Remember that coordination should occur with both code officials and emergency response personnel in a given jurisdiction (figure 2.10). In some cases, code officials have the authority and responsibility to speak for responders, but not so in other cases. The questions provided at the end of each chapter and the table in the Annex both facilitate this communication.

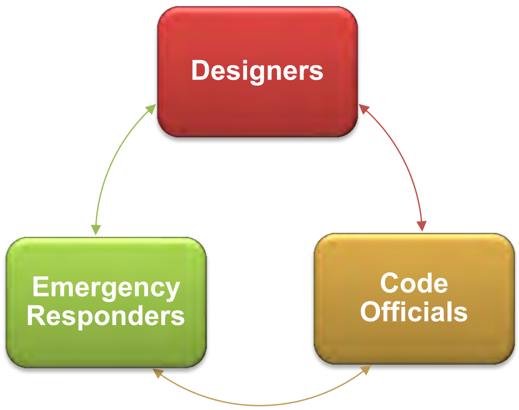


***Figure 2.10***. *Stakeholder communication.*

Although designer/responder communication is important for all systems and features discussed in this manual, codes and standards may have specific sections that require designers to obtain input from the responsible fire service. This mandatory coordination is to assure that the needs of emergency response personnel are met.

Pre-incident plans (often called pre-plans) are documents prepared by the fire service to assist in emergency operations in specific facilities. Their importance has been cited in many National Institute for Occupational Safety and Health (NIOSH) firefighter fatality reports. Pre-incident plans should contain the location of, and information about, the fire protection features discussed in this manual. The plans are usually prepared and maintained by the engine or truck company first due at each facility. Designers can assist in pre-incident planning by providing copies of building and system plans (paper or electronic) to the fire service, subject to permission from building owners. Tools such as computerized systems can facilitate communicating pre-incident plans among all responders that may credibly respond to an emergency at a particular building.

The fire service should prepare a thorough pre-incident plan, however, the best plan cannot overcome situations where the first due unit is committed to another emergency, is out of position, out of service, or involved in training. Personnel changes can also not be foreseen, so it is risky to count on all responding personnel to be aware of the pre-incident plan. Careful design, approval, and pre-incident planning should all function together to keep firefighters safe.

Specific ways in which all stakeholders can contribute to pre-incident planning are covered in several sections in Chapter 13.

***Questions to Ask – Fire Service Knowledge***

- Are challenges faced by the fire service understood?
- Do designers and code officials understand their role in creating workplaces for firefighters?
- Do designers understand the organization and operation of the fire service in specific project areas?
- Do designers and code officials understand the functions of different types of fire apparatus?
- Have designers begun coordinating with jurisdictional representatives early?
- Does the coordination include both code officials and emergency responders?
- How can stakeholders contribute to fire service pre-incident planning?

***Resources***

- The National Institute for Occupational Safety and Health conducts investigations of selected firefighter fatalities. Many of the investigation reports contain recommendations that relate to the built environment and are available at www.cdc.gov/niosh/fire.
- The UL Firefighter Safety Research Institute has produced several research reports that address aspects of firefighter safety in the built environment; available at http://ulfirefightersafety.com.
- The National Institute of Standards and Technology conducts research on fire protection, including firefighting technology and fire service staffing. Reports are available at www.nist.gov/fire.
- The National Institute of Standards and Technology issued extensive reports on the terrorist attacks of September 11, 2001 that are available at www.nist.gov/el/disasterstudies/wtc. This agency maintains a list of the recommendations in those reports and the resulting changes to the codes and standards. Several of these recommendations address emergency response and building design issues. This can serve as a resource for designers that want to exceed code requirements at high-risk buildings.
- The U.S. Fire Administration has reports, publications, online courses available at www.usfa.fema.gov.
- The National Fire Academy has online courses such as *Principles of Building Construction* (Q0751) available at www.usfa.fema.gov/nfa/nfaonline.
- Federal Emergency Management Agency, *Changing Severity of Home Fires Report,* available at www.usfa.fema.gov/downloads/pdf/publications/severity_home_fires_workshop.pdf.
- Polytechnic Institute of New York University, training module *Fires in Modern Lightweight Residential Construction,* available at www.poly.edu/fire/alive/alive8b.html.
- FM Global Data Sheet 1-3, *High-Rise Buildings*

## CHAPTER 3
# FIRE APPARATUS ACCESS

The faster the fire service can respond and set up, the sooner they can begin to mitigate an incident. This should translate into increased safety for firefighters and occupants as well as decreased property loss and indirect business loss. The time taken to set up and sustain firefighting operations can be considerable for high-rises and other complex buildings. This time can be extended when the fire location is not obvious or is remote from the arrival location.

Properly positioning fire apparatus at a fire scene can facilitate search and rescue efforts and effective use of hose streams and ladders. The more room apparatus have to operate, the more options will be available to mitigate the incident (figure 3.1). This is especially important when apparatus need to pass each other or reposition during an emergency. This chapter contains considerations to help with access and positioning fire apparatus.


Photo: M. Schwartzberg

***Figure 3.1.*** *An apartment fire where the fire apparatus access was adequate width and a proper distance from the building.*

Many buildings are located on public streets that provide good access to at least one side in the case of an emergency. Others are set back from public streets and have private fire lanes.  Both enable fire apparatus to approach the building and operate.

In all cases, consider the maximum practicable dimensions for design, since future apparatus purchases or mutual aid apparatus from other jurisdictions may exceed the requirements in a given jurisdiction at any given time.

Codes may contain provisions that allow reduced levels of access when approved fire sprinkler protection is provided. However, as discussed in Chapter 1 of this document, fire is only one of many types of emergencies that may occur and necessitate a fire service response. These provisions should be applied carefully and with a full understanding by all stakeholders of their ramifications.

Several concerns can conflict with the need for fire apparatus access. These concerns include security needs and the desire for green space and walkability. Flexible and innovative thinking, as well as early coordination among stakeholders, can usually overcome these challenges.

Related to fire apparatus access are premises identification and firefighter access. These are covered in Chapters 5 and 6, respectively.

### Extent and Number

In some cases, one route is available for fire apparatus to reach a building.  Sometimes optional (or secondary) access routes (figure 3.2) are needed for high-value or high-risk facilities or where a single access route may become impaired by factors such as traffic congestion or weather conditions.

Photo: M. Chibbaro

***Figure 3.2.*** *A secondary emergency access (foreground) supplements the main vehicle entrance/exit (background) in an apartment complex.*

The next consideration is the proximity of the access to the building (figure 3.3). Traffic and parking patterns should not inhibit apparatus access. The distance from the building to a road or fire lane is sometimes referred to as the setback distance. Codes may have variations that consider building size, height, sprinkler protection, and separation from other buildings.

Photo: M. Chibbaro

***Figure 3.3.*** *An overhead view of a hotel surrounded by fire lanes.*

The options available for attacking a fire increase when a building's perimeter becomes more accessible to fire apparatus. Building codes contain a concept known as frontage increase. This allows the maximum size of the building to be increased if a structure has more than a certain percentage of its perimeter on a public way or open space accessible to fire apparatus. Ideally the full perimeter would be accessible; however, this is not always feasible.

During site renovations and additions, designers should exercise particular caution to ensure that the perimeter access continues to meet applicable codes. The original building size may have been based upon a frontage increase allowance. Changing the amount of perimeter access can result in noncompliant building size without changing the building at all.

## Dimensions

### *Width*

The dimensions for roads and fire lanes that lead to a building must accommodate all apparatus that will use them. Spaces wider than the apparatus itself may be needed for several reasons. One is to enable apparatus to pass each other if necessary to facilitate developing and expanding operations. Near hydrants or other water sources, engine companies may need a wider area to facilitate hose connections, allow other fire service vehicles to pass, or permit water tenders to position alongside pumpers. Near buildings where aerial apparatus is available, accommodate the outriggers necessary to support the aerial ladder or elevating platform while in operation; this can greatly exceed the basic width of the apparatus (figure 3.4).

Photo: David Purcell, Post Road Photos

***Figure 3.4.*** *An aerial apparatus showing outriggers extended to support the aerial ladder.*

The area designated as the fire lane must be maintained clear. Additional space should be provided to accommodate vehicle parking (figure 3.5), trash containers, passenger drop-off, equipment staging, and loading or unloading areas. Anticipate as many such uses as possible to prevent encroachment on the clear width of fire lanes.

Photo: M. Chibbaro

***Figure 3.5.*** *The parking spaces on the right do not reduce the width of this fire lane.*

### *Proximity*

It is important for fire apparatus to have close access to buildings to facilitate the stretching of hose lines, the use of a master stream device, or the placement of portable ladders. Long hose stretches can delay the time it takes to contain or extinguish a fire. Similarly, carrying ladders a long distance can delay access or rescue.

In areas where an aerial apparatus may respond to an emergency, roads and fire lanes should be a sufficient distance from the building to accommodate aerial ladder operation (figure 3.6). Access too far away will preclude aerial ladder reach; locations too close may cause difficulty rotating the aerial ladder and prevent it from reaching some windows. Emergency responders should specify to designers and code officials a distance that is appropriate between the building and the edge of the access road or fire lane.

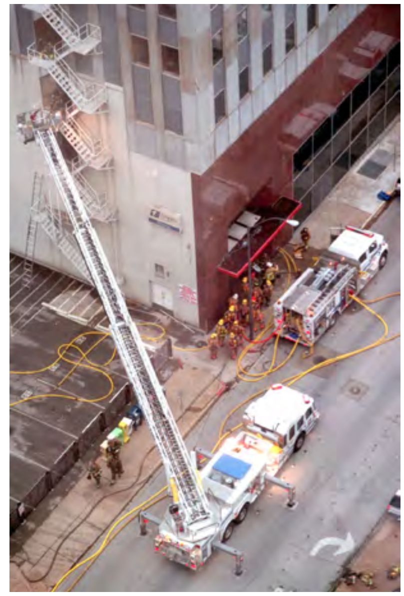

Photo: G. Ellman.

***Figure 3.6.*** *An aerial apparatus positioned at the corner of a building — a location that maximizes the number of windows that the aerial ladder can reach.*

### *Height*

All apparatus must have enough vertical clearance. Overhead obstacles such as trees or power lines can obstruct both portable and aerial ladders and should be avoided or minimized whenever possible (figure 3.7). Extra clearance should be considered in areas subject to snow accumulation.

Photo: M. Chibbaro

***Figure 3.7.*** *Lights strung across this street preclude the use of aerial ladders and limit the use of portable ladders.*

### *Turning Radius*

The minimum turning radius (inside and outside edges) for the most restrictive fire apparatus should be considered.

## Turnarounds

Dead-end fire lanes or roads that exceed a certain length should have a means for fire apparatus to turn around. Turnarounds save considerable time when a fire apparatus needs to reposition during an incident. They also eliminate the need to back up a long distance. Backing up apparatus is both difficult and dangerous, particularly during an emergency situation.

There are a number of configurations that facilitate turning maneuvers. These include "T-turn" and "Y-turn" arrangements (figure 3.8) as well as round cul-de-sacs of the proper radius and width.

## Design

### *Material*

All-weather paved or concrete surfaces are the best materials for fire lanes. Some jurisdictions permit using alternative material such as grass paver blocks (figure 3.9) that allow an area to be partially landscaped. Another is subsurface construction that permits an area to be partially or fully landscaped, while being strong enough to allow fire apparatus to negotiate the area. Permeable surfaces may be an important environmental feature.

Unless their perimeter is clearly marked, it is easy for apparatus to drive off the edge of alternative materials. Over time, the access can become obscured. Also, in regions where snow accumulates, grass paver blocks and subsurface construction cannot be plowed effectively (figures 3.9 and 3.10).

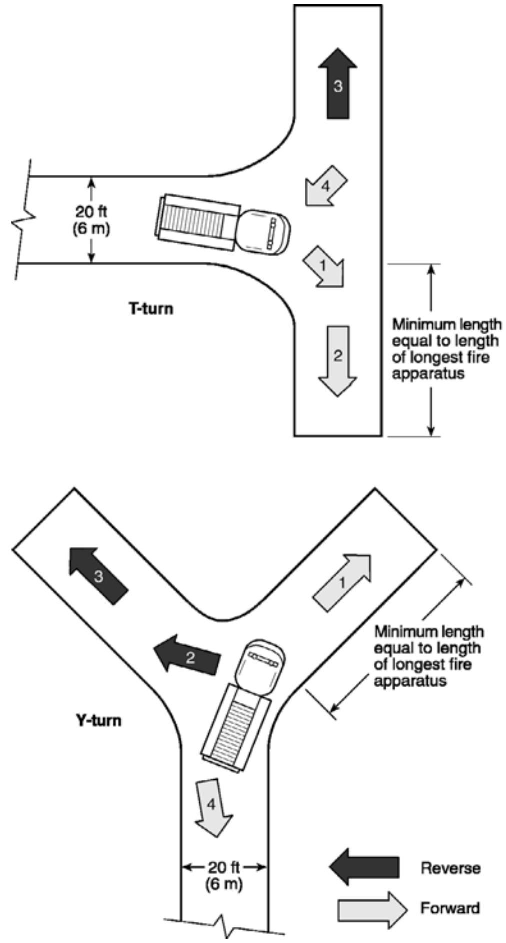


***Figure 3.8.*** *Fire apparatus "Y-" and "T-turnarounds." Reprinted with permission from NFPA® 1-2012, Fire Code Handbook, Copyright ©2011, National Fire Protection Association, Quincy, MA. This reprinted material is not the complete and official position of the NFPA on the referenced subject, which is represented only by the standard in its entirety.*

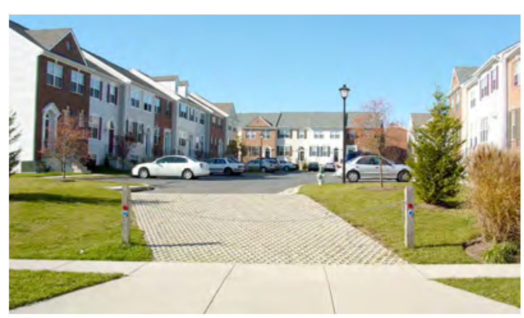

Photo: M. Chibbaro

***Figure 3.9.*** *Grass paver blocks were chosen instead of paving for this fire lane. The aesthetic benefits are minimal, and the road cannot be plowed effectively.*


***Figure 3.10.*** *The same fire lane covered with snow. Access is blocked by a mound of snow plowed from the adjacent parking lot.*

Where a surface is not readily identifiable by civilians as a fire lane, obstructions are more likely. Signage can help the fire lane remain clear of any items that can slow or impede responding fire apparatus.

### *Grade*

The maximum grade (slope) must accommodate all apparatus that may respond to an emergency. When aerial apparatus is set up for operation, the vehicle body must be leveled with the outriggers. Too steep of a grade will preclude aerial ladder operation. The shallowest grade possible would allow for the most rapid setup. However, a slight grade can be beneficial to help prevent pooling of water as well as ice buildup where applicable.

Dips should be avoided to preclude damage to undercarriage components and equipment. Apparatus with long wheel-bases are particularly vulnerable to this.

Traditional curbs cannot be negotiated easily by fire apparatus. However, rolled or rounded curbs (figure 3.11) can help in several ways. They can serve as the entry to a fire lane without giving civilians the impression of a driveway. Such curbs adjacent to properly designed sidewalks can effectively increase access width without widening the width of the road or fire lane.

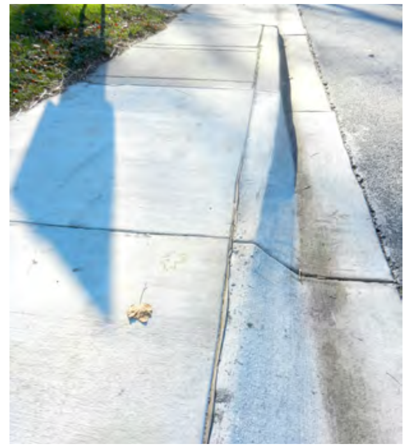


***Figure 3.11.*** *A rolled curb at the entrance to a private fire lane from a public street.*

### *Load*

Bridges, piers, boardwalks, plazas with underground structures, and other elevated surfaces should be built to withstand the necessary fire apparatus load. Load limits should be clearly posted at all vehicle entry points.

## Security

Fire lanes can be dedicated to fire service use (private), or can also serve ordinary vehicular traffic (public). Each approach has its advantages and limitations.

In public fire lanes, vehicle parking must be controlled (figure 3.12). Fire lane signage is important, both for the public and enforcement officials. Examples include signs (figure 3.13), curb painting, or curb stenciling. In areas subject to snow accumulations, curb painting or stenciling is subject to being obscured. A jurisdiction's requirements must be followed exactly to ensure that no-parking provisions are legally enforceable. However, even with the proper marking or signage, parking restrictions are often difficult to enforce.


Photo: M. Chibbaro

**Figure 3.12.** *A public fire lane.*

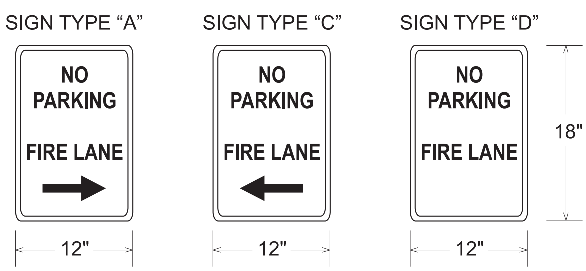


**Figure 3.13.** *Fire lane signs. Diagram excerpted from the 2012 International Fire Code and Commentary, Copyright 2011. Washington, DC: International Code Council. Reproduced with permission. All rights reserved. [www.ICCsafe.org].*

Clearly marking turnarounds is particularly important. One car can often make the entire turnaround impassible for fire apparatus.

Access to private fire lanes may be restricted by barriers such as bollards, pop-up barricades, or gates (manual or powered). These access control measures can be effective in keeping vehicular traffic out of fire lanes (figure 3.14) but can delay fire apparatus response time. During the design phase of a project, the persons responsible for security should coordinate with those who provide fire protection to help resolve concerns. Remote and automatic operators for gates address this concern. In addition, consider proper gate size, location, and swing direction.


Photo: M. Chibbaro

**Figure 3.14.** *An entrance to a private fire lane. The delays caused by electronic gates can be minimized by providing the fire service with access cards or remote access controls.*

All bollards must be removable in some fashion. Rapid removability allows quick access. Wooden bollards can be designed with cuts near their bases to allow access when apparatus bump them and break them (figure 3.15). However, the time needed to clear break-away bollards from the path of apparatus may cause delays and apparatus damage.

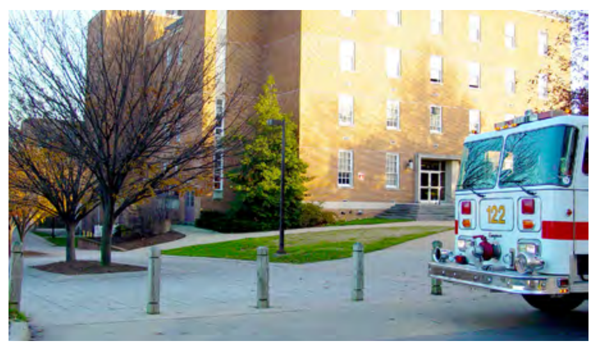


Photo: M. Chibbaro

**Figure 3.15.** *Wooden break-away bollards.*

Mechanisms for opening or gaining access through all apparatus access barriers should be clearly communicated to emergency responders. Pre-incident plans should document how emergency responders can open or remove access barriers.

## Traffic Calming Features

Speed bumps/humps/tables, narrow road widths, curvy arrangements, and islands are traffic calming features used to control vehicular traffic speed (figure 3.16). Most such measures that slow traffic also hinder fire apparatus access, delaying their arrival to a fire scene. Accordingly, jurisdictions may require special approval before traffic calming features can be installed.

Photo: M. Chibbaro

***Figure 3.16****. A traffic calming island.*

Some special speed bump designs allow only fire apparatus to straddle bumps. All speed bumps should be painted or striped. Provide signs nearby to indicate their location, especially in climates subject to the accumulation of snow and ice.

**Questions to Ask - Fire Apparatus Access**

- Is a single approach to the building acceptable or are more required?
- How near to the building must apparatus access reach?
- How many sides of the building must have access?
- What is the maximum dead-end access before a turnaround will be required?
- What are the minimum height, width, slope, and turning radius for apparatus access?
- What distance from the building will facilitate aerial use?
- Will overhead obstructions be prohibited to facilitate aerial access?
- What material is allowed for access routes?
- Are there any building areas housing hazardous materials or processes that would require unique or special apparatus access?
- Should the access be public? If so, how will parking be controlled?
- Should the access be private? If so, what means for rapid entry will be necessary?
- Are traffic calming devices allowed or restricted?

**Resources**

- IFC and IBC
- NFPA 1 and 5000
- NFPA 1141, *Standard for Fire Protection Infrastructure for Land Development in Wildland, Rural, and Suburban Areas*
- Congress for the New Urbanism, *Emergency Response and Street Design Initiative*, http://cnu.org/sites/default/files/erinitiative_0.pdf
- U.S. Department of Transportation standards, include *Manual on Uniform Traffic Control Devices,* available at http://mutcd.fhwa.dot.gov
- American Association of State Highway Transportation Officials (AASHTO), *Standard Specification for Highway Bridges*

# CHAPTER 4
# WATER SUPPLY

Water is used to suppress most fires, so an adequate water supply is crucial to fire service operations (figure 4.1). The supply must deliver an adequate amount of water through a distribution system to the locations needed. The system can serve manual firefighting (typically through fire hydrants), fire standpipe systems, fire sprinkler systems, other water-based suppression systems, and non-fire needs (industrial, commercial, domestic, etc.).

Photo: David Purcell, Post Road Photos

***Figure 4.1.*** *A pumper supplying water from a fire hydrant to a fire scene.*

Municipal water supply systems (including the distribution system and hydrants on public land) are generally under the jurisdiction of a local water authority. Municipal systems also feed water to private property for both fire and non-fire needs. The private property line is usually the boundary between the public portion (under the water authority) and the privately-owned portion. Property owners are primarily responsible for the private portion; however, designers and contractors share responsibility during the design and construction phases, respectively.

Private water supply systems are those contained fully on private property — for example, when the water supply consists of an on-site tank, pump, and piping system. The on-site system may feed private fire hydrants and/or building suppression systems.

In rural and suburban areas where a municipal water supply system is not available, static water sources such as lakes, ponds, cisterns, fountains, and swimming pools are often used. Pumpers draft water from static water sources to pump water through hose lines. The capacity of static water sources should take into consideration the frequency of drought conditions in accord with applicable codes or insurance standards.

Dry fire hydrants (figure 4.2) are often provided for static water sources. These hydrants allow pumpers to quickly draft water without the need to set up suction hoses to the static water source. Fire apparatus access must permit pumpers to drive close enough to use dry hydrants or to suction water directly from the static source.


Photo: M. Chibbaro

***Figure 4.2.*** *A dry fire hydrant piped to the lake in the background.*

Where an incident is remote from the water source, a shuttle is often set up. A shuttle operation involves several pumpers or tenders filling a temporary basin at the incident scene and other pumpers drafting water from the basin to attack the fire (figure 4.3). Rural fire services often have pumpers with large-capacity tanks for initial attack or tanker vehicles that carry a large amount of water.


***Figure 4.3.*** *A rural water supply operation. The water tender on the left is filling the yellow portable basin. The pumper on the right is drafting water from that basin to feed hose lines.*

## Fire Flow

Fire flow is the rate and amount of water the fire service needs to manually extinguish anticipated fires. The fire flow must be available in excess of that required for other purposes such as industrial, commercial, and domestic water demands. Several references in the resource section at the end of this chapter include fire flow tables or charts. The minimum fire flow is typically based on factors such as building construction, building size, occupancy, and contents.

To determine the minimum required fire flow, consider adequate flow rate (gallons per minute, or gpm), sufficient pressure (pounds per square inch, or psi), and total quantity of water (gallons). The flow rate is that needed to extinguish the materials anticipated to be burning. Pressure is provided by either pumping the water (using a fire pump) or elevating it (in a tank). As the flow rate from a system increases, the available pressure will decrease unless pumps are throttled up or additional pumps are started. The maximum flow rate available is usually given as the gpm available at 20 psi because the distribution system is subject to damage at lower pressures. The duration of an expected incident in terms of time will determine the quantity of water when multiplied by the required flow (for example: 1,500 gpm x 60 minutes = 90,000 gallons).

Water mains should be fed from two directions whenever possible. This increases reliability — for example, when flow from one direction must be shut off for repair or maintenance. Experience has also shown that dead-end piping fed from a single direction is subject to greater flow-restricting deposits due to smaller domestic flows.

Codes and installation standards for suppression systems such as sprinklers and standpipes have criteria that determine their water supply needs. The available water supply must meet the greater of the suppression system demand or the required fire flow for manual firefighting discussed above. The two are typically not additive because, for example, properly designed and installed full-coverage sprinkler systems should keep fires controlled, reducing the water needed for manual firefighting.

In some cases building and fire codes dictate certain water supply features. One example is a secondary water supply to supplement the primary supply to high-rise buildings. Another example is the use of cisterns to augment water distribution systems that are subject to earthquake damage.

Water supply systems are tested and evaluated in different ways, depending on the purpose of the evaluation (figure 4.4). Since systems may deteriorate over time in several ways, recent testing is very important for proper evaluation. Considering the possibility of future deterioration or additional demand on the system (for example, by applying a safety factor) can be equally as important.

| | |
|---|---|
| **Total fire flow for manual firefighting** | Evaluated by considering the supply system in its entirety to determine its adequacy for either the building expected to need the highest demand during an incident or a particular building served by the system. |
| **Flow and pressure available for a building's sprinkler and/or standpipe systems** | Evaluated at the system supply point(s). This can be the point(s) of connection to a municipal supply system and/or an on-site supply source. In existing buildings with fire pumps, testing at the discharge side of the fire pump will yield results corrected for the pump conditions and any deterioration or obstruction upstream of that point. |
| **Fire pumps** | Evaluated by measuring the pressure boost at various flows and comparing the values obtained with the expected performance based on the pump's rated capacity or certified performance curve. This is typically done when new pumps are acceptance-tested and periodically thereafter. |

***Figure 4.4.*** *Water supply evaluation.*

## Fire Pumps

Fire pumps are used in water distribution systems and at buildings or complexes to boost the water pressure to sprinkler and standpipe systems. The latter is necessary when the system is fed by an atmospheric (non-pressurized) water tank or when the water supply feeding the system has inadequate pressure. A fire pump may be driven by an electric motor, diesel engine, or steam turbine.

Fire pump controllers are the enclosures that contain electric circuitry and status indicators for a fire pump. They should be within sight of the fire pump motor or engine. An automatic transfer switch, which is often in a separate enclosure, transfers power to a secondary power source (when provided). Adequate space around all fire pump equipment will allow firefighter access during emergency incidents.

Fire pumps are remotely monitored for pump running, power failure, phase reversal, and controller trouble. Remote alarm signals are often incorporated into fire alarm annunciators or fire command centers to enable the fire service to quickly identify the status of a given fire pump. Designers and code officials should discuss whether these remote signals should cause an alarm condition as discussed in Chapter 11.

The most desirable location for a fire pump is in a separate building. This gives firefighters easy access to the pump and its controllers while providing the most protection from fire. If locating the pump in a separate building is not possible, a fire-rated room with an outside entrance is the next best option (figure 4.5). Least preferred is an interior room, in which case a fire-rated access corridor from the exterior is crucial. Regardless of its location, label the room and how to access it so firefighters are able to quickly identify it.

Fire pumps are usually provided with a test header consisting of several male hose outlets. These can resemble fire department connection female inlets from a distance, especially when the outlets are capped. Signs can help avoid confusion with wording such as "Do Not Pump Into These Fittings".

Hose connected to test headers and charged will be rigid. To avoid obstructing firefighter access and occupant egress, position test headers so their outlets point away from egress or access doors.


Photo: M. Chibbaro

***Figure 4.5***. *An outside door to a fire pump room identified by the red sign.*

Emergency responders should be trained on the operation of fire pumps. This is discussed further in Chapter 13.

## Fire Hydrant Features

### *Type*

Wet barrel hydrants are used in warm climates on pressurized water distribution systems. Water remains in the barrel of the hydrant at all times. Each hose outlet is individually valved, and can therefore be operated one at a time (figure 4.6).

Photo: M. Chibbaro

***Figure 4.6.*** *A wet barrel fire hydrant. The operating nut for the small hose outlet is on the right. The operating nut for the large outlet is on the rear of the hydrant.*

Dry barrel hydrants (figure 4.7) are used on pressurized water distribution systems in climates subject to freezing. A valve below the frost line is activated by an operating nut on the top. When the valve is opened, water fills the hydrant body (or barrel) above it. All hose outlets on the hydrant are then pressurized concurrently. A drain is provided to allow gravity to empty the barrel of water when the valve is off. Clogged drains and poor valve seals are common reasons for hydrants to freeze and become inoperable.

***Figure 4.7.*** *A dry barrel fire hydrant.*

Dry hydrants are used on static water supply sources. They facilitate pumpers drafting water from the static source (see figure 4.2).

### *Outlets*

The size, number, and type (threaded or quick-connect) of hydrant outlets vary between jurisdictions. It is essential that the outlets match the fire service's hose couplings. If the outlets do not match the couplings, adapters can be used, but will slow the set-up time. In addition, every pumper might not carry every adapter needed if numerous outlet types are used in the region.

All hydrant outlets should be provided with protective caps to help prevent vandalism. If the outlets are threaded, caps also protect the male threads.

Typically, hydrants have a large hose outlet (4 1/2 inches is a common size) called a pumper outlet or steamer connection. They normally also have one or more 2 1/2 inch hose outlets. Both wet-barrel type hydrants and the dry-barrel types used in areas subject to freezing have these features as shown in figures 4.6 and 4.7.

Dry hydrants (those connected to a static source such as a tank, well, or pond) usually have only a large pumper outlet as seen in figure 4.2 above. Often this outlet is 6 inches in diameter.

### *Marking and Signage*

Several methods are used to enable firefighters to rapidly identify hydrant locations. The color used for hydrants should contrast as much as possible with the surroundings. Some jurisdictions use reflective paint on hydrants or reflective tape around them. Other jurisdictions prefer reflectors (usually blue) in the roadway in front of each hydrant; however, in cold weather climates these reflectors are often obstructed by snow.

A common way to identify hydrants in areas subject to significant snowfalls is a locator pole which is visible above the highest expected snowfall. These are reflective or contrasting in color, and some have a flag, sign, or reflector mounted on top (figure 4.7). These poles should be flexible enough to allow a hydrant wrench to be utilized on the hydrant's operating nut. Some jurisdictions or sites go so far as mounting a light (usually red or blue) above or near hydrants.

A system to indicate the flow capability of individual hydrants can facilitate fire service operations. A color-coded system is described in NFPA 291, *Recommended Practice for Fire Flow Testing and Marking of Hydrants*. Another system is simply to mark hydrants with their flow range in gpm (figure 4.8) available at 20 psi (the minimum desired pressure).


Photo: M. Chibbaro

***Figure 4.8.*** *A fire hydrant with flow indicator sign.*

### *Security*

Fire hydrant operating nuts and outlet caps are subject to theft, so jurisdictions use various means to secure the operating nuts or caps.

## Fire Hydrant Placement

### *Spacing*

The maximum distance between hydrants (typically addressed in fire codes) determines how much hose will be needed to reach a fire. Pumpers carry a limited amount of hose. Relay pumping over longer distances is possible, but introduces significant delays in delivering water to an incident scene.

Where apparatus may approach from different directions, hydrants should be placed primarily at or near intersections. It may be desirable to place them a short distance from the intersection so that pumpers do not block the intersection for other fire apparatus (figure 4.9). This would depend on where pumper intake hoses are mounted as discussed in the following section.

Photo: David Purcell, Post Road Photos

***Figure 4.9.*** *A fire hydrant located too close to an intersection can result in pumpers blocking other apparatus access.*

Additional hydrants are placed within long blocks or as necessary to maintain a maximum spacing. This spacing is often based on the quantity of supply hose carried by a jurisdiction's pumpers.

### *Location*

Pumpers may utilize hydrants in different ways. If a hydrant is close enough to the emergency incident, a pumper can position at the hydrant and use its intake hose. These large-diameter hoses are often pre-connected to an intake on the pumper's front bumper (see the short length of hose in figure 4.9), rear step, or side. In some urban areas, pumpers carry intake hoses long enough to reach hydrants on the opposite side of a single line of parallel parked cars.

If an incident is not in close proximity to a hydrant, longer supply hose line(s) will be needed between the hydrant and the incident scene. This can be done by manually stretching hose, but it is usually faster and more efficient for a pumper to lay hose as it proceeds. A pumper laying a supply hose line from a hydrant towards the incident scene is called a straight or forward hose lay (figures 4.10 and 4.11). The opposite — laying supply hose from an emergency scene to a hydrant farther down the street — is called a reverse lay (figure 4.12).

Photo: Tempe, AZ Fire Department

***Figure 4.10.*** *A pumper stopped to initiate a straight hose lay from a hydrant.*

Photo: Tempe, AZ Fire Department

***Figure 4.11.*** *The same pumper completing the straight lay towards the fire scene, and a firefighter preparing to operate the hydrant.*

Photo: Tempe, AZ Fire Department

***Figure 4.12.*** *A pumper performing a reverse hose lay from a fire scene towards a hydrant. Once the hose lay is completed, the pumper will feed water through the hose line to the portable master stream device shown on the lower right.*

Fire services typically use either straight or reverse hose lays as their standard water supply procedure. Designers should take this into account when locating hydrants.

For instance, hydrants at the far end of dead-end streets will facilitate reverse lays. Hydrants at entrances to dead-end streets or building complexes will facilitate straight lays (figure 4.13).


Photo: M. Chibbaro

***Figure 4.13.*** *A fire hydrant (left foreground) at the vehicle entrance to a complex of buildings.*

A split lay is a combination of straight and reverse lays. When the first-arriving engine company does not pass a water source during its response, they can straight lay from any point such as a property entrance. Another engine company can reverse lay from that same point to a water source, completing the supply. The proper number and distribution of hydrants can reduce the need for split lays — which take two engine companies to accomplish — thereby making better use of resources.

Hydrants that are too close to a particular building are less likely to be used due to potential fire exposure or collapse. Consider locations with blank walls, no windows or doors, and where structural collapse is unlikely (such as building corners). A rule of thumb for collapse zone size is a horizontal distance equal to 150 percent of the building's height. This is not a concern in urban areas where a multitude of hydrants are typically available for any given location.

Hydrant position should also take into account the location of fire department connections that feed water-based suppression systems. This is covered in detail in Chapter 10.

### *Position and Protection*

Fire hydrants that are properly positioned facilitate rapid positioning of fire apparatus and full use of hydrants. Considerations for designers include height, orientation, distance from the apparatus access, distance from surrounding obstructions, and vehicle impact protection.

Positioning of hydrants at a proper height allows rapid connection of hose lines and devices. Positioning that is too low will preclude removing outlet caps and attaching hose or other devices. These devices include special hydrant valves to facilitate the connection of multiple pumpers to one hydrant.

Hydrants with a pumper outlet should be oriented so that the outlet faces the apparatus access. This will facilitate the use of pumper intake hoses.

Proper setback distance from the apparatus access will serve two functions. A maximum distance will allow the use of intake hoses on pumpers. A minimum distance will help avoid vehicle impact, especially if the fire lane or street is not curbed. Hydrants subject to vehicle damage can also be protected by guard posts that are often called bollards (figure 4.14).

Hydrants need a clear distance to enable a hydrant wrench to be swung 360 degrees on any operating nut or cap nut (figure 4.14). Designers and code officials must consider all obstructions. Fixed obstructions include utility poles, signs, walls, vegetation, planters, fences, pipes, poles, downspouts, built-in or heavy furniture, and vehicle impact protection bollards. Take into account potential growth of vegetation when planning for hydrant placement. Anticipate transient obstructions such as stock, merchandise, and vehicles.

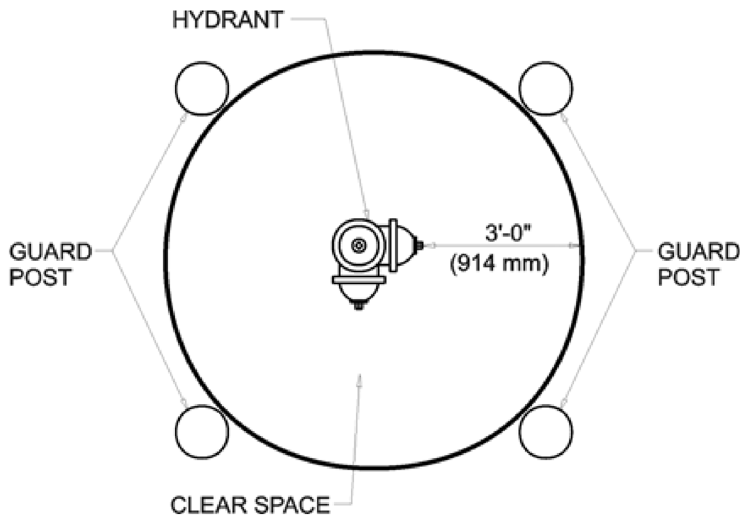


***Figure 4.14.*** *A diagram of hydrant impact protection bollards (shown as guard posts) and clearance distance. Diagram excerpted from the 2012 International Fire Code and Commentary, Copyright 2011. Washington, DC: International Code Council. Reproduced with permission. All rights reserved. [www.ICCsafe.org].*

**Questions to Ask – Water Supply**

- Are the proper water flow, pressure, and quantity available for manual firefighting?
- Is a recent flow test used for design of sprinkler and standpipe systems? Must a safety factor be provided for future supply system changes? For future tenant renovations?
- Are fire pumps easily accessible and marked?
- Are fire pumps located where they will be protected from fire and other hazards?
- Where must the remote fire pump alarm and supervisory signals be located?
- Have fire apparatus approach directions and hose-laying procedures been considered when locating hydrants?
- Are hydrants properly positioned relative to the street or apparatus access?
- Are hydrants outside of potential collapse zones?
- Are hydrants located away from fixed, temporary, and transient obstructions?
- Are hydrant locations coordinated with FDC locations (also see Chapter 10)?
- Are hydrants set at the proper height?
- Are hydrant outlets coordinated with fire service hose coupling types?
- Is vehicle impact protection (curbs, bollards, etc.) provided for hydrants?
- Will a hydrant marking or color-coding system to indicate flow be needed?
- Will hydrant locator poles be needed in areas subject to snow?
- Will hydrant outlets or operating nuts need to be locked?

**Resources**

- IFC
- NFPA 1
- NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*
- NFPA 24, *Standard for the Installation of Private Fire Service Mains and their Appurtenances*
- NFPA 291, *Recommended Practice for Fire Flow Testing and Marking of Hydrants*
- NFPA 1142, *Standard for Water Supplies for Suburban and Rural Firefighting*
- American Water Works Association standards
- U.S. Fire Administration, *Water Supply Systems and Evaluation Methods*, available at www.usfa.fema.gov/downloads/pdf/publications/water_supply_systems_volume_i.pdf
- Insurance Services Office, Inc., *Guide for Determination of Needed Fire Flow*, available at www.isomitigation.com/downloads/ppc3001.pdf
- FM Global Data Sheet 3-2, *Water Tanks for Fire Protection*
- FM Global Data Sheet 3-7, *Fire Protection Pumps*
- FM Global Data Sheet 3-10, *Installation/Maintenance of Fire Service Mains*
- Fire Protection Research Foundation, *Evaluation of Fire Flow Methodologies*, 2014, available at http://www.nfpa.org/research/fire-protection-research-foundation/projects-reports-and-proceedings/for-emergency-responders/fireground-operations/evaluation-of-fire-flow-methodologies
- Fire Protection Publications, Oklahoma State University, *Fire Protection Hydraulics and Water Supply Analysis*

## CHAPTER 5
# PREMISES IDENTIFICATION

The fire service must be able to rapidly locate and identify a specific building when an emergency incident is underway. While typically easy to locate a properly-displayed address where buildings face nearby streets, there are other instances where it is a challenge.

Assignment of address numbers and names is ordinarily the responsibility of the local jurisdiction. This can be complicated by unusually-shaped buildings or those fronting on two or more streets. It is important that the U.S. Postal Service and the local jurisdiction have the same understanding of all assigned address numbers.

Street name assignments are followed by a designator such as Street, Lane, Avenue, Boulevard, Court, Way, etc. It is important that this designator is properly assigned for each project and all records. This will help ensure proper fire service pre-incident planning and response.

Some cities have quadrant or section designators such as northwest (NW), southeast (SE), etc. Addresses may be duplicated in two or more quadrants or sections, making the full address assignment important for each project and all records.

Many jurisdictions have a minimum height requirement for address number characters, which is typically specified in building and fire codes. This can vary depending on whether the buildings are residential or other properties. Use of colors that sharply contrast with the background will increase legibility (readability).

Arabic numerals are often considered the easiest to read. If spelled-out numbers are permitted (for example, "One Hundred Twenty" instead of "120"), numerals should also be provided to allow responding firefighters to quickly locate an address.

Address numbers should be large enough to be legible from the street. Large address numbers for buildings set back from the street are helpful (figure 5.1).


Photo: M. Chibbaro

***Figure 5.1.*** *A large address number.*

If either obstructions or the location of the building prevent the address from being clearly visible from the street, supplemental signs should be provided (figure 5.2) in addition to displaying the address numbers on the building.


Photo: M. Chibbaro

***Figure 5.2.*** *A supplemental address sign at the vehicle entrance to a building (out of view on the left) that is set far back from the public street (on the right).*

A single address number will likely be sufficient even for large or long buildings — if they can be approached from a single direction. Otherwise, displaying addresses at multiple locations would be helpful.

Address numbers on the building should face the street on which the building is addressed. If one or more building entrances face a different street, it would be helpful to include both the street name and the number on each address sign (figure 5.3). This is also a good idea for rear or side entrances that face alleys or parking lots.

Photo: M. Chibbaro

***Figure 5.3.*** *An address sign that includes the street name and street designator.*

Rapidly locating a particular building within a building group (complex) can be particularly challenging. At the vehicle entrances to such sites, and at intersections within them, additional signs with directional arrows and/or diagrams of the buildings and access arrangement can quickly direct responding firefighters to the correct building (figures 5.4 and 5.5). Some jurisdictions may desire additional features on diagrammatic signs such as fire hydrants, fire department connections, fire alarm annunciator panels, swimming pools, and recreational courts.

Photo: M. Chibbaro

***Figure 5.4.*** *A directional address sign.*

Photo: M. Chibbaro

***Figure 5.5.*** *A diagrammatic sign showing an entire complex of buildings and their addresses.*

Building complex diagrams should be provided to the fire service. This will assist them with pre-incident planning (discussed further in Chapter 13) and the development of map books.

Consider a combined numbering scheme in complexes where buildings have several tenants with exterior entrances. The first digit(s) would be the address number and the following digit(s) would be the tenant number; for example, designation 2203-16 would be address number 2203, tenant 16. If an entire complex of buildings has a single address, a numbering scheme could coordinate building and tenant numbers; for example, designation 12-16 would be building 12, tenant 16. See the Room and Floor Designations section in Chapter 6 for a discussion of interior numbering.

Whenever possible, address numbers and any supplementary signs should be visible in all expected weather situations and all lighting conditions, including at night. Normally, site lighting is sufficient if designed with this in mind, but in some situations supplemental illumination (lighting fixtures or reflective materials) will be needed to maximize nighttime visibility.

In areas subject to snow accumulation, addresses and supplemental signs should be positioned above the height of anticipated accumulations. A canopy or small roof may help keep the sign legible.

See the Firefighter Access section of Chapter 6 for signage to assist the fire service in identifying interior locations and exterior entrances.

See Chapter 11 for additional means of identifying particular addresses, sections, wings, or tenants through fire alarm remote reporting.

**Questions to Ask – Premises Identification**

- Are project addresses coordinated between the local jurisdiction and the U.S. Postal Service?
- Do addresses include the proper street designator? Quadrant/section designator?
- Is each building provided with a clearly legible address number in Arabic numerals?
- Are address numerals large enough and high enough to be legible from the fire apparatus access?
- Will addresses be needed at multiple points on long or large buildings?
- For entrances facing other streets, will the street name and designator be required along with the address number?
- Will supplementary signs be needed at the street for buildings set far back from the street? The verification code for this document is 126013
- For building groups or complexes, will directional or diagrammatic signs be needed at entrances? At intersections within the complex?
- Must addresses and signs be illuminated?
- Do sign position and features take into account expected snowfall?

**Resources**

- IFC and IBC
- NFPA 1 and 5000
- NFPA 1141, *Standard for Fire Protection Infrastructure for Land Development in Wildland, Rural, and Suburban Areas*

CHAPTER 6

# FIREFIGHTER ACCESS

Once firefighters have arrived at an emergency scene and positioned their apparatus, they perform a variety of manual tasks. These include stretching hose lines, placing ladders, forcing entry, climbing stairs, and controlling utilities. Some factors affecting firefighters' efficiency include: the distance and terrain between the apparatus access and the building; how easily they can enter the building; the building's interior layout, vertical access (stairs/elevators/roof) and how quickly they can locate fire protection features and utilities (figure 6.1). Building designers and code officials can make a positive impact in all of these areas.

Photo: D. Polikoff

***Figure 6.1.*** *A building with poor apparatus access and challenging terrain for firefighters stretching hose lines and placing portable ladders.*

## Site Access

Firefighters must hand carry all equipment beyond the point where access for apparatus ends. Increased distances and steeply sloped terrain result in additional time and effort to set up ladders, hose lines, and other equipment. These delays can impact search, rescue, and suppression efforts. If the area is easy to negotiate by foot, firefighters can move relatively quickly.

Obstructions and hazards are often found around buildings that may hinder firefighter access. These include fences, landscaping, vehicles, power lines, merchandise, storage, etc. Proper design can eliminate or minimize many of these obstructions. Give consideration to the maximum growth potential of bushes and trees.

Sloped grade adjacent to a building has two drawbacks. First, it increases the exertion required to haul hose lines and other equipment. This exertion is often complicated by inclement weather. Secondly, steep slopes can hinder and even prevent the use of portable ladders. One rule of thumb is to place the base of a portable ladder a horizontal distance away from the building equal to one-quarter of the vertical distance the ladder is extended. Accordingly, grade that is slightly sloped for a distance from the building will make ladder use easier. This distance should be at least one-quarter the length of the longest fire service portable ladder or the height of the building roof — whichever is shorter.

## Key Boxes

Firefighters must enter the building at one or more points to conduct interior firefighting or rescue operations. The fire service has an array of tools to force entry into buildings. However, forcing entry takes extra time and usually causes damage.

Key boxes (also called access boxes or lock boxes) are small lockable vaults mounted on buildings (figure 6.2) or nearby (figure 6.3). The fire service retains the master key to unlock the boxes, which contain keys and key cards to the building doors, elevators, and other equipment. Some jurisdictions require listed key boxes for certain types of buildings or those with a fire alarm system; others give the code official the ability to require them when appropriate. In some jurisdictions, several sets of keys must be provided. Also, keys can be color coded for their specific use — such as access gates, elevators, fire command center, and special hazard areas (for example, swimming pools).


Photo: M. Chibbaro

***Figure 6.2.*** *A key box and sign (upper left) next to a building entrance.*

Photo: M. Chibbaro

***Figure 6.3.*** *A key box on a brick pedestal. In this complex, key boxes are located next to each fire hydrant rather than at each entrance.*

When building owners have the option of installing listed key boxes, they should weigh the cost against the risk of firefighters needing to force entry into their buildings along with any resulting damage. Knowledgeable designers and code officials can help educate building owners on the benefits of key boxes.

## Entry Points

The primary fire service entry point should be designated early in the planning and design of a building. This may or may not be the main occupant entrance/exit. One good location may be where a permanent security station is located — so the security staff can provide information to arriving firefighters. Emergency responders may also desire to coordinate their primary planned entry with features such as fire lanes (see Chapter 3), fire hydrants (see Chapter 4), key boxes (see previous section), fire department connections (see Chapter 10), and/or the fire alarm annunciator (see Chapter 11). Conversely, responders may not want too many features clustered near the same entrance, depending upon standard operating procedures (for example, a second-due engine company may be assigned to supply a fire department connection).

Any feature that helps speed entry into the building will facilitate emergency operations — especially those that make forcible entry unnecessary. One example is a feature that unlocks main entrance doors automatically upon fire alarm system activation.

Conversely, any feature that restricts firefighter entry should be avoided. Examples include fixed features over windows (figure 6.4).

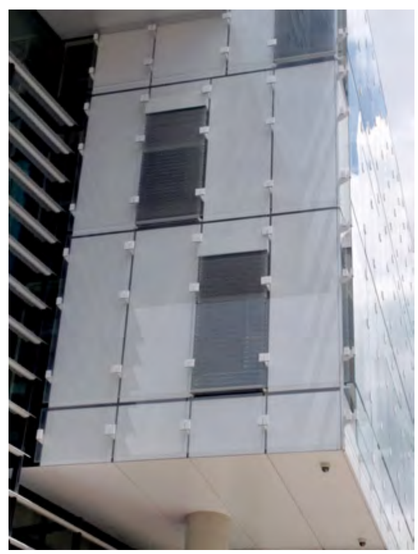

Photo: M. Chibbaro

***Figure 6.4.*** *The glass panels and sun screens surrounding this building's exterior walls would make exterior entry difficult.*

First arriving firefighters will often base their point of entry on which windows have fire or smoke venting from them. In most cases, entrances that serve any particular window will be readily apparent from the outside. If it is not obvious which doors provide access to various building areas, signs or diagrams outside each entrance door could eliminate confusion and save valuable time. The information on these signs should also be provided to the fire service for pre-incident planning (discussed further in Chapter 13).

In multi-tenant buildings, such as shopping centers and malls, tenants usually have rear exit or loading doors that firefighters use for access. Often these doors look alike, making it hard to correlate a given door with a particular tenant. This is solved by labeling rear doors on the outside with the tenant's name, address and/or suite number, in a size legible from the firefighters' vantage point (figure 6.5). Updating these signs as tenants change is important.

Photo: M. Chibbaro

***Figure 6.5.*** *A rear tenant door in a shopping center labeled with the address, suite number, and tenant name.*

Any door that appears to be functional from the outside, but is unusable for any reason, should have a sign reading "DOOR BLOCKED" or similar wording. The lettering size should be legible from the firefighters' vantage point. If these doors are properly marked, firefighters will not waste time trying to gain entry through them.

Access via stairs is addressed in the Stairs section of this chapter, below.

## Room and Floor Designations

Coordination of floor and room designations between all features is crucial. These features include stairs, elevators, fire alarm annunciators, building information signs or directories, public address systems, and all pre-incident planning documents. Consistent designations will avoid confusion, especially during time-sensitive emergency operations. Keep in mind that responders to emergency incidents unrelated to fire (such as spills or emergency medical calls) would not have the benefit of directions provided by a fire alarm annunciator, if available.

All numbering of floors and rooms should be easily readable and make common sense, even for those unfamiliar with the building. Confusing signage will delay emergency operations (figure 6.6).


Photo: M. Hurley

***Figure 6.6.*** *A confusing room number sign.*

Floor numbering is particularly important for firefighter safety. Firefighters prefer to approach a fire from below because heat and smoke normally rise. The numbering scheme should be intuitive, even in situations when visibility is low and when stair level signage is not available. In such situations, firefighters may need to count stair levels to keep track of the floor they are on.

Building floors should be numbered beginning at the main entry point. If the ground-level floor is designated as "ground", "lobby", or anything other than "first floor", then the next higher level should be designated as second, and so on. Confusion arises when first floor designations are used for upper levels (figure 6.7). For example, in a five-story building where the floors are designated G, 1, 2, 3, and 4, a fire on the level designated as 2 could be reported from the outside to be on the third floor. This could be dangerous as well as confusing if firefighters inadvertently make their way above the fire.

Photo: M. Chibbaro

***Figure 6.7.*** *An elevator car panel in a building with both a lobby level and first floor above it.*

Another example of a confusing numbering arrangement is one with arbitrary floor numbers. For example, a hotel that starts numbering at a high number — say floor 20 is the first floor, making floor 25 the fifth floor, and so on. Conversely, a hotel above another occupancy may restart numbering on an upper floor — floors 1 through 3 may be a mall and a hotel above starts numbering at 1 again on the fourth floor. Hotels sometimes also skip 13 when numbering floors. Great confusion can arise in such circumstances with fire reporting (as in the previous paragraph) or fire command located on the exterior while crews operate on the interior.

Where entry points exist on multiple levels, consider starting the floor numbering at the primary fire service entrance even if it is not the primary occupant or visitor entrance. Consultation with emergency responders is the only way to determine their primary entrance.

In buildings with many rooms or suites (such as apartments, hotels, and offices), room designation schemes should make it easy to find specific room numbers or to determine which direction to travel. Code officials and responders may have specific preferences. One preference could be numbers progressing higher or lower as you travel along a corridor; another could be even numbers on one side of the corridor and odd numbers on the other side. An example of a potentially confusing numbering scheme is one which proceeds in a circular fashion around the perimeter of a corridor; at any given point in such a corridor, the direction to specific room numbers would not be clear.

Where possible, room numbering should be consistent from floor to floor (i.e., rooms 212, 312, 412, etc. are located directly on top of one another. This is especially important where suites are similar such as hotels or apartments. Firefighters often investigate lower rooms or suites to determine their layout prior to initiating fire attack on a similar unit above. Where rooms or suites vary in size, consistent floor-to-floor numbering could mean skipping numbers on some floors.

Buildings with several wings introduce further challenges to room numbering. One way to handle this is to reserve certain number ranges for each wing (i.e., rooms 1 through 50 for wing A and rooms 51 through 100 for wing B). Another approach would be a four-digit number scheme where the first digit indicates floor, the second indicates wing, and the third and fourth indicate room or suite. For example, designation 9233 would mean floor 9, wing 2, room 33. Buildings with 10 or more floors would need more digits.

## Interior Access

Locking arrangements can hinder or facilitate firefighter entry. For example, stair doors may all be unlocked from the inside, may all unlock automatically upon fire alarm activation, or selective re-entry may be provided at certain levels. Special door-locking arrangements such as controlled access or delayed egress locks may need special approvals or permits from code officials. Locking arrangements should be carefully coordinated with egress schemes and voice alarm systems (see Chapter 11).


Photo: M. Chibbaro

***Figure 6.8.*** *A building diagram with the building features oriented properly but the text turned 90 degrees from the viewing angle.*

Large, unusual, or complex buildings present a challenge to maneuvering and locating specific areas. Building directory signs with room/tenant numbers, and graphic directories of tenant/agency layout can assist the public (figure 6.8). The same diagrams may assist firefighters. They will be of additional assistance if they include information such as stair and elevator identifiers, fire protection system information, and other fire protection features (see the Graphic Displays section of Chapter 11 for a full list of possible features).

Directories should contain features to assist unfamiliar users with orientation, such as road names or a compass point. The floor label designations on the directory must be consistent with those in the stairs, elevators, and fire alarm annunciator. Designations within floors should be descriptive of location in addition to the name of the tenant. Orient the building direction and text in the same direction as the viewing angle (figure 6.8).

Schematic floor plans showing the building layout and fire protection systems can assist the fire service. In buildings with fire command centers, the plans should be located there. In other buildings, these plans may be locked inside the fire alarm annunciator panel or control panel. Copies of these plans should also be provided to the fire service for pre-incident planning (discussed further in Chapter 13).

## Stairs

Stairs, especially those enclosed with fire-rated construction, are the primary means for firefighter access to above- and below-grade floors of buildings. In some cases, stairs serve the roof level — a feature that greatly facilitates roof access for tasks such as vertical ventilation of heat and smoke.


Photo: M. Chibbaro

***Figure 6.9.*** *A stair identification sign.*

Identification signage inside stairs at every level (figure 6.9) is a common provision in building and fire codes. These signs assist both occupants and firefighters. The exact information required on the signs varies according to the specific code.

Information that could be included on such signs includes the stair identifier, floor level, terminus of the top and bottom, discharge level, and direction to exit/discharge. Emergency responders may prefer a specific type of stair identifier (numerical vs. letter). The floor level designations must be consistent with the elevators, building directories, and fire alarm annunciators. A directional indicator (arrow or chevron) should also be provided, especially where upward travel is required to the discharge point. It is important that these signs be located at approximately adult eye level and be visible with the stair door open or closed.

Stair signs in stairs that lead to a flat or low-pitched roof should also indicate roof access. This can be identified as "fire service access to roof" or similar wording — to prevent the public from mistaking the roof for a safe way out. Signs in stairs without roof access should indicate "no roof access" or similar wording.

In hotels or other buildings with room or suite numbers, stair signs could also include the room or suite numbers most directly accessed by each stair on every level, (i.e., second floor of stair 3 has direct access to rooms 202 through 256). The latter signage would be extremely important where certain stairs provide no access to some sections of the building.

Some stairs discharge directly to the outside and others discharge at interior locations. The exterior of all stair discharge doors, whether interior or exterior, should also be labeled so that firefighters can quickly locate them for access to other floors (figure 6.10).


Photo: M. Chibbaro

***Figure 6.10.*** *Signs outside a stair discharge door indicating fire service access (right) and the levels served by the stair (left).*

The illuminated exit signs that should be at stair entry doors help facilitate firefighter egress. Floor-level exit marking will help if the exit signs are obscured by smoke.

## Stair Capacity

Building and fire codes require that stairs accommodate exiting occupants. Fire service personnel who may use the stairs are not typically factored into egress capacity calculations. When occupants are still exiting and firefighters are using the same stairs to enter the building (known as counter-flow), both occupant evacuation and firefighter access may take longer. This situation can be addressed by factoring the counter-flow into egress analysis — in particular for buildings with floors beyond the reach of available fire service ladders.

Furthermore, in most cases, stair capacity is calculated based on the floor with the highest occupant load. Typically, stairs are not widened as one travels in the direction of egress unless the stairs converge from both above and below. This approach assumes that people will evacuate in a phased manner, beginning with the floor(s) closest to the fire's origin. In an immediate general evacuation, or when people from unaffected areas choose to evacuate, the increased occupant flow may slow evacuation.

Both of these bottlenecks will be made worse as the height of the building increases. Furthermore, total evacuation is an increasing consideration due to major emergency events such as terrorism and natural disasters. A designer may encounter these issues on projects for large, high-security, or high-profile facilities. Egress delays caused by either counter-flow or total evacuation can be addressed with additional egress capacity by means of additional stairs, widened stairs, or properly designed and installed occupant evacuation elevators.

Another solution to the counter-flow issue is to provide an additional stair. This gives the fire service more flexibility to choose one of the stairs for firefighting while the remaining stairs are used solely for occupant evacuation. Some codes require an additional stair in buildings over a certain height; this is an outcome of a National Institute of Standards and Technology (NIST) recommendation regarding counter-flow following the 9/11 terrorist attacks.

Owners or operators of existing high-security or high-profile facilities may incorporate full evacuation into their emergency planning without considering any increase in egress capacity. Code officials should look for such situations.

## Elevators

Elevators have traditionally not been used for occupant evacuation. Two exceptions are when trained operators are available to evacuate occupants with special needs or where special features are incorporated to make some elevators safe for occupant use during an emergency (known as occupant evacuation elevators).

Building and fire codes typically require elevators to be designed for fire service use, in two phases of emergency operations. The installation standard used throughout the country for elevators is ANSI A17.1, *Safety Code for Elevators and Escalators.*

Firefighters are especially dependent on elevators in high-rise buildings. Loss of elevators due to a power outage was cited as a factor in the 1991 Meridian Plaza high-rise fire in Philadelphia, which killed three firefighters.[1]

Phase 1 of elevator emergency operation consists of a recall system that sends elevators to a designated primary level — with the intent being that this occurs before a fire can affect its safe operation. The recall occurs manually upon activation of a keyed recall switch (figure 6.11) at the designated level or automatically upon activation of detectors in certain areas. These areas typically include elevator lobbies, machine rooms, machinery space, and hoistways (if the hoistways have sprinklers). If a detector is activated on the designated primary level, the elevator cars are automatically sent to an alternate floor level. In either case, the elevators are rendered unavailable to building occupants. They remain at the recall level with doors open, so the fire service can quickly determine that they are clear of occupants and then use them in a manual control (Phase 2) mode. Coordinate with both code officials and emergency responders regarding which levels to designate for primary and alternate recall.


Photo: M. Chibbaro

***Figure 6.11.*** *An elevator lobby switch for manual fire service recall.*

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

The designated recall level is usually the ground or entry level. This will facilitate rapid firefighter access. For buildings with entrances on multiple levels, designers and code officials should consult emergency responders about the entrance firefighters intend to use initially. The fire service may also prefer to coordinate the designated recall level with the location of the fire alarm annunciator, fire control room, and/or the sprinkler/standpipe fire department connection(s).

Phase 2 emergency operation permits the fire service to use the elevators under their manual control (figure 6.12). This phase overrides all automatic controls, including the Phase 1 recall.

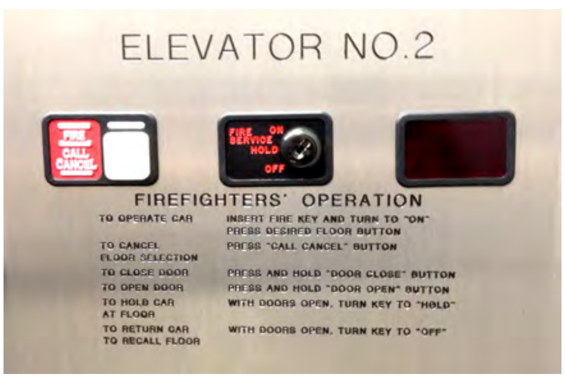

Photo: M. Chibbaro

***Figure 6.12.*** *Elevator cab controls for Phase 2 firefighter operation.*

Automatic power shutdown is a standard feature for elevators that have fire sprinklers located in their machine rooms, machine spaces, or hoistways. The intent is that shutdown occurs prior to, or upon, the discharge of water; this precludes water affecting the elevator circuits or braking system. Consider methods that will reduce the chances that emergency responders will be inadvertently trapped by such a shutdown. For example, if heat detectors mounted next to each sprinkler head are used to activate the shutdown feature, consider both their temperature rating and sensitivity relative to the sprinklers. Note that in many cases sprinklers may be omitted from these areas, thereby eliminating this as a potential cause of firefighter entrapment.

Detectors in the elevator machine rooms, machine spaces, or hoistways trigger separate and distinct visible indicators at the fire alarm control unit and the fire alarm annunciator. These indicators notify firefighters that the elevators are no longer safe to use, and they also provide some warning time prior to the shutdown feature that is required with sprinkler protection. In addition, visual warning signals with fire helmet symbols are provided in elevator cabs — these flash to warn firefighters when an elevator problem is imminent.

Fire service access elevators are those specifically designed and designated for use by emergency responders. These elevators open onto fire service elevator access lobbies that provide a safe staging area for firefighters to conduct operations or for occupants to await assistance (figure 6.13). These lobbies have access to both an elevator and an exit stair with a standpipe; this increases the access and fire attack options available to firefighters. The lobbies are also fire-rated and doors to the corridor or other floor areas have viewing panels to allow both firefighters and occupants to see conditions on the opposite side of the doors. Other features are incorporated to increase reliability – for example, hardened shaft enclosures, water infiltration protection, and a prohibition of sprinklers in the hoistway, machine room, or machinery space.

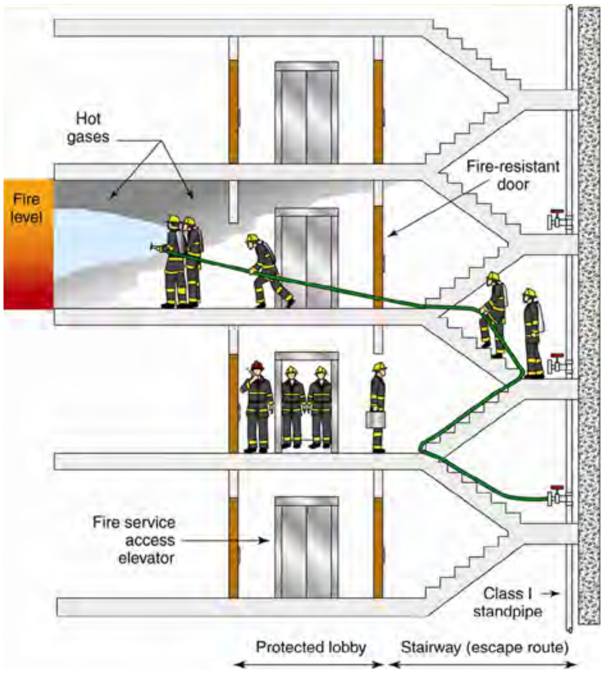


***Figure 6.13.*** *A section view of fire service access elevator lobbies. Figure excerpted from the 2012 IBC Transition from the 2006 IBC, Copyright 2012. Washington, DC: International Code Council. Reproduced with permission. All rights reserved. [www.ICCsafe.org].*

Firefighters regularly respond to elevator-related emergencies such as civilians trapped in elevator cars. In some cases, the entrapped person(s) may be experiencing a medical or psychiatric emergency. Properly-trained firefighters can interact with elevator systems to mitigate such incidents. A standard elevator key has been developed to increase consistency between buildings. Labeling elevator machine rooms or machinery spaces and indicating their locations on fire alarm annunciators will facilitate access. Communication with both emergency responders and elevator code authorities may be necessary for a full understanding of proper procedures.

## Utility and Equipment Identification

A routine function in any advanced fire suppression operation is to control (usually shut down) utilities to minimize hazards to firefighters. Making utilities easy to locate and identify will speed firefighters' progress. Electric, gas, and other fuel controls should be located either in dedicated rooms with marked exterior entrances (figure 6.14), or at exterior locations away from openings such as windows or doors. Several paragraphs in OSHA's electrical standards mandate signage for electrical rooms, switchgear, substations, and other equipment. OSHA's Specifications for Accident Prevention Signs and Tags standard covers signs to be used within buildings to protect workers, including firefighters.


***Figure 6.14.*** *A room with signage indicating (top to bottom), the main electric service, the location of a secondary electric service, and the fire alarm system control panel.*

Examples of such equipment include main water service, sprinkler or standpipe control valves, fire pumps, electric service, switchgear, generators, and air handling equipment. Labels on rooms containing this equipment will facilitate rapid access. Signage should be legible from the firefighters' vantage point.

Marking of fire protection system devices is discussed in more detail in Chapters 8 through 12.

**Questions to Ask – Firefighter Access**

- Does the terrain and landscaping around the building facilitate firefighting operations?
- Are all stakeholders aware of which entrance is designated as the primary fire service entry point and which features should be located there?
- Are key boxes required? Desired? At what location(s)? Which keys should they contain? How many sets? Must they be color-coded by use?
- Are floor levels designated sensibly such as limiting “first floor” designations to ground levels?
- Are floor designations coordinated between stair signs, elevators, building directories, and fire alarm annunciators?
- Are interior rooms labeled or numbered in an organized way to make them easy to find?
- Will signage be beneficial at limited access entrances?
- Are building directories needed at entrances? Should fire protection features be included?
- Are exterior entry doors labeled, especially rear or secondary entries?
- Will floor-level exit signs be needed?
- Are blocked doors provided with exterior warning signs?
- Are stair identification signs provided in each stair? Must stair identifiers be numbers or letters? Does each sign indicate whether or not roof access is available? Must room, tenant, or suite numbers served by each stair be shown?
- Are stair discharge doors marked on the discharge side?
- For unusual facilities or those which may need total evacuation, should firefighter access be augmented with widened stairs, additional stair(s), or dedicated stairs?
- Are elevators designed with recall features? Firefighter safety features? Standard elevator keys?
- Must elevator door keys or Phase II operation keys meet any specific local requirements?
- Must fire service access elevators and lobbies be provided for fire attack staging areas?
- Are rooms containing utility shutoffs, building service equipment, and fire protection equipment properly identified?

**Resources**

- IFC and IBC
- NFPA 1 and 5000
- Society of Fire Protection Engineers, *Human Behavior in Fire*
- ANSI A17.1, *Safety Code for Elevators and Escalators*
- NFPA 72, *Fire Alarm Code*
- NFPA 170, *Standard for Fire Safety and Emergency Symbols*
- OSHA Standard *Specifications for accident prevention signs and tags*, 29 CFR 1910.145
- OSHA Electrical standards, 29 CFR Part 1910, Subpart S

# CHAPTER 7
# HAZARDS TO FIREFIGHTERS

Several building features present unique or unexpected hazards to firefighters. Designers and code officials can mitigate some but not all hazards that firefighters face (figure 7.1). This chapter discusses the hazards and mitigation methods over which designers and code officials may have some control.

Photo: Glen Ellman

***Figure 7.1.*** *A firefighter bailing out of a building after running out of air.*

## Building Information

Several systems exist for exterior signage that contains building information specifically for firefighters. One is shown in figure 7.2; NFPA 1 contains another. Information that could be included on such a sign include construction type, presence of lightweight construction, contents hazard level, presence of fire sprinkler systems (full or partial), presence of standpipe systems, occupancy type, life safety issues, any special hazards present, and specific tactical considerations. Emergency responders must determine the appropriate tactical considerations, which may include conditions under which interior fire attack should not be undertaken. Signs should be highly visible, resistant to weather, and mounted at the main fire service entry point.

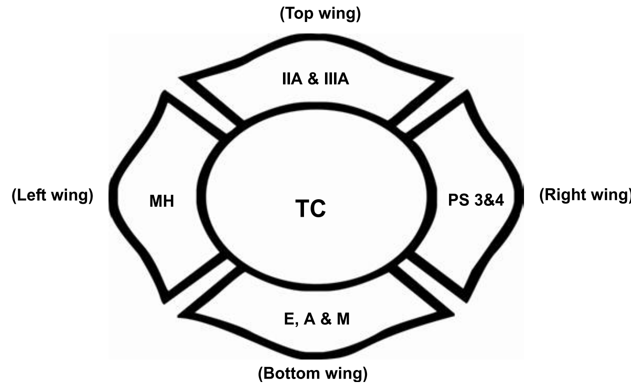


***Figure 7.2.*** *A sample sign for a building marking system. Diagram excerpted from the 2012 International Fire Code and Commentary, Copyright 2011. Washington, DC: International Code Council. Reproduced with permission. All rights reserved. [www.ICCsafe.org].*

More detailed information can be placed in a locked cabinet easily accessible to firefighters (figure 7.3) or in the Fire Command Center (see Chapter 11). Include the building information listed above as well as more detailed materials such as:

- Building schematic plans
- Occupancy details such as occupant load
- Hazardous material information (see the following section)
- Hazardous operations such as MRI machines
- Building service and fire protection equipment
- Facility contact persons
- Special occupant needs


Photo: M. Chibbaro

***Figure 7.3.*** *A cabinet containing building fire safety information for the fire service. The cabinet is conveniently located just below the fire alarm annunciator.*

Fire codes can list information to be provided on a Building Information Card. This can be an actual card or in electronic format. The latter makes the information very easy to access and read. The card can be located at a fire alarm annunciator, in a separate enclosure (see figure 7.3), or in a fire command center, if provided.

The preferred location for building information may be just inside or just outside the main fire service entry point. If the annunciator panel has adequate capacity, it can serve as the cabinet for building information.

Vacant buildings pose particular risks for firefighters. They are often in a deteriorated state and are sometimes structurally unstable. However, vacant does not necessarily mean unoccupied because such buildings may attract those seeking shelter or a place to perform illicit activities. These aspects complicate the decision regarding whether to attempt an interior fire attack or to fall back to an exterior attack.

Signage to quickly identify the condition of vacant buildings can provide critical information to factor into this decision. Such signage was recommended after a 2012 Philadelphia fire that killed two firefighters. The signage should include a highly-visible symbol and any specific hazards such as holes in roofs or floors, missing stairs or steps, and unsafe fire escapes (figure 7.4).


Photo: Cleveland Division of Fire

***Figure 7.4.*** *A vacancy status sign that warns firefighters that a building is unsafe to enter. Space at the bottom of the sign is for information on specific hazards.*

For any of the building information approaches in this section, information must be updated when any changes occur. Incorrect information can be more dangerous to firefighters than a lack of information. Initial information and any updates should also be shared with the fire service for pre-incident planning, which is discussed further in Chapter 13.

## Hazardous Materials

Several federal agencies regulate hazardous materials (HAZMAT) within or near buildings, including the Occupational Safety and Health Administration (OSHA), the Environmental Protection Agency, the Department of Homeland Security, and the Bureau of Alcohol, Tobacco, Firearms, and Explosives. At the local and state levels, regulation is usually handled under the auspices of a fire code and its enforcement system and may include permitting and associated requirements.

HAZMAT information and compliance is normally handled by facility management. Building codes typically require designers to report maximum quantities of certain hazardous materials during the initial building permit application. In some cases designers and code officials may have information on hazardous materials due to the need to provide features such as fire-rated barriers, fuel tank containment, or special protection systems. Designers and code officials should be aware of the following aspects of hazardous materials for situations when they can work with building owners and emergency responders to facilitate pre-incident planning:

- HAZMAT management plan
- HAZMAT information statement, inventory, or manifest
- Facility emergency contact or liaison
- HAZMAT marking
- Flammable liquid or gas tank approval
- Permits needed for any HAZMAT

One HAZMAT marking system that has been used for several decades is outlined in NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*. NFPA 704 symbols (figure 7.5) contain numerical designations for the severity of health hazards, flammability, and instability. They also have space for special hazards such as water-incompatible material.


Photo: M. Chibbaro

***Figure 7.5.*** *An NFPA 704 symbol.*

OSHA's Hazard Communication standard contains a HAZMAT marking system that is based on the United Nations' Globally Harmonized System. The numerical designations are in reverse order of those in NFPA's system. A comparison of these two approaches showing OSHA's pictograms is available at www.osha.gov/Publications/HazComm_QuickCard_Pictogram.html.

Processes or equipment hazardous to firefighters should also be labeled. Examples include MRI (Magnetic Resonance Imaging) or NMR (Nuclear Magnetic Resonance) machines, operations with flash fire or explosion potential, and hazardous atmospheres. Signage is appropriate outside the entrances of spaces containing such processes or equipment. OSHA's Specifications for Accident Prevention Signs and Tags standard covers signs for various hazards to protect workers, including firefighters.

Accurate HAZMAT information is vital for firefighters. Hazardous materials and processes change regularly and current information enables better decision-making during an emergency incident.

## Lightweight Construction

Lightweight structural components such as trusses, wood I-beams, and bar joists are routinely used in construction to span wide areas and minimize the need for vertical supports, reducing both material and construction costs (figure 7.6). Under ordinary conditions, these components work well and building codes have permitted them for many years. However, lightweight components often fail suddenly and catastrophically during fires. For example, wood and metal trusses are made of interdependent members that can all fail if one member fails. Adjacent trusses, in their weakened state, are then unable to carry the additional load and these can also fail in quick succession.

Even relatively small fires can cause failures depending on the fire's specific location in relation to the lightweight members.

Photo: M. Chibbaro

***Figure 7.6.*** *Steel bar joists.*

Lightweight wood structural members such as trusses (figure 7.7) and I-beams, sometimes called engineered wood products, are combinations of smaller components that form floor or roof assemblies.[2] These are used as an alternative to the traditional solid (dimensional) lumber joists that would burn through more slowly and likely provide additional time for fire operations before collapse. Lightweight members have less mass in terms of extra wood not needed for structural stability. The members therefore have reduced inherent ability to provide advance warning of collapse while under attack from fire. Also, the higher surface area-to-volume ratio of trusses compared to joists allows trusses to burn more quickly than traditional lumber. In addition, the metal gusset plates that hold lightweight wood components together may fail suddenly as fire consumes the wood in which the gusset teeth are shallowly embedded. A similar outcome may occur with components glued together with adhesives.

Photo: M. Chibbaro

***Figure 7.7.*** *The building on the right is being constructed with wood trusses. The adjacent finished building shows no indication from the exterior that wood trusses were used in its construction.*

Many firefighters have been killed in collapses attributed to lightweight construction members since the 1970s. It is extremely hard for firefighters operating at a fire with lightweight members to predict the time or extent of a collapse (figure 7.8). They typically cannot see how many members are affected, which components, and to what extent. When lightweight members become unstable, they exhibit little or no warning signs of imminent collapse. Little or no time will be available for firefighters below or above such construction to evacuate or to be rescued. As a result, incident commanders and/or safety officers typically consider the presence of these members in their incident risk analysis.

Photo: G. Jakubowski

***Figure 7.8.*** *Wood trusses after an attic fire.*

Marking buildings that contain lightweight structural members makes this information immediately available to the fire service. New Jersey requires a truss marking system

2. Some engineered wood products replicate heavy timber structural members and have inherent fire resistance. The discussion here is limited to lightweight engineered wood products.

(figure 7.9) as a direct result of the deaths of five firefighters in Hackensack in 1988.[3] Florida enacted a similar law after the deaths of two firefighters.[4] Other jurisdictions have similar requirements.

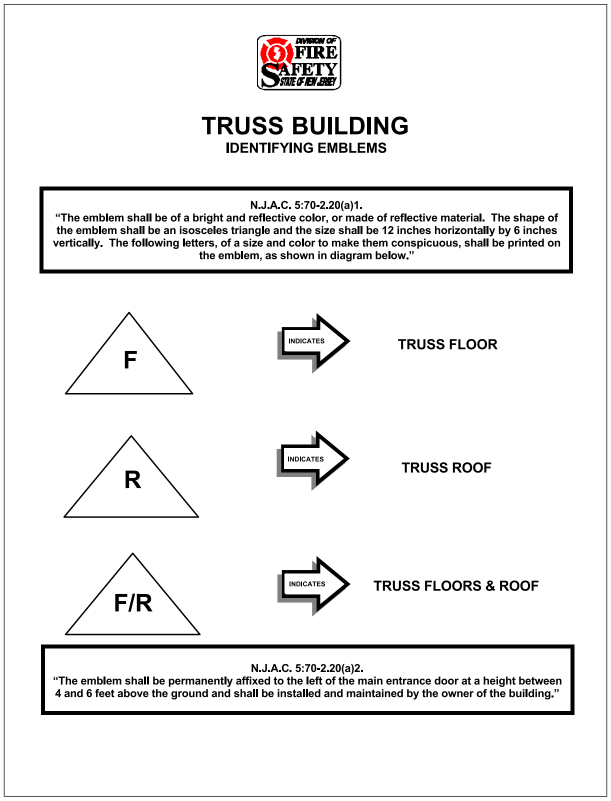


***Figure 7.9.*** *New Jersey truss building identification emblems.*

One approach to protect firefighters in buildings with lightweight construction is to cover the lightweight members with a protective layer of gypsum board. Alternative methods of protection are available, but designers must ensure that such methods are listed and approved. Model codes have expanded this approach to protect firefighters in all residential buildings, including one- and two-family dwellings.

Wherever lightweight construction techniques are used, serious consideration should be given to providing sprinkler protection throughout the building, if it is not already required. Sprinkler protection of combustible concealed spaces is an important feature for firefighter safety. After lightweight construction became prevalent, several codes expanded residential sprinkler system requirements – partly justified by the need for improved firefighter safety.

3. New Jersey Division of Fire Safety, NJAC 5:70 - 2.20(a)1 and 2.
4. Aldridge/Benge Firefighter Safety Act, Florida state Bill H727, 2008.

## Shaftways

Vertical shafts within buildings sometimes have exterior openings accessible to firefighters. These doors or windows should be marked on the exterior (figure 7.10). This indicates to firefighters that this is an unsafe entry point (figure 7.11) and to make entry at other locations.


Photo: J. Cisney

***Figure 7.10.*** *Exterior shaftway marking.*

Photo: M. Chibbaro

***Figure 7.11.*** *Interior view of an elevator shaft with windows.*

Often interior openings to shafts are readily identifiable. For example, ordinary elevator doors are not likely to be mistaken for anything else. However, shaftway marking is important for other interior shaft openings that could be mistaken for ordinary doors. One example would be a ventilation shaft with full-size doors rather than access panels.

## Rooftop Hazards

### *Skylights*

Skylights are convenient places for firefighters to ventilate roofs (figure 7.12). However, a firefighter could inadvertently fall through a skylight when it is obscured by smoke or snow. In 2015, a Colorado firefighter fell through a skylight and died several weeks later. Building owners and managers are required to take precautions to prevent such falls.


***Figure 7.12.*** *Several skylights on a roof.*

OSHA's Walking-Working Surfaces standard requires guarding for skylight openings and holes. One way to accomplish this is by using a screen or cover; however, a firefighter with protective equipment and tools will likely exceed the weight capacity of the screen or cover. Furthermore, skylight covers can become brittle over time. For the protection of firefighters, a protective railing may be a more reliable guard.

### *Obstructions*

As discussed above, firefighters often operate on roofs to accomplish tasks. This occurs frequently when visibility is limited due to darkness or smoke. When cables, wires, ropes, or other obstructions are suspended below the height of firefighters, firefighters may inadvertently walk into them, causing injury or even a fall from the roof. Ways to mitigate this hazard include brightly-colored markings or a guard or equipment below the obstruction (figure 7.13) to preclude firefighters from contacting it.

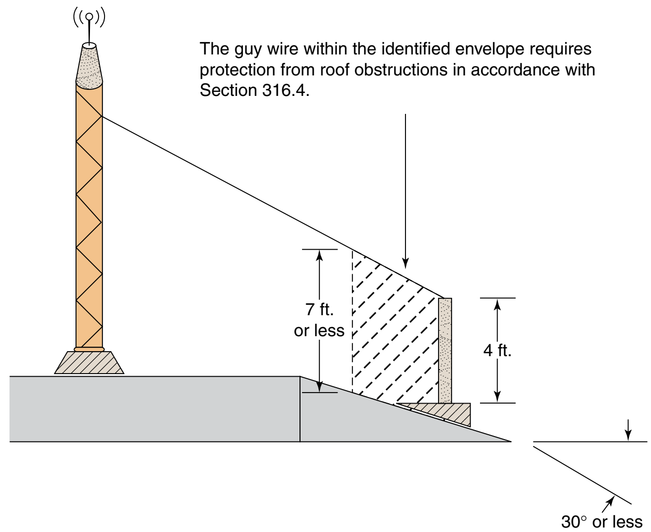


***Figure 7.13.*** *Diagram showing the area needing protection from overhead obstructions on a roof. Diagram excerpted from Significant Changes to the 2012 International Fire Code, 2012 Edition, Copyright 2012. Washington, DC: International Code Council. Reproduced with permission. All rights reserved. [www.ICCsafe.org].*

## Energy Conservation and Alternative Energy Features

Energy conservation and alternative energy features have become very important components of buildings. Associated technology has evolved rapidly. However, the risks associated with new technology should be thoroughly considered. Hazards associated with these features have arisen in several fire incidents.

A 2013 fire in an office building in Wisconsin[5] illustrated several such hazards. Concealed spaces insulated with recycled denim material allowed a fire to spread out of the reach of the fire sprinkler system and fire service hose lines. The photovoltaic system on the roof prevented vertical

5. "Perfect Storm", B. Duval, Fire Journal, January/February 2014.

ventilation due to the electrical hazard. As the fire progressed, the photovoltaic system energized the building's metal roof and wall panels, further complicating firefighting efforts. The 18-hour firefighting operation resulted in a $13 million dollar loss and completely depleted the town's water supply.

### *Photovoltaic Systems*

Photovoltaic systems (figure 7.14) pose several challenges to firefighters. The electric shock hazard is complicated by the fact that electricity is usually fed in two directions; from the photovoltaic cells and from the electric service or storage batteries. What looks like a disconnect switch can simply isolate individual panels or circuits from each other, leaving both live. In some cases, scene lighting the fire service uses at night can provide enough illumination to keep the cells live. Clear warning signs and circuit marking can help firefighters operate safely around such systems, along with effective pre-incident planning. Several fire and electric code provisions provide for emergency responder safety and access.


Photo: M. Chibbaro

***Figure 7.14.*** *Photovoltaic panels on a roof.*

Another consideration is the difficulty to access and ventilate a roof with photovoltaic cells. It would be prudent to arrange cells to provide clear access paths (wide enough to accommodate firefighters) and clear areas (large enough for effective ventilation at high points on the roof). Such arrangements are addressed in recent fire code revisions.

Photovoltaic panels are often mounted on roofs supported by lightweight components. This will compound the issues involving lightweight construction discussed above.

### *Vegetative Roof Systems*

The same access and ventilation concerns arise when roofs are covered with vegetation. As with photovoltaic cells, consider space for access paths and ventilation locations (figure 7.15).


Photo: M. Chibbaro

***Figure 7.15.*** *A vegetative roof system with paths that could be used for access and ventilation.*

Maintenance of the landscaping is important to keep vegetation from drying out and becoming a fire hazard itself. In addition, proper maintenance of drainage systems will prevent overloading the roof. Programs for such maintenance will help ensure that maintenance continues on an ongoing basis.

Due to their weight, vegetative roof systems must be supported by substantial roof construction such as reinforced concrete. This construction is difficult or impossible for firefighters to cut for ventilation. Consider built-in vents that are manually operable from the exterior (see the Smoke Control and Ventilation Systems section in Chapter 12).

### *Other Features*

Energy conservation and alternative energy technology continues to evolve at a rapid pace. Stakeholders should discuss features such as the following to facilitate emergency operations and ensure adequate firefighter protection:

- Wind turbines
- High-powered antennae
- Hydrogen fuel cell power systems
- Battery storage systems
- Nuclear power generation
- High-performance glazing
- Insulation systems

General considerations for energy conservation and alternative energy features that may assist emergency responders include:

- Notifying responders before a feature is installed and seeking their guidance
- Obtaining all required permits and inspections
- Protecting the feature with suitable fire barriers and suppression systems
- Providing remote alarms
- Providing emergency access for fire apparatus and/or firefighters
- Providing clearly-identified fuel or electric shutoffs in safe locations
- Providing warning signage and appropriate system diagrams
- Posting emergency contact information for owners and technical personnel
- Sharing information for pre-incident planning
- Training emergency responders to help them operate safety
- Maintaining the feature in good working order
- Notifying emergency responders when the feature is removed, relocated, or modified

**Questions to Ask – Hazards to Firefighters**

- Will a building information signage system be needed?
- Should a cabinet containing building information be provided?
- Will vacancy status signs be needed?
- Can HAZMAT information be provided to firefighters?
- Will a HAZMAT marking system be needed?
- Will lightweight construction signage be needed?
- Must lightweight construction be protected using a listed and approved method?
- Must exterior shaftway openings and interior shaftway doors be marked?
- What precautions are needed to prevent falls through skylights?
- Are rooftop obstructions marked or blocked off?
- Photovoltaic systems: have signage, circuit marking, access, and ventilation been considered?
- Vegetative roof systems: have access, ventilation, and maintenance been considered?
- Has firefighter safety been considered when implementing other energy conservation and alternative energy features?

**Resources**

- IFC
- NFPA 1
- NFPA 70, *National Electrical Code*
- NFPA 170, *Standard for Fire Safety and Emergency Symbols*
- NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*
- NFPA 1620, *Standard for Pre-Incident Planning*
- NFPA *Building Construction for the Fire Service*
- OSHA Standard *Walking-Working Surfaces, Guarding Floor and Wall Openings and Holes*, 29 CFR 1910.23
- OSHA Standard *Specifications for Accident Prevention Signs and Tags*, 29 CFR 1910.145
- NIST web site containing research on firefighter safety: http://www.nist.gov/fire
- NIOSH Publication 2005-132, *Preventing Injuries and Deaths of Fire Fighters Due to Truss System Failures*, available at www.cdc.gov/niosh/docs/2005-132
- Fire Protection Research Foundation, *National Engineered Lightweight Construction Research Project report*, 1992
- Fire Protection Research Foundation, *Fire Safety Challenges of Green Buildings*, 2012, http://www.nfpa.org/~/media/files/research/research-foundation/research-foundation-reports/building-and-life-safety/rffiresafetygreenbuildings.pdf
- National Association of State Fire Marshals, *Bridging the Gap: Fire Safety and Green Buildings Guide* available at http://www.firemarshalsarchives.org
- Underwriters Laboratories Fire Safety Engineering, *Firefighter Safety and Photovoltaic Systems,* http://www.ul.com/global/documents/offerings/industries/buildingmaterials/fireservice/PV-FF_SafetyFinalReport.pdf
- Underwriters Laboratories Fire Safety Engineering, *Structural Stability of Engineered Lumber in Fire Conditions,* http://ul.com/global/documents/offerings/industries/buildingmaterials/fireservice/NC9140-20090512-Report-Independent.pdf
- California State Fire Marshal, *Solar Photovoltaic Installation Guide*, 2008, available at http://osfm.fire.ca.gov/training/pdf/photovoltaics/solarphotovoltaicguideline.pdf
- FM Global Data Sheet 1-15, *Roof Mounted Solar Photovoltaic Panels*
- FM Global Data Sheet 1-35, *Green Roof Systems*
- ANSO/ASSE A1264.1, *Safety Requirements for Workplace Walking/Working Surfaces and Their Access; Workplace, Floor, Wall, and Roof Openings; Stairs and Guardrail Systems*

CHAPTER 8

# SPRINKLER SYSTEMS

Fire sprinkler systems (figure 8.1) provide early fire control or extinguishment. If properly designed, approved, installed, and maintained, sprinkler systems help to mitigate the fire hazard to both occupants and firefighters. The importance and effectiveness of sprinkler systems has been demonstrated for many years.[6] Lack of sprinkler systems, inadequate coverage, or sprinkler impairments have been cited after many major fire incidents. For example, deficiencies in the sprinkler system of a Georgia textile recycling plant in 2007 led to one worker fatality and a challenging incident for firefighters to control, which resulted in the destruction of the plant.[7]

Photo: M. Chibbaro

***Figure 8.1.*** *A fire sprinkler system.*

Building codes, fire codes, life safety codes, and owner criteria specify when to provide sprinkler systems. The code is usually a model code adopted by a jurisdiction, sometimes with local amendments. Various sections of the OSHA standards require the installation of sprinkler systems, or reference standards that contain such requirements. In addition, sprinkler systems may be required by insurance carriers or provided voluntarily to reduce fire insurance premiums for buildings in which proper sprinkler coverage is provided.

Sprinkler systems should be designed to meet an installation standard. This is important for both occupants and firefighters — whether the system is mandatory or installed voluntarily. NFPA has promulgated several standards for commercial and residential sprinkler systems. These standards contain some flexibility in portions of the system that may impact the fire service. This chapter provides guidance to designers so they may exercise this flexibility to benefit fire service operations.

Designers and code officials may also refer to NFPA 13E, *Recommended Practice for Fire Department Operations in Properties Protected by Sprinkler and Standpipe Systems*. Keep in mind that any given fire service organization may follow different standard operating procedures, and communicating with local emergency responders is important.

The provisions in this chapter also apply to similar water-based suppression systems such as foam-water sprinkler systems. Standpipe systems (which are often integrated with sprinkler systems) are covered in Chapter 9. Fire department connections for sprinkler systems are covered in Chapter 10. Sprinkler designers should also see Chapters 11 and 12 for special coordination considerations regarding fire alarm and smoke control systems.

For sprinkler systems to be effective, it is imperative that they are regularly inspected, tested, and maintained. Impairment programs and maintenance are covered in Chapter 13.

## Zoning

It is important for sprinkler designers and fire alarm designers to work together in buildings of any size or complexity. The fire alarm system will often have an annunciator to indicate the location of the alarm to the fire

6. National Fire Protection Association, Fire Analysis and Research Division, *U.S. Experience with Sprinklers*, June 2013.
7. 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.

service. Coordination is essential to furnish the fire service with clear information on the fire or its location.

The sprinkler piping arrangement will determine how specific a fire alarm annunciator is able to indicate water flow signals. In other than very small buildings, a separate sprinkler zone should be provided for each floor level. This will allow the fire alarm annunciator to indicate the floor level, directing the firefighters to the correct floor.

As the size of each floor increases, the amount of time it takes firefighters to search a floor to find the fire location increases. Large floor levels should be divided into zones (figure 8.2). This accomplishes two things: (1) it allows the fire alarm to indicate the fire location more specifically within a floor, and (2) it limits the system area taken out of service for maintenance, repairs, or renovations.


Photo: M. Chibbaro

***Figure 8.2.*** *A sprinkler zone control station. The sign on the control valve indicates "first floor south" but there is no indication where the boundary is between south and north.*

Sprinkler designers should consider firefighter access when arranging zones. As a case in point, consider an apartment building in which some individual apartments span two stories (figure 8.3). If the two-story units can only be accessed from one level, the sprinklers in both levels of those units should be zoned with the level of entry.

Photo: M. Chibbaro

***Figure 8.3.*** *Some apartment units in this building span the fourth and fifth floors. Each two-story unit has a single entry door on the fourth floor.*

Similar zoning challenges can arise in multi-story lobbies or in buildings where a multi-level area is adjacent to a one-level area with a high ceiling. In such scenarios, it may be clearer for fire service response if the sprinklers in the high area were zoned with the level sharing the same floor level. If you zone sprinkler piping in terms of floor level rather than ceiling level (even if this means additional piping) firefighters will know to what level they must stretch hose lines.

In buildings with standpipe systems, sprinkler systems are usually combined with them and fed by a single water supply. Typically, all sprinklers would be located downstream from a zone control valve that will shut off water to all sprinklers but not to fire hose connections. This allows the hose connections to remain available for manual fire suppression during times when one or more sprinkler zones are shut off for any reason, either before or during an emergency incident.

## Control Valves

Valves that control sprinkler systems or specific zones must normally 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.

Fire service personnel often need rapid access to water supply control valves. If a valve is closed when an incident occurs, it may need to be opened to permit the flow of water. Conversely, a sprinkler valve may need to be closed to assist in manual suppression efforts. At the conclusion of an incident, valves are turned off as quickly as possible to limit water damage. This also allows the fire service units to return to service as soon as possible to be available for other responses. Accordingly, careful consideration should be given to access, signage and proper pre-incident planning.

Valves can be installed for a variety of purposes, including main shutoff, zone (sectional) shutoff, fire pump bypass, pump testing, draining, and testing. Control valves are not installed in fire department connection (FDC) feed lines; this ensures that this important backup to the primary water source can never be shut down easily or inadvertently.

Labeling each valve clearly to indicate its purpose avoids confusion. This can be helpful during an emergency incident and during repair or maintenance, when a valve can inadvertently be shut off or left shut. Using descriptive labels such as “sprinkler system 12th floor” or “pump bypass — normally closed” are far better than simply “control valve.” Some jurisdictions also require color-coding of valves or valve handles.

If the area fed by a valve is not obvious, an additional diagram can provide important information. For instance, if a floor has multiple zones, each control valve sign should identify the corresponding zone, such as “12th floor east” or “zone 5-4.” A diagram of zones and the boundaries between them should be mounted adjacent to each valve (figure 8.4). This will enable firefighters to quickly determine which valve controls each specific area. It will also help prevent inadvertent maintenance/repair/renovation related shut-offs of an area not intended to be disconnected.

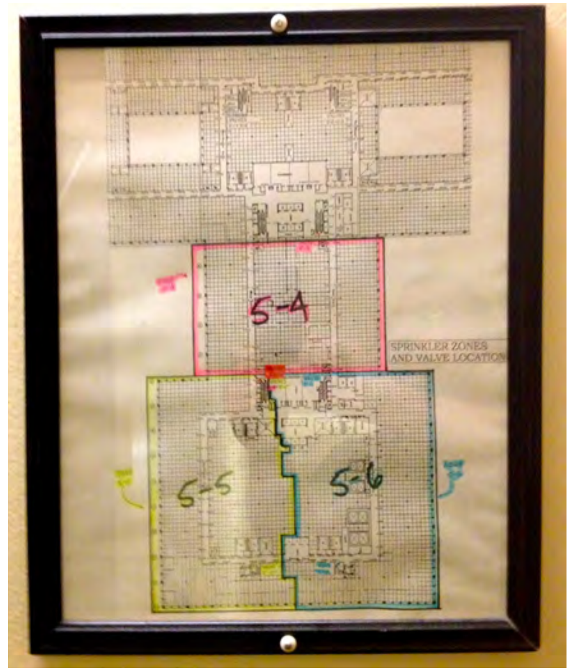


Photo: M. Chibbaro

***Figure 8.4****. A sprinkler zone diagram showing the outline of three zones.*

The location and position of a valve will determine how easily it can be accessed during an emergency incident. Some code officials or emergency responders prefer that valves be at a height reachable without the need for a ladder. Others prefer that valves be located higher to make tampering more difficult.

On rare occasions, sprinklers will not control a fire as expected — for example, where the occupancy or storage has changed without a corresponding upgrade of the sprinkler system. In such scenarios, firefighters may need to shut off water to interior systems to conserve water for hose streams. Properly-located exterior valves, such as post indicator valves, will be accessible even during a serious fire incident. Wall-mounted valves should be positioned far enough from windows, doors, or vents (figure 8.5) to minimize the chances that fire or smoke will make them inaccessible.

Photo: M. Chibbaro

***Figure 8.5.*** *A wall control valve next to a window. Fire issuing from this window could prevent access to the valve.*

Interior control valves are best located in fire-rated stairs (figure 8.6) or fire-rated rooms with exterior entrances. There they will be both readily accessible to firefighters and protected during a fire event.

Photo: M. Chibbaro

***Figure 8.6.*** *A sprinkler zone control valve in a stair enclosure.*

When a water supply control valve must be located in a room, a sign outside the door helps firefighters to quickly locate it (figure 8.7). If the valve is in a concealed space, provide a sign outside the access panel – for example, "ELEVATOR SPRINKLER VALVE ABOVE". If the concealed space is above a suspended ceiling, the appropriate place for the sign is on the fixed ceiling grid, rather than on a removable ceiling tile.


Photo: M. Chibbaro

***Figure 8.7.*** *The sign on this door indicates that a sprinkler control valve is located within the room.*

In some cases, sprinkler systems are fed from two different standpipes or feed mains, in a dual feed arrangement. This redundancy may be required in very tall buildings and other high-risk occupancies. Designers may also elect this arrangement to provide a hydraulic advantage when determining pipe sizes. However, the dual valve arrangement may add confusion when a system must be shut down. Cross-reference signs should be provided at each such valve (figure 8.8) to indicate the location of the companion valve that feeds the same system.


Photo: M. Chibbaro

***Figure 8.8.*** *A sign near a sprinkler control valve indicating the location of the other valve that controls the same system.*

Some jurisdictions require exterior signs that indicate the locations of interior valves. An example of wording is "Sprinkler Control Valve 15 Ft. Opposite this Sign." The disadvantage of such signs is that they provide valuable information to potential arsonists.

## Partial Sprinkler Systems

Sprinkler systems often provide full coverage for buildings. In other cases, only a portion of a building will be protected. Perhaps only an underground level or high-hazard tenant has sprinkler protection. Incident commanders will factor sprinkler coverage into their strategy. Accordingly, the locations that are sprinklered and unsprinklered in a building should be indicated in the building information or marking system used (see the Building Information section of Chapter 7) and on pre-incident plans. Partial system coverage should also be indicated on the fire alarm annunciator and by signage at the FDC (figure 8.9). Conversely, signs indicating full coverage might be desired for all buildings that are fully protected.


Photo: M. Chibbaro

***Figure 8.9.*** *A sign indicating the areas covered by the sprinkler system that is fed by the FDC shown.*

The primary purpose of residential sprinkler systems installed in multi-family occupancies under NFPA 13R is the protection of occupants' lives. These systems usually have significant unsprinklered areas such as attics and concealed spaces. This is allowed even if the areas are built with combustible construction materials because they have a low rate of fatal fires occurring. However, fires have originated in or extended into attics and concealed spaces from the exterior, resulting in major fires with significant property losses. Buildings with NFPA 13R sprinkler systems are limited in height to four stories; however, they can be large and the type of sprinkler system will not be apparent from the exterior (figure 8.10). Signage should inform firefighters that they are operating at buildings with residential sprinkler systems. One example could be a sign at the FDC indicating "Residential Sprinkler System – Partial Coverage" or similar wording.

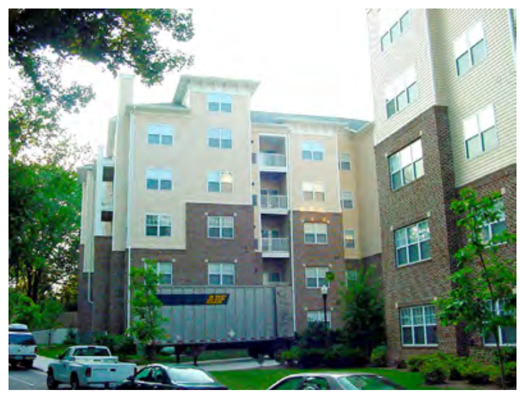

Photo: I. Humberson

***Figure 8.10.*** *A building with six occupied levels from this vantage point. However, from a code standpoint, it is a four-story building because the top level is a loft and the bottom level is a basement mostly below grade. Its residential sprinkler system does not cover the combustible attic space or the truss spaces between floors.*

Residential sprinkler systems installed in one- and two-family dwellings under NFPA 13D are also life safety systems with significant unsprinklered areas. However, unlike multi-family occupancies, they are recognizable and should not necessitate any special signage.

## Unwanted Alarms

Unwanted sprinkler alarm scenarios involve alarm conditions without an actual emergency. Such nuisance alarms are not "false alarms" or malfunctions because the equipment usually performed as designed. Proper design, installation and approval can contribute to the reduction of unwanted nuisance alarms. This both decreases the hazards to firefighters and keeps them available for actual emergency incidents.

Water flow indicators sense the movement of water or pressure changes. Their activation triggers a water flow alarm signal to a fire alarm system or remote monitoring location. It is important that these devices operate when water is actually flowing from sprinklers rather than due to other non-emergency circumstances such as water surges. Devices such as excess pressure pumps (that maintain pressure on systems at a higher pressure than the highest expected surge) or retard chambers (that fill to accommodate expected surges) help prevent unwanted alarms.