NFPA
National Fire Protection Association

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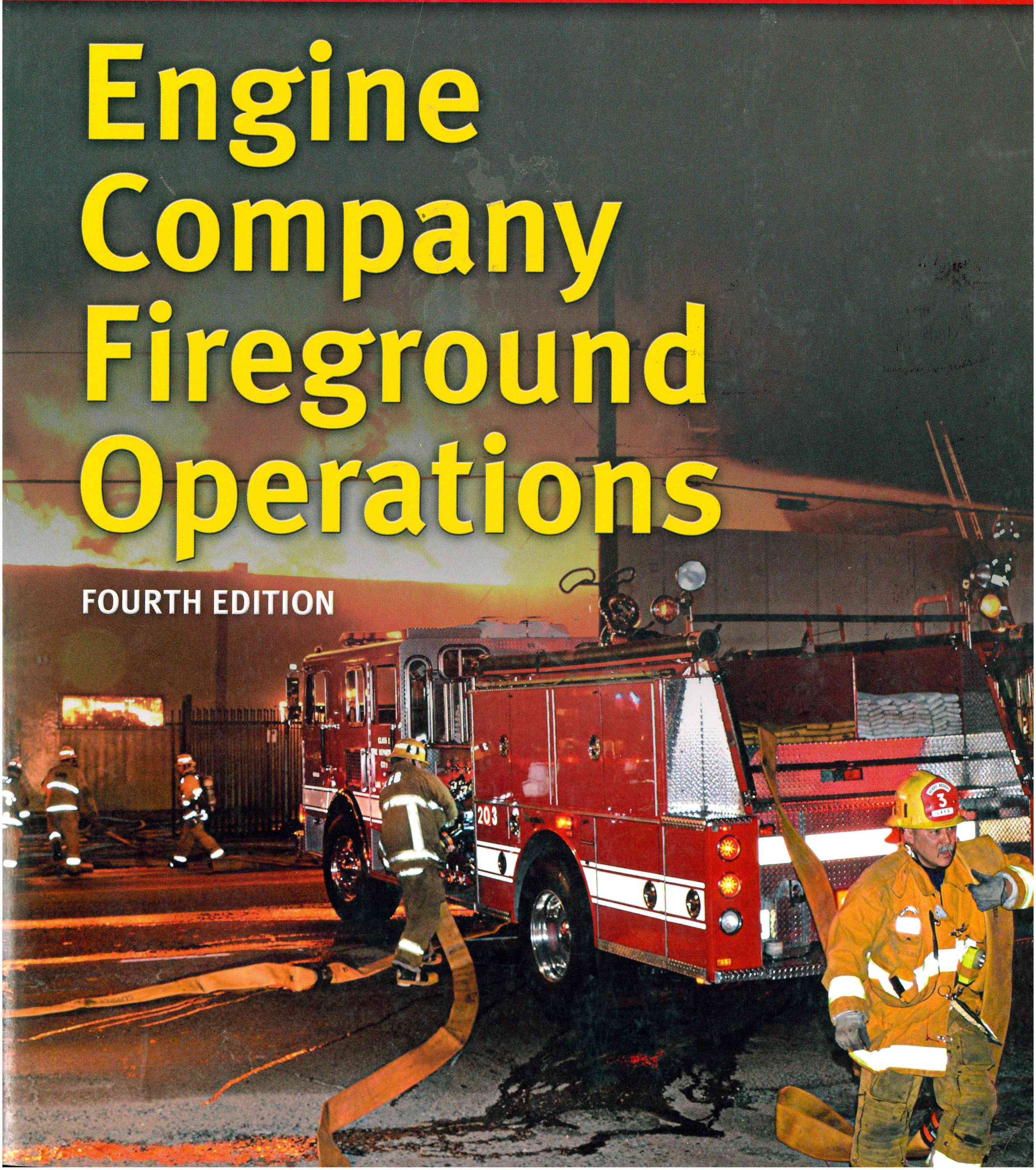
Engine Company Fireground Operations

FOURTH EDITION



CHAPTER 15

High-Rise Firefighting

LEARNING OBJECTIVES

- Define a high-rise building.
- Describe center-core and side-core construction.
- List the specialized problems and hazards encountered in high-rise firefighting.
- Identify the keys to success for fighting fires in high-rise buildings.
- List the various high-rise building systems.
- List the responsibilities of lobby control.
- Examine the sequences of engine apparatus positioning.
- List and describe the dangers that can occur in the firefighting stairway.
- Explain the multiple strategies and tactics that can be used in high-rise firefighting.
- Explore the various fire attack methods using 1¾-inch hose, 2-inch hose, 2½-inch hose, and master streams.
- Understand the change in emphasis from search and rescue (SAR) to search-evacuate-rescue (SER) in high-rise firefighting.
- Explain the defend-in-place strategy.
- Explain the reasons ventilation should be withheld until after the fire is extinguished.

Introduction

This chapter covers the basic strategy, tactics, and responsibilities that may be assigned to the engine company in moving and delivering water to a high-rise fire. It also covers other support tactics involved in high-rise firefighting. The official definition of a high-rise building is any building where the floor of an occupied story is greater than 75 feet (23 m) above the lowest level of fire department vehicle access. That means you don't have to be a major city fire department to deal with all the problems encountered in high-rise firefighting.

Between 1977 and 1996, 16 firefighters were killed from traumatic injuries while fighting fires in high-rise buildings—a relatively high number compared to the actual confirmed high-rise fires we respond to in the United States. A high-rise apartment or office building that is on fire is a complex environment that presents several difficult challenges for firefighters to overcome. The primary goals are still to save lives and quickly put out the fire. Most firefighters, even those in major cities, may go their entire career without battling a true significant high-rise fire. Those who have actual experience are a select few. Almost all of us must rely on study, theory, fire science, high-rise case studies, computer modeling, and fire simulators, as well as diligent new and old construction inspections; pre-incident planning (prefires); and on-site, hands-on training.

Findings from the NFPA Research Report and Others

The economic opportunities in urban cities increase the population, and new construction projects can accommodate more people with a greater profit margin if construction is shifted from horizontal to vertical development. Because of the tremendous fire load and occupancy load potentials, the loss of life can be great. According to the National Fire Protection Association (NFPA) 2016 research report *High-Rise Building Fires,* there were, on average, 40 civilian deaths, 520 civilian injuries, and $154 million in direct property loss occurring annually between 2009 and 2013. Yet because of Type I construction and built-in fire protection systems in modern high-rises, fires in high-rise buildings are less likely to spread beyond the room and floor of origin than are fires in shorter buildings, making high-rise structures actually safer than all the other types of buildings we respond to. The NFPA report on *High-Rise Building Fires* breaks down high-rise buildings into six property classes:

- Apartments (including multifamily housing)
- Hotels
- Dormitories
- Offices (business and commercial)
- Facilities that care for the sick (hospitals, retirement nursing homes)
- Other (multi-use occupancies)

During the 4-year study, U.S. fire departments responded to an average of 14,500 high-rise structure fires per year. Sixty-two percent of all high-rise fires occurred in apartments, and 64% of all the high-rise civilian fatalities also occurred in apartments. Of all the property classes, residential buildings are least likely to be sprinklered. Regardless of the building height, the leading cause of fires in all the property classes involved fires in the kitchen, in cooking areas, and with cooking equipment—in other words, *food on the stove.*

The primary factor that makes fighting fires in skyscrapers so challenging is their height. Fires are beyond the reach of ground-based operations and deprive the fire department of exterior rescues and firefighting, even with aerial apparatus. Ladder pipe master streams may reach the sixteenth floor to fight against auto exposure, but it is unlikely these streams will be effective in penetrating fires above the eighth floor **FIGURE 15-1**.

On the upside, most of the high-rise building fires in the NFPA 2016 report began on floors no higher

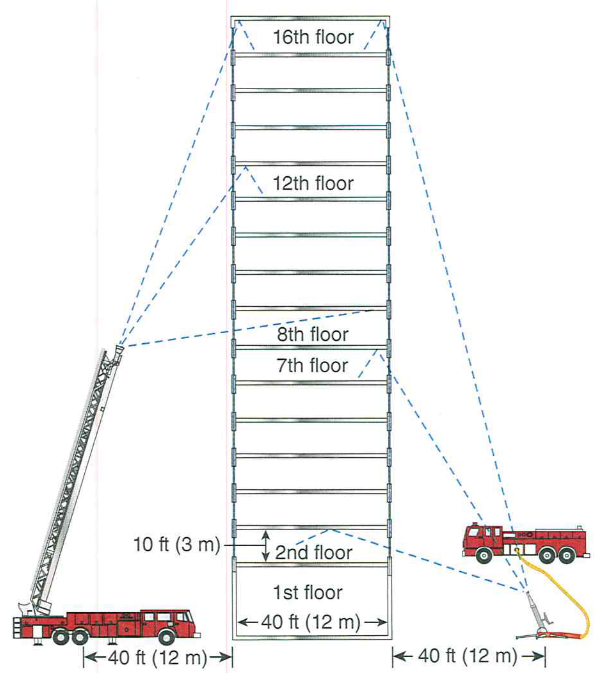


FIGURE 15-1 In high-rise buildings, it is unlikely that elevated master streams will be effective in penetrating fires above the eighth floor.

than the sixth floor. This report contains other valuable statistical information, and the findings read like a pre-incident plan on what we can expect. Not all high-rise fires will be as spectacular as the First Interstate Fire, but if we're going to respond to one, more than likely it will be a high-rise apartment building fire.

Ladder companies are traditionally assigned reconnaissance (recon), lobby control, elevators, forcible entry, search-evacuate-rescue (SER), ventilation, occupant management, and many other support activities. Although the engine company's primary responsibility is fire suppression, many supporting tactics, tasks, and responsibilities under the incident management system/incident command system (IMS/ICS) fall to an engine company during a high-rise fire. It is assumed that all engine and ladder companies will work together within the IMS, but this topic goes beyond the scope of this book.

The One Meridian Plaza Fire and the First Interstate Fire are referred to extensively throughout this chapter for the lessons learned. These are not just old stories of historical fires; these are examples of the realities we may face before the end of shift. In these two spectacular fires combined, everything that could go wrong did go wrong—and both fires can play out exactly the same way today. Standard operating procedures (SOPs) were drastically changed within their respective departments, and they should serve as blueprints about what to expect and how every fire department should approach fire attack in high-rise buildings. The One Meridian Plaza Fire claimed the lives of Captain David Holcombe, Firefighter Phyllis McAllister, and Firefighter James Chappell, all from Engine Company 11. We owe it to them to learn and apply the lessons learned so their sacrifices weren't in vain. They died, so that you could learn and live. Engraved on the One Meridian Plaza Firefighter Memorial are the following words:

To Sacrifice One's Own Safety In The Service To Others Requires A Courage That Is Rare. Those Among Us Who Do Are True Heroes.

Case studies and National Institute of Standards and Technology (NIST) experiments have shown that fire growth and heat release rates have increased with modern synthetic fuels used in residential and commercial furnishings. In compartments with office furnishings and computer equipment, total room involvement has occurred within 7 minutes of ignition; therefore, the speed at which firefighters can access, confine, and extinguish the fire greatly increases the safety of building occupants and the firefighters themselves. The increased heat release rate coupled with the toxicity of the deadly smoke makes it essential that the initial attack effort be planned to overwhelm or at least contain the fire effectively.

Specialized Problems and Hazards

The major issues that firefighters face is heat, elevation, water, breathable air, and wind. Due to the elimination of ground-level access and the inability to ventilate a high-rise fire quickly, intense sustained heat can quickly fatigue firefighters during interior operations **FIGURE 15-2**. Frequent rotation of crews helps prevent heat exhaustion. Elevation affects the physical stamina of firefighters and creates possible water pressure and supply problems. Spare self-contained breathing apparatus (SCBA) cylinders may not be readily available in the initial stages of the fire attack. Unlike house fires, gaining quick access to a window or door for fresh air is not possible while fighting a fire inside a high-rise building. Wind, along with stack effect (which will be covered later), affect the movement of smoke within the building; often the wind can create unpredictable air movement and complicate the fire problem by spreading heat and smoke.

FIGURE 15-2 Working in sustained intense heat along with elevation can quickly fatigue firefighters. Frequent rotation of crews allows them to recover quickly and prevents heat exhaustion.

Courtesy of Mike Handoga.

Other problems and hazards include, but are not limited to:

- Large open spaces allowing for rapid fire spread
- Large fire loads
- Low water pressure
- High occupancy loads
- Numerous forcible entry problems
- Cubicle configurations, maze-like spaces, obstructions, and barriers
- Dead-end corridors
- Plenums, which contribute to horizontal fire spread
- Poor maintenance of building systems, especially in older buildings
- Lack of training for firefighters in high-rise hydraulics
- Lack of training for firefighters in dealing with all the high-rise building systems
- Inadequate prefire planning
- Lack of continual review of existing prefire plans at the company level
- Unfamiliarity with new security technology
- Inadequate training and education on high-rise fire and emergency procedures for building occupants

A high-rise acronym that existed in the early 1970s is worth reviving for the newest generation of firefighters:

Hazards
In
Greater
Heights

Reach is beyond the capabilities of aerial apparatus and ground-based operations.
Interior fire attack is essential on upper floors.
Significant smoke and stack effect potential is present.
Evacuation time required to remove all building occupants is unreasonable and impractical.

Variables in High-Rise Firefighting

This chapter introduces you to the basics of high-rise firefighting, along with the many engine company responsibilities and problems that may (or will) be encountered in this low-frequency, high-risk event. The many variables include the size of the fire department; the number and types of apparatus available, including specialized apparatus; the number of on-duty personnel; their level of training in high-rise operations; the availability of well-trained mutual aid resources; water supply within the building; the existing public water supply for the incident; water delivery capability within the building; type of occupancy; building size, height, and design; and building systems.

Automatic fire alarm systems are not all the same; some are basic, some are very sophisticated and divided into zones. Elevator recall and emergency control systems are different. Heating, ventilation, and air-conditioning (HVAC) systems are also unique, with some having the ability to ventilate smoke while keeping the stairways pressurized—even with two or three doors open on different floors. In other words, all these variables combined make each high-rise building unique.

The fire attack is based on the building design, the number of occupants, the number of stairways, their configuration, and their proximity to the seat of the fire. There is no simple solution or single way to fight fires in high-rise buildings. Fire behavior, fire load, the location and size of the fire within the building, the heat, and the speed of smoke spread, as well as the extra time and physical exertion to initiate the fire attack and conduct every phase of firefighting, increase the complexity of high-rise operations.

Successful High-Rise Firefighting

The secrets to success in fighting fires in high-rise buildings are pre-incident planning, consulting with the building or maintenance engineer, developing a prefire plan, and following the IC high-rise fire checklist. All the possible scenarios, foreseeable problems, and questions regarding water pressure, sprinklers, fire pumps, standpipes, pressure-reducing valves (PRVs), elevators, the capability of the HVAC system to pressurize and ventilate the structure, electrical system for the building, and emergency generators need to be identified and discussed with the building engineer or maintenance supervisor and entered into the prefire plans, which are now accessible on in-cab mobile data computers. A department incident commander (IC) high-rise fire checklist should be developed and carried on every fire apparatus. This checklist ensures that important considerations are not missed or overlooked; however, following a high-rise checklist is not an initial action plan. As for any structure fire size-up, problems still need to be identified before strategies and tactics can be selected to solve them. Once the incident action plan is developed, follow it.

High-rise buildings are rarely left unattended. There is usually some responsible person on duty 24 hours a day who has knowledge of the building systems or can quickly contact a knowledgeable person by phone. If the fire safety director or the building engineer is on site, that person needs to have building and system plans at the ready and stay glued to the IC at the command post. Once the prefire plan is in place, stick to it. It is impossible for a company officer to be knowledgeable of all the buildings and systems within her or his jurisdiction. The importance of building surveys; on-site, hands-on training; and prefire planning cannot be overemphasized.

General Information on High-Rise Building Construction

High-rise building construction falls into three groups:

- High-rise structures built before 1945
  - Heavyweight building: 20–30 pounds per cubic foot
  - Structural steel component encased in concrete
  - Exterior walls are masonry
  - Floors are reinforced concrete
  - Lack of plenum spaces
  - Exterior walls are tied to the floors
  - Steam heated; lack of HVAC systems
  - Core construction was not used
  - Most exterior windows can be opened
- High-rise structures built between 1945 and 1968, when the post–World War II economy forced changes in the building industry
  - Medium weight: 10–20 pounds per cubic foot
  - Fire or smoke towers
  - Many exterior windows can be opened
- High-rise structures built after 1968
  - Lightweight buildings: 8–10 pounds per cubic foot
  - Lack of compartmentation
  - Wide open, unobstructed floor space
  - Spray-on fireproofing for steel structural members
  - Exterior and curtain walls are a combination of glass and steel
  - Exterior windows do not open
  - Open plenums with lack of fire stops
  - Q decking used for floors
  - Center-core construction used extensively

Center-Core and Side-Core Design

Center-core construction is used in the majority of super-high-rise buildings. It is also known as central-core design. Constructed of reinforced concrete, it is a giant vertical shaft that runs the entire height of the skyscraper and contains the elevators, enclosed stairways, standpipes, sprinkler system piping, power, water and plumbing, restrooms, air supply, return air shafts, and other building systems **FIGURE 15-3**. Central-core design allows for 360° views with unobstructed floor space. The potential problem with central-core design is that the fire can also whip around 360° and flank the fire attack team. The fire attack strategy may have to be a pincer or double-flanking attack using a second attack team accessing the fire floor from the same or a second stairway to confine the fire and prevent it from circling around.

Side-core design puts the giant vertical shaft with all the major building systems to one side of the building **FIGURE 15-4**. There may still be additional stairways with standpipes (if required) on the opposite side of the structure for access and egress. Fire attack strategy in side-core construction should most likely be a direct frontal attack.

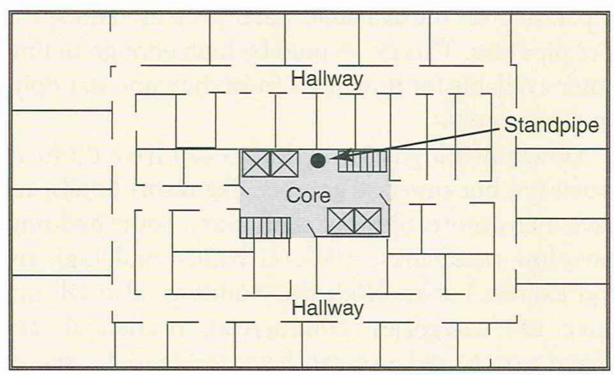


FIGURE 15-3 Center-core or central-core design.

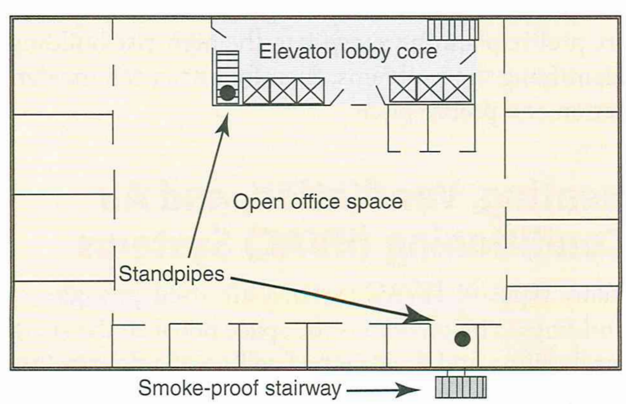


FIGURE 15-4 Side-core design.

Non-core design is found in low-rise buildings and older high-rise buildings, and it will require standpipe operations above the third floor. Access and egress stairways that would be used for fire attack and evacuation are found on either end or side of the building, with elevators and an additional stairway in the center or elsewhere.

Floor Area

Floor area or square footage in a high-rise building can range between 10,000 square feet and well over 300,000 square feet, as found in city-block buildings, Las Vegas hotels and casinos, as well as other exotic resorts; 80,000 square feet per floor in a skyscraper is not unusual. Total floor fire involvement of such structures requires 6,000 to 10,000 gallons per minute (gpm) to control, which is an unrealistic number obtainable from manual firefighting efforts.

Large fires in such structures may end up being a "controlled burn" that relies on the fire resistance integrity of Type I construction until the fuel load is consumed. In the controlled burn scenario, the sprinkler valves (often two) might need to be turned off because all sprinklers on the floor will fuse open from the heat. Significant water flow onto the fire floor could occur depending on the available water pressure and sprinkler pipe size. This flow could be high enough to limit water available for hose lines from the same standpipe on other floors.

Downtown high-rise buildings can have up to six stairways, but super-structures, like resort hotels, can have many more. Elevator shafts vary. Some buildings have low-rise banks, midlevel banks, and high-rise and express banks. High-rise buildings also fall into three use categories: commercial, residential, and mixed use. Mixed use can have residential units on the upper floors, while the main street level can be offices, stores, banks, showrooms, restaurants, and other public assemblies. All vary by design and are uniquely complex among themselves. Again, the keys to success are prefire planning specific to the high-rise building, identifying the problems, then following the incident action and prefire plans.

Heating, Ventilation, and Air Conditioning (HVAC) Systems

Many types of HVAC systems are used in high-rise buildings. The **plenum** is the space between the structural ceiling and the dropped ceiling of a floor/ceiling assembly—the underside of the floor above. It is used to house and conceal telecommunications cables for telephone and computer networks. It is also used to support and conceal a labyrinth of HVAC ductwork containing forced-air supply shafts; forced-air return shafts, which are usually the plenum spaces themselves; supply air fans; return air fans; outside air intake dampers; exhaust dampers; mixing dampers; fire dampers; air diffusers; air filters; humidity control equipment; and wiring for smoke and heat detectors.

To keep them heated or cooled, high-rise buildings are well-sealed to control interior temperatures. The lack of functional windows makes ventilation during the fire attack nearly impossible, and because wind currents can make fire behavior unpredictable, opening windows is not recommended during fire attack. Ventilation tactics often take place after the fire has been controlled or extinguished. The lack of ventilation creates the greatest physical stressor—trapped heat—that firefighters must deal with in high-rise firefighting.

There are system variables, but the strategic objective for smoke control is to rely on the HVAC system to limit the spread of fire and control the movement of smoke within the building during the fire by pressurizing the stairways. In many high-rise buildings built during the 1960s, 1970s, and 1980s, only the stairways were pressurized. Usually the elevator shafts were not. Unfortunately, many of these systems are not tested on a regular basis. In older systems, some stairways may be underpressurized, allowing for smoke to enter the stairway, especially when many occupants are self-evacuating from numerous floors. In other cases, the stairways may be overpressurized on floors in close proximity to the pressurization fans, making some doors very difficult to open from the inside of the hallway as they open against the stairwell pressure. This can cause problems and panic for elderly occupants, children, or those with disabilities who may not have the strength to push the door against the pressure in the stairway. Therefore, annual testing of stair pressurization is important to prevent over- or underpressurization of the system when operating in alarm.

Many practices still recommend completely shutting down the HVAC system during a fire alarm, so the fresh air intakes don't provide additional oxygen to the fire. Smoke and heat detectors within the air ducts should automatically close the dampers to isolate the fire area, but if they don't, an operating HVAC system can spread smoke throughout the entire building. This was the case on November 21, 1980, at the MGM Grand Hotel Fire in Las Vegas, Nevada. Workers were tired of having the air conditioning shut down in the casino and hotel after years of false alarms and having to reset the system and smoke dampers, so they decided to solve the problem by screwing the smoke dampers open. This action prevented the HVAC system from automatically shutting down during the fire, and 85 people were killed.

When the movement of air is intensifying the fire, shutting down the HVAC system is the correct action to take. On the other hand, shutting down the system may also eliminate the ability of the system to pressurize the elevator shafts, stairwells, and floors above and below the fire—something that is essential for high-rise firefighting because it prevents smoke from entering these areas. In most high-rise modern construction, the elevator shafts and floors above and below the fire are now pressurized, sandwiching the fire floor to prevent its spread. Newer HVAC systems are extremely powerful and efficient in pressurization and removing smoke from the affected areas. They are designed to remain in operation during a fire, and they protect firefighters from the development of a flow path.

It is impossible for a fire officer to know every working detail about the various HVAC systems. The only way to be sure if the HVAC system should be shut down or left running as designed in order to utilize the system to its maximum potential during a fire is for the IC to rely on the expertise and judgment of the building engineer or the building maintenance supervisor, or to refer to the recommended procedures that have already been determined in the prefire plan. All units should report to the IC any adverse effects of smoke movement or of the fire intensifying from the HVAC system so it can be shut down.

Automatic Sprinkler Systems

An automatic sprinkler system is the most effective way to prevent, control, or suppress a major high-rise fire. Firefighters must rely on the built-in fire protection systems to help them protect occupants and property. For these systems to work as designed, it is essential that they are installed, tested, inspected, and maintained according to NFPA 13, *Standard for the Installation of Sprinkler Systems* and NFPA 25, *Standard for Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems.* Major fires have occurred in high-rise buildings where the fire protection systems failed to work properly, creating tactical and logistical nightmares where even the most experienced and well-equipped fire departments could not control the fires.

At the One Meridian Plaza Fire, only the below-grade levels were sprinklered. When the building systems were upgraded, the dry standpipe system was converted to a wet system with two fire pumps, one serving the lower floors and a mid-rise pump serving the upper floors. This conversion facilitated the installation of sprinklers throughout the building, but it still wasn't required. At the request of the tenants, automatic sprinklers were installed on floors 30, 31, 34, and 35. After all the Philadelphia Fire Department efforts and sacrifices, the fusing of 10 sprinkler heads on floor 30 finally extinguished the fire, but not before it consumed eight floors of the building.

At the First Interstate Fire in Los Angeles, California, a major sprinkler renovation was nearly complete: 90% of the building was fully sprinklered, including all the fire floors. But the building manager and sprinkler contractor decided to wait until the water flow alarms were installed before charging the system. Sectional valves were closed between the standpipe risers and the sprinkler system on each floor. The fire pumps were also shut down. Los Angeles Fire Department (LAFD) firefighters were left with static head pressure in the standpipe to fight the fire initially. Fortunately, the sprinkler installation supervisor was still on site, but he was trapped on the roof. He was rescued by a police helicopter and eventually returned to the command post. He was taken to the basement where he manually started the two fire pumps. Then he coached firefighters to open the sprinkler sectional valves on floors 17 and 18 in anticipation of the fire lapping past floor 16; however, the fire was stopped on floor 16, with the *flow the floor* strategy, which will be covered later in this chapter.

Nozzle Water Flow and Pressure Problems in Fully Sprinklered High-Rise Buildings

This section on nozzle water flow is offered by Deputy Chief Gary English, Assistant Fire Marshal (Retired) of the Seattle Fire Department:

Water flow and pressure problems at the nozzle are caused by many reasons, such as kinked hose, multiple hand lines flowing, relying solely on the building's fire pump, the engine pumping at too low a pressure into the fire department connection (FDC), supply lines from the engine to the FDC too small, or too few, standpipe friction loss (common with 4-inch standpipes), in-line valves partially closed, or the simple lack of water in the municipal water system from the hydrants. But there is another, albeit not altogether common, problem that might occur in buildings with fire sprinklers. Simply, the fire sprinkler flow is so high that the available water flow for hose lines from a combination (sprinkler and fire hose) standpipe is reduced. How? Sprinklers are expected to flow a set amount of water in a finite "design area," that is, where a handful of sprinklers are designed to prevent fire spread, or control the fire to a limited area. This is based on the hazard class and area size, along with other variables. For example, the flow for a designed area might be 90 gpm, delivered by 6 sprinkler heads, flowing at 15 gpm each. A flow requirement is based on the hazard and fuel load of what is "expected" to be in the design fire area.

We know from hard-earned experience and the UL/NIST tests that a fire consuming legacy fuels (office furniture made up of organic material like cotton, paper, wool, and wood) grows slower and produces less heat than similar furniture made up of modern fuels of hydrocarbons (synthetics and plastics). When sprinklers designed for a slower, cooler fire (organics) are used to cover new materials that create much hotter, faster fires (hydrocarbons), this can result in inadequate flow from the "unexpected" fire load. In most cases, the difference is not extreme enough to create problems unless there is much more fuel in one area, that is, an area with high concentrations of hydrocarbons such as a large computer server area.

Because the hydrocarbons burn hotter and faster, the hazard is greater, but the volume of water produced by the sprinkler stays the same for the legacy fuel-designed area. As this fire spreads beyond the designed area, more and more sprinklers open, using more and more water from the combination standpipe. More flow for sprinklers equals less flow for hose lines and potentially less pressure available.

This phenomenon is not limited to changes in office furniture construction and adding computers; it can happen any time the hazard is greater than the sprinkler design. A potent example is using a large area to store new furniture and new computers while the office is in transition, and piles of empty cardboard boxes are created when new computers are set up. Piling hundred-plus sets of boxes, Styrofoam, plastic wrap, computers, furniture, and so on, in a concentrated area within an open floor plan space creates a fire hazard greater than the sprinklers were designed to control. A fire in this pile could rapidly overwhelm the fire sprinklers in the design area and continue to spread. Although some may think the sprinklers activating ahead of the fire will prevent fire spread, this is not necessarily true because the lower levels of the pile are protected from the sprinkler water by the layers in the pile itself.

Fire sprinklers do not shut off once the fire has burned out in their design area or in the area beyond the design area; rather they simply just keep flowing until they're manually shut off at the valve. An uncontrolled fire might send heat well beyond the combustion area, opening fire sprinkler heads across a ceiling area where nothing is burning. In this example, rather than a 90-gpm flow, the additional fused sprinkler heads operating in an area five times larger could result in a flow of 450 gpm. As a practical matter, the pipe sizes supplying the sprinkler might not allow this full flow, but even a sprinkler flow of 350 gpm is greater than a 2½-inch hand line.

How would we recognize this reality and what can we do to prevent this occurrence? Exterior size-up might reveal visible flames that, in a building with sprinklers throughout, would indicate either sprinkler system failure or excessive fire loads not being controlled by sprinklers. When firefighters arrived at the First Interstate Fire, flames were visible from every window of the twelfth floor. This would be the first on-site clue that they were dealing with a nonsprinklered building or that the sprinkler system was not working. Eyewitnesses or floor cameras might have revealed dramatic fire buildup before cameras were obscured. First-arriving units at the fire floor might find heat levels greater than what would be expected if sprinklers were controlling the fire.

In these types of scenarios, command should consider the possibility that sprinklers are not controlling the fire; turning off sprinklers to the floor helps preserve adequate flows and pressures for the operation of hand lines. This was the concern at the First Interstate Fire. The fire floors were sprinklered, but the system was shut down for renovation. Because the fire was so advanced on the involved floors, the sprinkler technician felt the sprinkler demand would only rob water from the fire attack hose lines, so the decision was made to leave the sprinkler valves closed.

Turning off sprinklers may be more complicated than you might expect, especially when the fire sprinkler valve is located in the same area as the fire. Even when sprinkler valves are located in stairwells (and these valves are not always located there), the correct valve must be located for the area to stop sprinkler flow. For looped sprinkler systems, closing more than one valve might be necessary. Examining sprinkler layout on plans is not always possible, but a quick survey of a lower floor might indicate valve locations for the fire floor (sometimes hidden in drop ceilings). It is most effective to confer with building engineers because they will have information on sprinkler zones and valves.

Using standpipes that are *not* interconnected with a sprinkler system (Class 1 standpipes) might be more effective. For interconnected combination standpipes, it may be necessary to turn off some or all of the sprinkler flow before an attack can be initiated to allow adequate hand-line flow with the required minimum tip pressure. The potential for low-pressure flows makes the use of 2½-inch hose lines with 1⅛-inch smooth-bore tips for attack lines a safe bet for maximum efficiency in the worst-case scenario.

Keep in mind that the sprinkler flow from a standpipe may significantly affect all hand lines on all floors from that particular standpipe. Thus, flows from exposure lines on upper floors must be considered. Low-flow pressures from interconnected standpipes also results from the activation of a combined sprinkler system. Once sprinkler valves are located for the fire area, a firefighter should be assigned to close and control the valves slowly and be ready to reopen them quickly if sprinklers are needed to support the fire attack. Closing the valves too early, before the attack team gains control of the fire, could allow for rapid fire growth.

Simply being aware of this potential problem is not enough. Building inspections that identify unusually high fire loads in any sprinklered building should result in having the owner or tenant remove or reduce the fire load or verifying that the fire sprinklers are adequate for the load through the department fire marshal.

NFPA 14

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, is a must-read reference document for any firefighter who will be involved in standpipe operations. NFPA 14 has evolved over time; thus, a standpipe system built according to the 1970s version of NFPA 14 could be very different from a new building built to the latest standards. Understanding the standpipe requirement differences by year is important to understanding the capacity and pressure availability and system limits. NFPA 14 provides minimum requirements for the design of the standpipe system, which is determined by the height of the building, the floor area of each story, the occupancy classification, egress system design, required flow rate and residual pressure, and the distance of the hose connections from the sources of the water supply.

Early high-rise buildings used 4-inch standpipes. Newer buildings (since the late 1980s) use 6-inch standpipes. Standpipes and hose are classified by the intended user. Class I is for firefighter use, Class II is for tenant use, and Class III has both Class I and Class II features that can be used by both tenants and firefighters. Both Class II and Class III also have 1-inch-diameter hose lines with a nozzle installed in building hose cabinets for ready use by tenants. Because tenant hose is designed for tenant use, the pressure and flows are much less than those for firefighter hose. When properly supplied by an adequate municipal water supply and engines pumping in tandem,

FIGURE 15-5 The fire code requires standpipe and sprinkler FDCs to be labeled. If there is signage for pressure requirements, pump to the posted pressure.

Courtesy of Raul Angulo.

you can attain approximately 1,000 gpm from a 4-inch pipe and approximately 2,500 gpm from a 6-inch pipe. Because water sources and apparatus vary, attaining 1,000 gpm from a standpipe is the most realistic expectation.

The following list highlights some key points in NFPA 14 that can be helpful in identifying potential dilemmas and takes the guesswork out of possible solutions. It also provides clues for quick decision making by the company officer and the engine apparatus driver. Although codes and standards have requirements, not all buildings comply. Many older buildings may be in compliance with older requirements, and these buildings are not required to meet newer codes and/or standards. Therefore, the following may not always be true for older buildings.

- The fire code requires standpipe at sprinkler FDCs to be labeled. If there is signage for pressure requirements, pump to the FDC at the posted pressure **FIGURE 15-5**.
- Where the standpipe connections (FDCs) serve more than one building or location, signage should be provided by the FDC for the buildings and locations served **FIGURE 15-6**.
- Where two or more standpipes are installed in the same building or section of the building, the standpipes will be interconnected (with some exceptions).
- There should be a fire hydrant within 100 feet of an FDC.
- If the required inlet pressure at the Siamese is 150 pounds per square inch (psi) (10.3 bar) or less, there will be no signage.
- Maximum pressure at any point in the standpipe system shall not exceed 400 psi (28 bar) (with some exceptions).

FIGURE 15-6 When standpipe FDCs serve more than one building or location, signage should be provided for the buildings and locations served.

Courtesy of Raul Angulo.

- Buildings constructed before 1993 have a minimum flow rating of 500 gpm at 65 psi. These are low-pressure standpipes. Multiple 2½-inch hand lines can exceed the flow capability depending on nozzle selection and use, and you will run out of water. (Some cities, such as Seattle, Washington, required retrofits of older buildings and all newer construction to have a minimum pressure of 125 psi but reduced gpm to 300 gpm at outlets. This allowed smaller, more maneuverable hand lines in the sprinklered buildings).
- Where the static pressure of a 2½-inch (65-mm) hose connection exceeds 175 psi (12.1 bar), a listed pressure regulating device must be installed to limit the static and residual pressures at the hose connections to no more than 175 psi. (Expect a pressure-reducing valve [PRV].)
- A PRV is designed to reduce the downstream water pressure under *both* flowing (residual) and nonflowing (static) conditions.
- A pressure-restricting device (PRD) is designed to reduce the downstream water pressure under flowing (residual) conditions *only*, which allows higher static pressure in the line.
- For Class I, the minimum flow rate of the most remote standpipe is 500 gpm (1,893 L/min) through the two most remote 2½-inch (65-mm) hose connections.
- The minimum flow rate for additional standpipes is 250 gpm (946 L/min) per standpipe for buildings with floor areas that do not exceed 80,000 square feet (7,432 m^2) per floor.
- For buildings that exceed 80,000 square feet per floor, the minimum flow rate for additional standpipes is 500 gpm (1,893 L/min) for the second standpipe and 250 gpm (946 L/min) for the third standpipe if the additional flow is required for an unsprinklered building.
- The maximum standpipe flow rates are 1,000 gpm (3,785 L/min) for buildings that are fully sprinklered, and 1,250 gpm (4,731 L/min) for buildings that are not sprinklered.
- For Class II systems, the maximum flow required from a 2 ½-inch hose connection is 250 gpm.
- Based on the travel distances required to cover all portions of each floor level of the building and starting from the hose connection, the travel distance shall be 200 feet (61 m) for sprinklered buildings built after 2005 (older buildings have shorter travel distances, e.g., 150 feet). These distances are measured in a straight line; therefore, longer hose is needed.
- The travel distance shall be 130 feet (39.7 m) for nonsprinklered buildings. Two hundred feet of hose should be the minimum to start any fire attack.
- A hose connection should be provided at the highest landing of the stairway with roof access, or it should be provided on the roof.
- In stairways without roof access, there may, be a hose connection at the top of the standpipe on the roof.

Solid strategy and tactics are rooted in the engine officer's understanding of NFPA 14.

Strategic and Tactical Limitations

Tactical Clarifications

Consideration must be given to the size of a fire department and its established SOPs. The high-rise tasks and responsibilities in this chapter are written in a logical sequence, but the sequences may vary and even take place simultaneously depending on the practices of your department and the size of the initial response. Because the number of firefighters and apparatus available also vary, any support assignment or function that is usually assigned to the ladder company is most likely assigned to an engine company. Staffing for specific assignments also varies; it is not specific to any unit. Members of a ladder company may easily find themselves operating hose lines on a large fire because the ability to complete their assigned tactical objectives are prevented until the fire is knocked down. For example, if 2½-inch hose lines are utilized, it will obviously require more firefighters and maybe even two companies to advance and operate a single line than if 1¾-inch hand lines are used. This chapter does not address how many firefighters are needed to advance a 2½-inch hose line or how far the firefighters should be spaced out. These specifics depend on the experience and physical ability of every firefighter. Although some hose and nozzle techniques are covered, 2½-inch hose-handling techniques are part of Firefighter I and II training, and efficient hose-handling techniques should have already been developed through on-site and hands-on training. Nevertheless, certain tactics and responsibilities need to be carried out regardless of who is assigned the task. If more firefighters are needed to accomplish essential tactics, call for them; if they are not available, the IC has to manage the available resources as best as can be expected.

Firefighter Safety Considerations

High-rise building fires and standpipe operations require the efforts of many firefighters. Every person engaged in firefighting or rescue operations must be in full personal protective equipment (PPE), including SCBA, and no one is to be assigned to work in the building alone. All assignments should be given to teams of at least two firefighters. The only exception is the firefighter assigned to run the elevator car in Phase II. Because this firefighter is shuffling crews between the ground floor and staging, he or she is not alone, even though technically it is a stand-alone assignment.

Smoke cannot usually be removed or ventilated quickly in high-rise buildings; therefore, visibility can be limited. Firefighters working together can keep track of each other by sight, touch, voice, radio communications, or they can remain in contact with the hose line or search rope stretched for that purpose. A firefighter working alone is in great danger of being injured or lost no matter how menial the task, so maintain the buddy system. Numerous firefighters have died in high-rise fires as a result of becoming disoriented and then lost in the thick smoke.

The decisions on what fire attack actions to take may ultimately be made by the fire. The amount of radiant heat energy is tremendous, and it is hard to convey its power with words. Keep in mind that your PPE has a threshold rating of 572°F (300°C) for 15 to 30 seconds. Like everything else in the room, your bunker gear absorbs heat, and once it's heat-saturated, you will get burned. No PPE has been invented to counter the effects of the heat that a firefighter endures during prolonged operational periods in a high-rise fire. Basic maneuvers, like the ability to advance a charged hose line, take longer and become more difficult, and crews may succumb to heat exhaustion much faster in a high-rise fire than in other types. Flashover and post-flashover ceiling temperatures can be up to 2,000°F (1,093°C), melting everything in the overhead and all office furnishings throughout. These drips of burning plastic land on the carpeting, igniting the floor and the adhesive mastic underneath. Floor temperatures when the floor is on fire can be around 500°F (260°C).

At the DeWitt-Chestnut Fire in Chicago, Illinois, firefighters were pushed back numerous times attempting to attack the fire on floor 36. Ceiling temperatures in the hallway were well over 1,500°F (816°C). Every time the firefighters attempted entry, these superhot temperatures rushed up the firefighting stairway, so much so that they melted the floor 37 placard on the landing above **FIGURE 15-7**.

The lens and the facepiece of SCBA is often considered the weakest component of a firefighter's protective gear ensemble in high-heat conditions. The literature from different manufacturers varies, but the glass transitioning or the *softening* of the polycarbonate lens occurs between 293°F and 302°F (145°C and 150°C), and melting of the lens can occur in varying temperatures between 419°F and 640°F (215°C to 338°C). In tests conducted with NIST, U.S. Fire Administration (USFA), and the Chicago Fire Department, fire experiments performed in furnished townhouses demonstrated the effects of a range of realistic firefighting environments on eight different makes of SCBA facepiece lenses. The maximum exterior lens temperatures were as high as 572°F (300°C). Thermal degradation of SCBA facepiece lenses was observed in all cases when the facepiece lens temperature exceeded

FIGURE 15-7 The floor 37 placard melted from the heat on floor 36 at the DeWitt-Chestnut Fire in Chicago, Illinois.
Photo by Battalion Chief Michael Wielgat, Chicago Fire Department.

FIGURE 15-8 Thermal degradation of an SCBA facepiece.
Courtesy of Raul Angulo.

the lower end of the melting temperature range for polycarbonate, and the integrated heat flux exceeded 3.1 MJ/m2. These lenses exhibited bubbling and loss of visual acuity, as well as severe deformation; in one case, a hole was evident **FIGURE 15-8**.

The Utilization and Preservation of Firefighters

Considering the information provided so far in this chapter, the firefighter's greatest adversary in a high-rise building fire is the heat. One of the first safety considerations that must be anticipated is the frequent rotation of crews. In a fast-moving fire that can double in size every minute, operational times and the amount of interior firefighting accomplished by members may be shortened due to fatigue. This is the primary reason that high-rise fires require multiple alarms and mutual aid. NFPA 1500, 8.9.1.1 states that crews shall not be permitted to use more than two SCBA cylinders before being rotated through rehab. To sustain a prolonged attack strategy, crews must be relieved frequently on a regular rotation. Keep in mind that every 50-foot (15.24-m) section of charged 2½-inch hose weighs approximately 105 pounds (48 kg). Five to 10 minutes of wrestling with a charged 2½-inch hose line on air, in full PPE, in a hot smoky environment is about the limit for the average firefighter. After that, firefighters begin to lose their strength and may be too weak to advance the heavy hoses effectively. Frequent rotations allow them to recover quickly and reenter the battle. Over the long haul, this strategy extends the operational period of assigned crews for the duration of the incident.

Company officers may meet with resistance because firefighters naturally feel a sense of failure and defeat when they're pulled off the fire before they're ready. Pre-incident coaching should convey that every attempt should be made to attack the fire and search for occupants with speed but that a high-rise fire attack should be viewed as running a marathon, not running a sprint. Frequent rotation of crews actually prevents injuries from heat and fatigue. Firefighters and company officers who push themselves beyond a self-limiting rotation may actually succumb to the effects of heat exhaustion and be taken off the fire incident completely. Thus, the IC loses valuable resources and must replace them. Also, pushing past a self-limiting point may lead to a firefighter collapsing and triggering a rapid intervention rescue, thus changing the incident priority and shifting resources from extinguishing the fire to rescuing a downed firefighter.

Conservative Approach for Smaller Fire Departments

Not every fire department has the resources of a large city fire department, but small cities and even towns still have to deal with high-rise structures due to urban growth. The heavy work is getting sufficient hose lines in place and in operation on upper floors. Once set, conserve your resources by allowing only the number of firefighters required to operate the lines. Pull the excess crews back and hold them in reserve for rotation. There is no need to expose all your limited resources at once to the effects of heat. Smaller departments may have to take a more conservative approach by attacking a large high-rise fire defensively with the use of portable master streams or by taking up a defensive position from a place of shelter, thus giving up additional property loss to the fire. This may mean relying on the integrity of Class I fire-resistive construction to contain the fire to the floor of origin and taking up exposure positions on the floor above after the life hazard on the fire floor has been mitigated. Uncontrolled high-rise fires cannot be contained without a large contingent of firefighters. Preserving the effectiveness of crews with frequent rotations actually extinguishes the fire faster by extending the working capability of limited resources. This safety strategy inevitably concludes the incident in a shorter time with the fewest amount of injuries.

Firefighter Accountability

The NFPA 1500 safety standard states, "[A]n accountability system shall be used on all emergency incidents, and the initial IC shall maintain an awareness of the location and function of all companies or crews at the scene and must be maintained throughout the incident." Officers that are assigned to divisions or

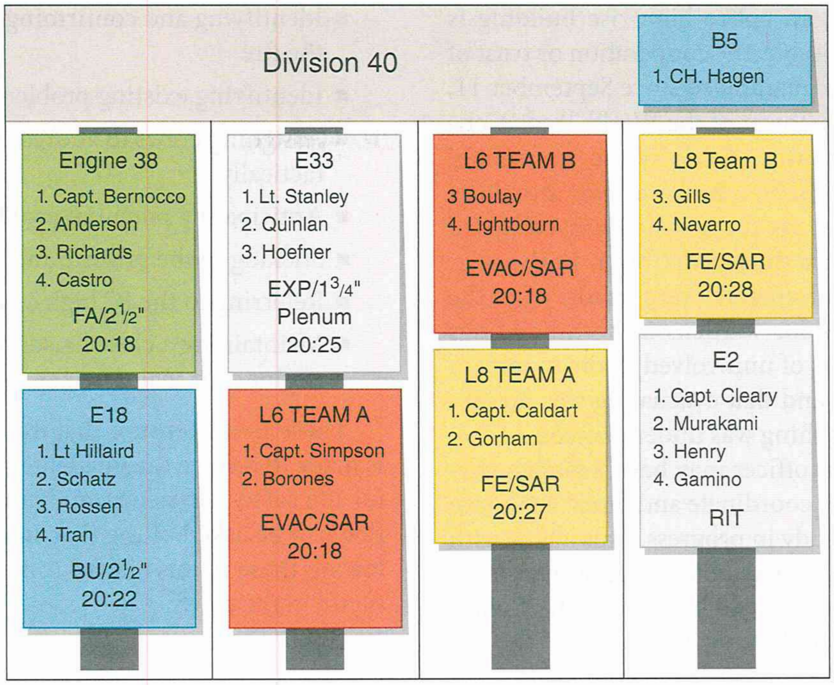


FIGURE 15-9 This accountability status board accurately reflects the fire attack on division 40 (floor 40).

Courtesy of Raul Angulo.

special tactical groups have the responsibility to supervise and account directly for all companies operating in their specific area of responsibility. Company officers shall maintain on ongoing awareness of the location and condition of all crew members. A significant number of firefighters are required to accomplish assigned tasks with the proper tools and equipment, making accountability at a high-rise extremely challenging—but not impossible. The key to keeping accurate accountability is to work the status board as the assignments are being made.

The accountability status board in **FIGURE 15-9** depicts a fire attack on the fortieth floor. The companies, the names of crew members, their assignments, and the times they made entry onto floor 40 are accurately accounted for and are listed below:

- E38 started the fire attack with a 2½-inch hose line at 20:18.
- L6 split their crew and also entered at 20:18. Both teams are ensuring complete evacuation on floor 40, then commencing the primary search.
- E18 is using a 2½-inch backup line and entered the fire floor at 20:22.
- E33 took a 1¾-inch exposure line and entered at 20:25. They protect the search teams and are also responsible for checking for horizontal fire spread in the plenum.
- L8 also split their crew to cover more ground. They are forcing any doors and assisting with search and rescue (SAR).
- E22 is the rapid intervention team (RIT) for floor 40.
- B5 is division 40.

If any member on the hose line calls a Mayday, division 40 and the RIT know which company and hose line she or he is on. By checking the stencil on the hose jacket, the RIT can follow the correct hose line to the nozzle. If a member on the ladder company calls a Mayday, division 40 can notify the rest of the company. The ladder officer or crew can direct the RIT to her or his location. If a member panics and yells that he or she is out of air, more than likely it's a member of E38 because they have been on air the longest.

Command Priorities

Command must have a plan for fire attack. The four incident priorities remain the same for high-rise building fires, except on a much grander scale:

- Life safety
- Incident stabilization
- Extinguishment
- Property conservation

For example, life safety by itself may be ensuring the safe evacuation of several thousands of people.

Although evacuating an entire high-rise building is not desirable nor advisable, the cooperation or trust of the public may not be guaranteed since September 11, 2001, when the North Tower of the World Trade Center in New York City was struck by the jet airliner. It was struck before the South Tower was struck by the second jet airliner, yet the South Tower collapsed first: 29 minutes before the North Tower. In the confusion, many announcements were made over the loudspeaker and by floor wardens in both buildings instructing the tenants of uninvolved floors to remain at their workstations and that evacuating was not necessary because everything was under control.

A first-in company officer may have to assign personnel immediately to coordinate and direct a massive evacuation that is already in progress. This aligns with life safety as the first incident objective; however, large evacuations crowd the stairwells and make firefighter ascent into those stairwells very difficult.

Incident stabilization and extinguishment also take place on a grander scale. For example, it might take the first company 10 or more minutes before the initial hose line can apply water on a fire on upper floors. Controlling the fire and extinguishment takes even longer. At the First Interstate Fire in Los Angeles, California, it took the fire department approximately 27 minutes after arrival before the initial attack was commenced on the twelfth floor.

Rescue, exposures, confinement, extinguishment, overhaul/ventilation and salvage (RECEO/VS) also takes more time to initiate and accomplish. For example, the search, evacuation, and rescue of possible occupants may require a search of stairwells and access to numerous floors before the primary search is complete. It may even require that the fire is first knocked down and contained. Due to heavy smoke and heat in all the four stairways at the First Interstate Fire, the trapped occupants on floor 37 and floor 50 were not able to be rescued until after the fire was knocked down: over three hours from the start of the initial attack. The seven major problems that present themselves at any fire also present themselves on the fire floor of a high-rise building: possible trapped occupants, visible trapped occupants, gaining access, exposures, fire, smoke, and the presence of hazardous materials. The initial IC should remain calm and approach a high-rise emergency systematically by:

- Performing a complete size-up and risk-benefit analysis
- Remaining guided by the four incident priorities
- Remaining guided by the strategic and tactical objectives of RECEO/VS
- Identifying and confirming the location of the fire
- Identifying existing problems
- Assigning crews to address the problems tactically
- Anticipating potential problems
- Sticking to the pre-fire and incident action plans
- Referring to the IC high-rise fire checklist
- Maintaining a close liaison with the building engineer or maintenance supervisor

These points ensure that every professional effort is made to resolve the incident with the highest regard for life safety, efficiency, and effectiveness. That is all that can be asked of the first-in company officer. Following these points allows a smooth transfer of command to the chief.

Initial Size-Up for High-Rise Buildings

All the size-up points covered in Chapter 8 also apply to fires in high-rise buildings but, again, on a grander level. The gathering of significant information happens when the first-in company officer actually enters the lobby to access the fire alarm control panel (FACP). It may also take a considerable amount of time to confirm exactly what's happening within the building.

Time of day, day of the week, and weather can contribute to stack effect. Holidays, ongoing road construction, and the schedule of large public assembly events are all known factors before the alarm is even received. The movement of apparatus, adjacent companies that are out of service on alarms or out of position for in-service department training should be monitored throughout the shift, as should the beginning and end of commuter traffic. The address, building name and occupancy, and the anticipated occupancy load is learned at dispatch before the company even leaves the station. The size of the initial response is also an indication of the caller information that was given to the dispatcher. A reduced response, for example, two engines and a ladder company, may mean an automatic alarm has been activated with no other information. An unusually large initial full response with extra units dispatched indicates additional information was received by the dispatchers that confirm an actual fire.

While en route, the company officer can notice the presence or lack of wind conditions. Taking note of flags flying from buildings and cranes, smoke from chimneys, steam plumes from industrial facilities, and branches blown about by breezes gives clues to wind direction and wind speed—factors that may lead to unpredictable or extreme fire behavior, including stack effect. The radio report from the dispatcher provides all the currently available information that was reported by callers, the building staff, and the monitoring alarm company.

As the first-due engine approaches the address, a 360-degree **approach assessment** should be made to view exterior conditions and as many sides of the building as possible. There may be nothing visible from the outside of the skyscraper. Fog and cloud cover during inclement weather may also shroud the upper stories of the building from visual confirmation of smoke or fire. If flames are visible with the magnitude of the One Meridian Plaza Fire or the First Interstate Fire, where the entire twelfth floor was involved when the fire department arrived, it is the first on-scene indication that you're dealing with a nonsprinklered building or that, for a variety of reasons, the sprinkler system is not operating.

Although driving around the block may seem impractical, the extra time taken may pay big dividends in determining the safest and most advantageous location to connect to the FDC and access the building. For example, if flames are visible and it appears that autoexposure is imminent, connecting to an FDC on the side below the fire may prove to be extremely dangerous for the pump operator and the exposed FDC supply hoses, which could be subject to falling burning debris and large shards of glass from broken windows. A reverse lay to the next hydrant is warranted to increase the safety margin for the pump operator and apparatus. Supply lines have to be protected. If there is another FDC on the opposite side of the building and the standpipes are interconnected, the second-due engine can connect to that FDC and the hazards can become non-issues unless the fire spreads to the other side of the building. These initial actions with the first two engines need to be deliberate to set up the fireground properly.

The urgency, adrenaline, and pressure of all the incoming units quickly descending on the closest intersection can be controlled by the first-in officer announcing that all units shall stand by two blocks from the building except for the first two engines and first-due ladder company. Announcing the numbers of those companies reduces confusion, for example, "All units stand by at 1st Avenue and Denny Way except for Engine 2, Engine 8, and Ladder 6." This single action sets up the command presence of the first-in company officer and allows time for gathering information, identifying problems, and making rational well-thought-out decisions instead of making random assignments because units are anxiously waiting for orders.

The initial radio report should be given and should include the arrival of the first-in unit; confirmation of the address and the occupancy; the building description, including dimensions; any visible smoke and fire conditions; and current wind direction. The officer should announce if this is a high-rise office building, a high-rise residential building, or a high-rise mixed-use building, and whether the building is fully sprinklered or nonsprinklered. This can easily be determined by looking at the FDC signage, asking the pump operator at the FDC, or looking for sprinkler heads in the lobby. If the building is known to have a high or large interior atrium, this information also needs to be announced to incoming units because this building feature poses a significant smoke accumulation hazard to everyone inside, including firefighters. The first-in company officer needs to establish command and announce the initiation of lobby control. The initial command post is usually in the lobby, close to the FACP or inside the building's fire control center (FCC), where additional information is available along with the controls for the HVAC system, interior communications, and the elevators.

Lobby Control

Lobby control consists of the following tasks:

- Verifying the alarm location
- Verifying the location of any sprinkler activation
- Establishing contact with the building engineer or safety supervisor
- Acquiring emergency procedures documents, including building plans
- Selecting the firefighting and evacuation stairways
- Managing the evacuation of occupants to a safe location
- Gaining control of the building systems, including the elevators, the HVAC system, access keys, communications, electrical generators, and fire pumps
- Directing incoming units to the up elevator or the firefighting stairwell

Verifying the Fire Location

The first detail that the company officer needs to determine when arriving at a high-rise fire is to verify the initial location of the fire or the location of the fire alarm activation on the FACP. (There may be more than one fire.) This is done by pushing the acknowledgment (ACK) button, which notifies the monitoring company that the fire department is on scene at the control panel. Pushing the ACK button turns off the alarm buzzer in the FACP but leaves the alarm status lights and building alarm on. For newer FACPs, this also starts scrolling specific information in the viewing window. Automatic fire alarm systems vary; some provide general information, while newer systems provide very specific information **FIGURE 15-10**. For example, basic systems may have a red light on the panel indicating a fire alarm on a certain floor, while other sophisticated systems give you a specific zone; location on the fire floor; location in front of a room number or inside a room number; and whether the alarm is a pull station, a smoke detector, a heat detector, or a water flow from a sprinkler. Often there is a remote annunciator panel right inside the front entrance to the building. This mini-panel reflects the information on the main panel with select buttons, including the ACK button. This information identifies the problem and allows the initial IC to formulate the plan of attack as well as gives firefighters notice about what to expect. Firsthand information should also be gathered from occupants evacuating the building; this information may include visible signs of flame or smoke; elevated heat; difficulty breathing with or without smoke; status of evacuation stair door locks (are they all unlocked?); status of other occupants, for example, the specific location of people trapped or having trouble evacuating, known occupants with limited mobility, suspicious behaviors, and so on.

FIGURE 15-10 Automatic fire alarm control panel.
Courtesy of Raul Angulo.

Other building system control panels for elevators and the HVAC system may also be mounted on the wall next to the automatic fire alarm panel in the FCC. **FIGURE 15-11** shows a smoke control panel that illuminates which floor is in alarm, along with a smoke detector alarm for the elevator mechanical room. It also has automatic mode and manual switches for the stairwell pressurization fans and elevator shaft pressurization, damper and pressure relief switches for the shafts, and a smart-lock switch that unlocks all the doors in the stairwells for exit and reentry to any floor.

Determine the fire floor and other floors that show in alarm. The fire floor must be physically verified as soon as possible. *Everything hinges on this information.* This may be accomplished by the maintenance supervisor or security personnel, but unless you're willing to bet on the veracity of their conclusions, it's best to send two firefighters from the first-in ladder company to confirm this information and find out exactly what's on fire. Pressurized smoke rises, and, depending on the status of the HVAC system and stack effect, the smoke may have spread and activated one or multiple smoke detectors several floors above the actual fire. The activated smoke detectors also register on the FACP, and it may seem as though there are numerous fires on upper levels when the actual seat of the fire is several floors below. In an example from Seattle,

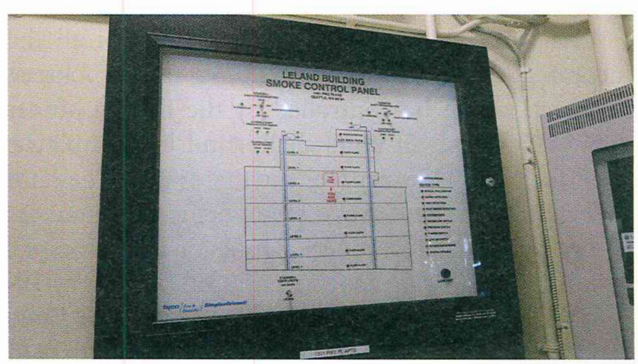


FIGURE 15-11 Automatic smoke control panel.
Courtesy of Raul Angulo.

Washington, a fire occurred on the fourth floor of an eight-story building. When fire units arrived on scene, heavy smoke was showing from the eighth floor. The door to the fire apartment was left open, and the hallway doors to the exit stairs were propped open throughout the building—a common fire code violation. The smoke from the hallway entered the stairway and rose to the eighth floor. The recon team entered the stairway and discovered the source of the smoke was actually from floor 4. Only the smoke from the eighth floor was visible from the exterior, and everyone was convinced the fire was on floor 8. The standpipe was in the opposite stairway. Had a recon team not been assigned to confirm the location, the hose teams would have hiked to floor 7.

It is best to use ladder company members for this initial recon assignment because the initial commitments to high-rise firefighting are to utilize the engine companies to establish a water supply and move crews, hose, and equipment into position within the building to initiate a direct frontal attack and thus confine and extinguish the fire. Along with determining the location of the fire, the recon crew should report heat and smoke conditions in the stairway, the extent of the fire area, and the fire floor itself if possible. All this information should be relayed via radio to the initial IC. Once a fire is confirmed, the IC should immediately call for a second or third alarm. Even with a small fire in a high-rise building, the complexity of the life hazard requires numerous personnel to assist in SAR and control the evacuation in order to avoid panic.

Never silence the building's audible fire alarm horn or siren until the activated alarm is verified. Although it is loud and obnoxious, and it can interfere with fire department communications, it is alerting the occupants of a fire. Once the alarm is determined to be false, the alarm can be silenced. In an actual fire, once the evacuation is complete and the life hazard mitigated, the IC can order the alarm to be silenced to improve fireground communications.

Identifying the Firefighting and Evacuation Stairways

The same recon team should then determine how many stairways access the fire floor, which stairway is closest to the fire, which one has the standpipe, and if hallways and stairways are contaminated by smoke. The recon team should also determine if any portion of the floor plan will require more than 200 feet of hose from the standpipe connection. The stairway with the most advantages should be designated the firefighting stairway. Usually it is the stairway with the standpipe, but that isn't always the case. In unusual circumstances, a stairway without the standpipe may have to be designated as the firefighting stairway because it's closer to the seat of the fire **FIGURE 15-12**. All this information should be related to the IC via radio. Ideally, the stairway closest to the fire means sooner water application. In modern high-rise buildings, there's usually more than one standpipe. The faster water that is applied to the fire, the sooner it can be contained and extinguished, meaning less of a beating for the firefighters and a reduced, if not eliminated, threat to trapped or exposed occupants. Once the fire is out, effective ventilation can begin. Everything gets better when the fire goes out.

The next responsibility for the recon team should be to search and ensure that the firefighting stairway is clear of fleeing occupants above the fire floor. Some fire departments call this team a **rapid ascent team (RAT)**. Any occupants in the firefighting stairway above the fire floor should immediately be directed back into the hallway and toward the evacuation stairway by the RAT. The entire firefighting stairway needs to be cleared, but especially from the fire floor up to the roof.

Usually the stairs opposite the firefighting stairway are designated as the evacuation stairway. In older buildings with a smoke or **fire tower**, it should be the preferred choice for the evacuation stairway. A fire tower is an enclosed stairway connected at each story by an outside balcony or a fireproof vestibule vented

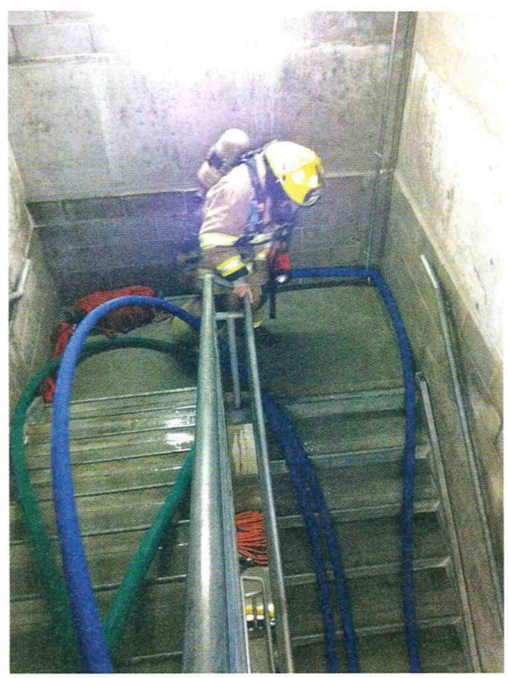


FIGURE 15-12 In unusual circumstances, the stairway without the standpipe may have to be designated as the firefighting stairway because it's closer to the seat of the fire.
Courtesy of Mike Handoga.

to the outside. If there is no fire tower, the evacuation stairway should be pressurized by the building's HVAC system and free of smoke. Once the evacuation stairway is identified, the IC should make it known by announcing it over the building's public address (PA) system to all building occupants and firefighters. Instructions should be specific, utilizing the established designators familiar to the building occupants. The stairways have signage designating them "A," "B," and so on. An example of such a PA announcement is: "All occupants should use the B stairway to exit the building." Avoid using terms like *the north stairwell*, *the south stairwell*, or *the Bravo stairwell*. Using adjacent street names has also proven effective, for example, "Use the stairwell on the Broadway side of the building."

Evacuation Control

In keeping with the first incident priority of life safety, the initial IC needs to confirm and control the evacuation that is in progress. The post–September 11 human factor needs to be considered to avoid a panic. Sheltering occupants in place or convincing them to stay in their rooms or offices requires clear communications via the building's PA system. Even then, there may be a complete disregard of direction, and occupants who are self-evacuating can be anywhere; stairways could be congested with hundreds of people. The primary emphasis should be to search and evacuate occupants on the fire floor and the floor above the fire. The IC should check with building security or the dispatcher if there are any reports of people trapped or if there are disabled occupants who require assistance in evacuation. People may follow building training protocols to leave the affected floors and reenter the building several floors below the fire floor, or they might go to the roof or down to the street. Managing an evacuation in progress may require the use of several companies and requires the following considerations:

- What is the current status of the evacuation?
- Are the stairwells pressurized?
- Is there smoke in the stairwells?
- Are floor wardens involved in directing people?
- Are the proper floors being evacuated?
- Are there floors that still need to be evacuated?
- Is the entire building being dumped?
- Where are the building occupants being evacuated to?
- Is there a safe gathering area?
- Are occupants exiting the front of the building where they may be subjected to falling glass or burning debris?
- Are there reentry floors in the stairway?
- Can building occupants be moved to a sky lobby?
- Can they utilize a skybridge to an adjacent building?
- Are personnel positioned to control every entrance and exit to the building?
- Have safe evacuation routes been established to move occupants away from the building?
- Are building occupants exiting to extreme or inclement weather?
- Can they be moved to an underground parking garage for shelter?
- Are buses needed to shelter building occupants in severe weather?

An evacuation is not a rescue. It is a fast, fluid event that moves the largest number of able-bodied people as possible in an organized manner to an initial place of refuge.

Gaining Control of the Elevators

Gaining control and accounting for every elevator can require multiple companies. For example, The 76-story Columbia Center in Seattle, Washington stands at 937 feet (286 m). It has 14 elevator zones and 49 elevator cars. With the help of the maintenance supervisor, the status of all elevators needs to be confirmed, including freight, garage, and service elevators. If the automatic fire alarm system did not recall all the elevators to the lobby, it should be done manually. Every elevator should be searched and accounted for, then manually shut down except those that will be used for firefighting operations. Elevators in high-rise buildings should not be used for fires below the fourth floor because not much is gained (remember, staging is two floors below the fire). Valuable time and personnel resources are wasted just to ride up one or two floors. Elevators should not be used at all until it is verified that there is no smoke or water entering the shaft. Water can cause electrical shorts and malfunctions. The HVAC system should be able to pressurize the elevator shafts along with stairways to ensure that smoke is kept out. Elevator shaft pressurization also needs to be verified.

The initial IC should perform a risk-benefit analysis to determine if elevators will be used for the operation. Every mechanical advantage should be used to carry firefighters and equipment to upper floors to ward off fatigue before the fire attack. Firefighters should follow their department standard operating guidelines (SOGs) regarding their use in Phase I and Phase II operations.

Control of the HVAC System

After the standpipes, the HVAC system is a critical high-rise fire system, especially for systems designed for smoke management. The initial IC must rely on the recommendation of the building engineer or refer to the recommended procedures in the prefire plan to shut the system down or leave it running as designed.

Emergency Power Generators

A significant fire can affect the electrical power to the building. It must be determined if the building has an emergency power generator and whether it starts automatically or needs to be started manually. At the One Meridian Plaza Fire in Philadelphia, Pennsylvania, all electrical power was lost, which rendered the stairway pressurization fans, elevators, and fire pumps inoperable. The battery-powered emergency lighting failed quickly, and all firefighting operations were hampered by darkness within the hallways and stairwells. A large supply of batteries for flashlights is needed for extended operations in darkness. The running time for generators may be limited due to fuel supply, which should be monitored to ensure that fuel levels are adequate or if additional fuel needs to be brought in. Portable generators and portable lighting should also be brought to the staging area.

Access Keys

The FCC has access master keys, key cards, or fobs to gain access to floors, offices, utility rooms, mechanical rooms, electrical rooms, and a variety of occupancies within the building. When available, they should be distributed to teams and utilized. This saves time by providing quick and easy access without causing damage from traditional forcible entry tools and techniques. In residential high-rise buildings, they may not have master keys to individual private units, in which case, forcible entry must be used to gain access.

Communications

Sound-powered handsets are often available for distribution to specific crews in order to establish in-house communications. These phones can be used in the elevator cars and on every stairway landing. The phone is plugged into the wall jack and connects directly to the FCC. This allows division or group supervisors to communicate directly with the IC as well as with other division supervisors floor to floor. The benefit of the phones is that they are not subject to radio interference or dead zones within a steel Type I building. Typically, however, only a few handsets can operate simultaneously, and the handset wiring can deteriorate over time or be subjected to damage during a fire. At the First Interstate Fire in Los Angeles, California, these handsets had a lot of static and kept cutting out. In the end, they proved ineffective, and runners had to be utilized to ensure that messages were received without confusion.

Radio checks or status reports should be given periodically to ensure that messages are transmitted and received. Portable radio signals through repeaters are often lost in Type I construction. It may be necessary for interior crews to use a simplex (radio-to-radio) channel. Throughout the incident, company officers, divisions, and group supervisors must be mindful about moving toward a window to get a better signal if they cannot transmit messages over their portable radios. At the First Interstate Fire, one of the battalion chiefs in charge of the fire attack had to break out a window in order to achieve line-of-sight communications with the command post below. Cell phones are another way for division supervisors to communicate with the command post in steel high-rise buildings.

The Fire Pump

If the building has a fire pump, an indicator light for it will be on the fire alarm panel. If illuminated, it should be running. The fire pumps are usually found in the basement, but there could be a midlevel pump house to supply the upper floors of super-high-rise buildings. They can be electrically hardwired or powered by a diesel motor. Some have both, and the diesel motor serves as the backup pump in case of a power outage. Two firefighters should be assigned to ensure that the pump is operating properly. There is a discharge pressure gauge on the pump, and the pressure should be reported to the IC to note the capability of the pump. If low-pressure problems occur, the pump may need to be shut off so that the standpipe and sprinklers can be supplied by fire department pumpers. If a maintenance person knowledgeable about the system is available, that person should accompany the firefighters. Just because a high-rise building has a fire pump doesn't mean it is regularly tested or has been properly maintained. For example, if firefighters arrive and see flames from numerous windows or even from an entire floor of a fully sprinklered high-rise building, it is an indication that the fire pump is not supplying the sprinkler system properly or that the water tank level is low and shouldn't be relied on during the fire attack. In this case, the standpipe must be supplied exclusively by fire department pumpers.

Fire pumps for wet standpipe and automatic sprinkler systems may be supplied by gravity tanks, public water mains, pressurized reservoir tanks, or private water supplies. In addition to the supply flow requirements, tanks are also required to maintain the flow for a given period of time; for example, a tank may need to supply a fire attack for 120 minutes. These time periods should be noted during prefire inspections and included in the prefire plan document. Fire pumps are typically rated at 750 gpm.

The reservoir tank at the First Interstate Fire held 85,000 gallons (321,760 L) of water and was replenished by the city water main. This particular tank did not have the intake valves to be replenished by fire department pumpers. It was estimated that 4,000 gpm (15,142 L/m) were supplied to the risers, and 2,500 gpm (9,464 L/m) were flowing through the 20 fire attack hose lines. The city water main could not keep up with the flow demand and drained the tank to less than one-third of its capacity. Had the tank emptied out, fire department pumpers would have had to supply the entire system.

During a fire, there can be only one source of water supplying a standpipe system: either the building's fire pump or the fire department engine. Whichever one has the highest pressure becomes the source. The fire pump in a wet system draws water from the tank reservoir until a fire department engine increases its pressure beyond that of the fire pump. When this occurs, the building system's check valves close to keep the water from flowing back through the fire pump, and the engine apparatus supplies the standpipe system. If the engine pressure is reduced or insufficient, then it is pumping against a check valve held closed by the higher pressure from the fire pump, which again reengages and supplies the standpipe. Super-high-rise buildings may have zones requiring up to 500 psi for the systems. These buildings require fire pumps to obtain operating flows at these elevations because regular fire hose and engine apparatus cannot sustain these high pressures. Tall buildings can have more than one fire pump set to operate in tandem series. Initially, the driver should pump to the signage pressure (Figure 15-5). Some major cities have specialized high-pressure fire engines equipped with 3-stage pumps and high-pressure supply hose. These pumpers can double the water pressure of standard engines to 1,000 psi, surpassing the building's fire pump systems and eliminating the need for tandem pumping operations.

Directing Crews and the Initial Action Plan

A fire that requires the use of a standpipe system for water supply is most likely on a floor higher than the fourth story and is therefore some distance from the fire apparatus. Before they can attack the fire, firefighters have to carry all their equipment into the building. Often, the front entrance is fine, but certain fires, where glass and burning debris may be falling all around, may require the use of underground parking lots, tunnels, or loading docks to access the lobby of the building safely. These alternate access routes should be identified on the prefire plan.

The initial IC needs to decide where to place the first hose line. He or she should brief and direct the officers of the incoming crews to the firefighting stairway or to the up elevator to transport crews to staging, two floors below the fire floor. Many high-rise fires are beyond the reach of effective ground and exterior operations, so the initial strategy must start with a direct frontal attack on the fire floor from the stairway. The primary efforts are to advance hose lines to get water on the fire and to conduct search-evacuate-rescue (SER). Forcible entry in high-rise offices and residential units shouldn't require specialized tools. If aerial ladders and ground ladders are not used, engine company personnel may find themselves assigned to tasks that are normally the responsibility of the ladder company, and they are certainly capable of completing them. If smoke and heat makes the fire floor and the floors above untenable, ladder company members may find themselves assisting and supporting hose operations until the fire is knocked down and heat temperatures are reduced before they can resume SER and ventilation.

That being said, the priorities for the engine companies are to:

1. Get the initial hose line onto the fire floor and in operation. This may take two companies.
2. Stretch a backup line of equal or greater diameter to support the initial attack. This may take two companies. The backup line supports the position of the initial attack line, helps contain the fire from spreading, and protects the SER on the fire floor. The backup line can serve as the initial RIT as long as two members (minimum) remain outside the hazard area in the stairway prepared to provide assistance or rescue in case of an emergency.
3. Get an exposure line to the floor above the fire. This may take two companies.
4. Ready a charged hose line close to the fire floor for the RIT, and assign an entire company dedicated to rapid intervention.

The priorities for the ladder companies are to:

- Oversee the evacuation and initiate the primary SAR on the fire floor. Remove occupants to the evacuation stairway.

- Send a second team to assist in the primary search, evacuation, and rescue of the fire floor. Remove occupants to the evacuation stairway.
- Initiate the primary search, evacuation, and rescue of the floor above the fire. Remove occupants to the evacuation stairway.
- Support the pressurization of the firefighting stairway with positive-pressure ventilation (PPV) fans.
- Ensure that the rooftop access door or hatch remains closed during the fire attack to maintain stairway pressurization.
- Determine the operation status and effectiveness of the HVAC system and shut it down if needed.
- Search the attack stairway and the upper floors above the fire, notably the top of stairwells, if smoke is rising. The evacuation and the firefighting stairways should be checked throughout the fire incident.

Every fire is different, and the above sequences may be changed, but they all need to be addressed.

Engine Apparatus/Pumper Positioning

First-In Engine

While approaching the location, the driver can gather information by what he or she can visually observe from the cab. Newer fire codes require a hydrant within 100 feet (30.5 m) of an FDC. Otherwise, a hydrant should be within 300 feet (91.4 m) of an FDC. The best arrangement for supplying a standpipe system is to have a pumper positioned within 100 feet of the hydrant and 100 feet of the standpipe FDC so that only one or two sections need to be pulled from the hose bed. Positioning the first-in engine in front of the building keeps the supply lines to the standpipe system close to the apparatus and reduces friction loss, and avoids pumping through several hundred feet of hose **FIGURE 15-13**. Because of the amount of time it will take to get to the fire floor with all their equipment, firefighters do not have to assist in laying a supply to the standpipe connection. There is plenty of time for the driver to handle this alone. For safety, on side-mount pump panels, the hoses should be connected to the opposite side of the pump. If flames are visible and it appears that autoexposure is imminent, connecting to an FDC on the side below the fire may prove to be extremely dangerous for the pump operator and the exposed FDC supply hoses, which could be subject to falling burning debris and large shards of glass from broken windows **FIGURE 15-14**. In this case, the first-in engine may have to lay reverse to the next hydrant down the street. If there is another FDC on the opposite side of the building and the standpipes are interconnected, spotting the apparatus at that position would be safer. If the first-in engine is already hooked up to the FDC, the second- or third-in engine

FIGURE 15-13 Positioning the first-in pumper within 100 feet of the hydrant and 100 feet of the standpipe FDC reduces friction loss.

Photo by John Odegard.

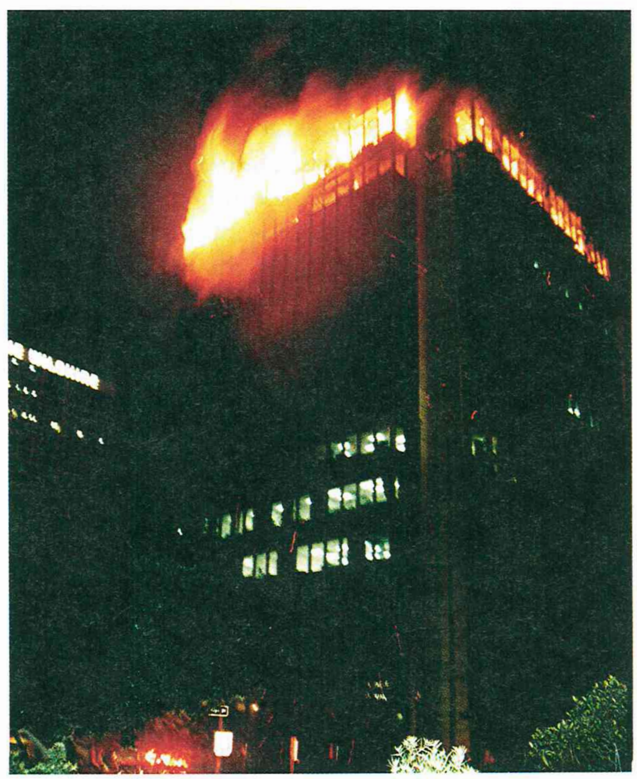


FIGURE 15-14 If flames are visible and it appears that autoexposure is imminent, connecting to an FDC on the side below the fire may prove to be extremely dangerous.

Courtesy of Rick McClure (LAFD ret.).

should connect to the opposite FDC to provide a second, separate supply to the standpipe with a system of redundancy.

Signs should be provided to indicate whether a connection serves a standpipe system, a sprinkler system, or both. The Siamese connection or the FDC and the signage should be visible and unobstructed. In addition, the signage should indicate the area being serviced by the connection, and many have the required pressure that the driver should pump into the system. Pump to the posted pressure if the apparatus pump will supply the standpipe. Lacking this signage, pump to the outlet pressure of the building's fire pump (labeled at the pump or on the prefire plan). Pump to rooftop pressure by adding 5 psi per floor for friction loss and adding 25 psi for the standpipe Siamese friction loss. If the building is equipped with a fire pump, let the pump do its job. Pump 50 to 100 psi below the signage pressure.

Here are two helpful tricks for the driver to know if the building's fire pump is operating. First, put an ear against the FDC or a riser; the driver will be able to hear and feel the vibration of the fire pump when it is operating. The other tip is to close the supply line to the FDC. If the building's fire pump is running, the supply from the apparatus to the FDC should be static, and closing the discharge ball valve from the apparatus should be effortless. If there is noise and resistance closing the ball valve, that means water is flowing from the apparatus into the standpipe system and the fire pump has failed or is not operating properly. Another indication that water is flowing into the standpipe system is that the driver can see a drop on the discharge gauge. This means the standpipe must be supplied by the fire apparatus pump; hydraulic calculations for pressure and friction loss need to be adjusted for the standpipe, the elevation, and the hose lays.

The Siamese intakes have female swivel couplings that should spin freely; however, they are often painted over or rusted shut. They should also have a plug or a frangible disc cover to prevent trash and debris from entering the intake. Before hooking it up to the standpipe system, you should check the FDC intake for trash, rocks, and other debris **FIGURE 15-15**. People sometimes use these open Siamese appliances as trash receptacles, and plastic debris and small rocks can be pushed into the system, flow all the way to the nozzle, and clog the water stream. This is one reason why many firefighters prefer smooth-bore nozzles: small pieces of debris flow right through.

Many fire departments, including LAFD, have special high-pressure hose bundles to supply high-rise standpipes. At least two high-pressure supply lines should be connected into the Siamese intake. If

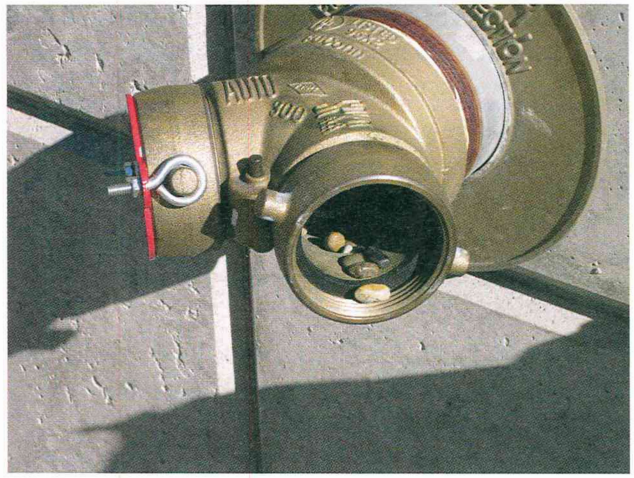


FIGURE 15-15 Before hooking up to the standpipe system, you should check the FDC intake for trash, rocks, and other debris.

Courtesy of Raul Angulo.

more inlets are available, each inlet should receive a high-pressure supply line. The number of inlets indicates the flow available from the standpipe. The first line should be hooked to the left intake and charged to get water into the system quickly. The second line should then be connected to the right intake. This sequence was originally established because connecting the right side first meant that the right hose line would get in the way, thus slowing down use of a spanner wrench to tighten the left female swivel.

When the fire is severe, two fire department Siamese appliances can be hooked up to the standpipe FDC. This allows four lines to supply the system **FIGURE 15-16**. Many fire departments mandate that a single 3- or 4-inch large-diameter hose (LDH) connection be used instead of multiple 2½-inch hose connections. The goal is to get as much flow into the standpipe as possible; however, the LDH needs to be in high-pressure sections to withstand higher pump pressures, and a single supply line to an FDC could result in catastrophic loss of pressure if that single line fails or is cut by falling glass.

Once the FDC is hooked up, the driver should make all the connections to the hydrant by using as many ports and pump intakes as possible to maximize the intake water flow. The driver should announce "supply established" over the radio. The supply hose to the FDC should be protected from falling glass and debris with the use of ground ladders, covered with tarps and backboards, or by any means necessary. Traffic cones and fire scene tape should be used to mark off a safety area for the supply hoses into the FDC in case higher pressures rupture the hoses. An additional area, anywhere from 50 to 100 feet, should be cordoned off to create a safety zone for possible falling glass and debris.

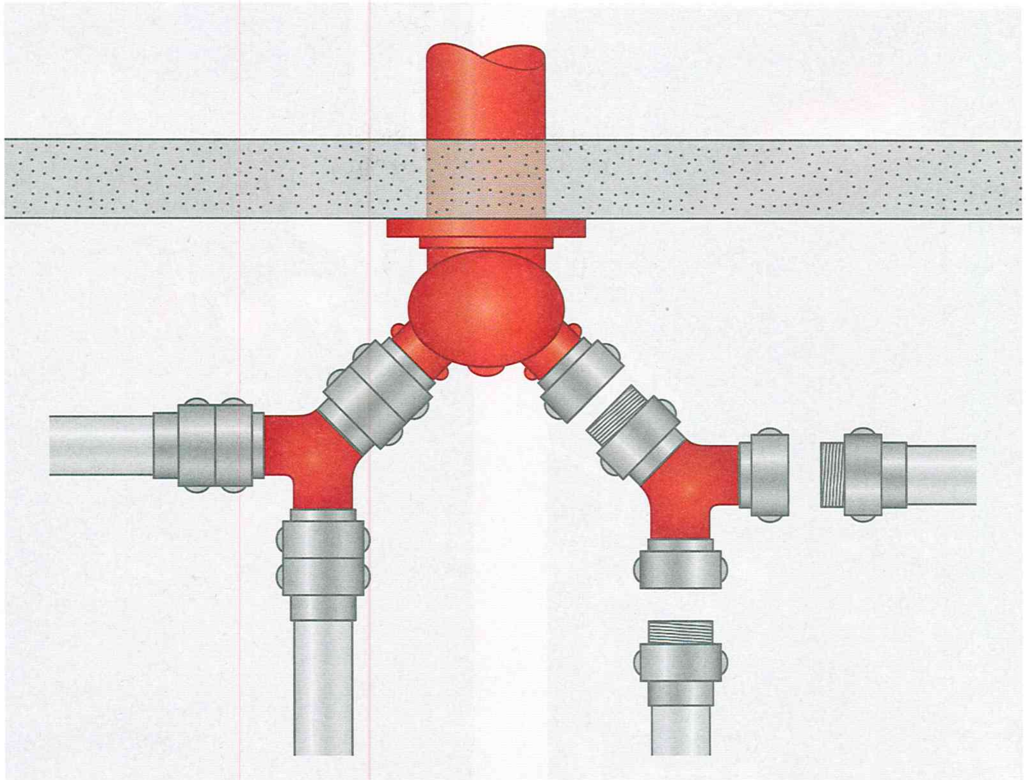


FIGURE 15-16 For a large fire, two fire department Siamese appliances can be hooked up to the standpipe FDC. This allows four high-pressure lines to supply the system.

At the First Interstate Fire, glass and debris covered a 100-foot area around the base of the building. LAFD tests have shown glass can "sail" roughly 200 feet out from a high-rise building.

Because the driver is on the exterior of the building for the duration, he or she is also in an advantageous position to see at least two sides of the building. Exterior fire and smoke conditions, persons in distress, or any unusual conditions should be reported immediately to the IC. The driver should consider personal safety and inform the IC when and where debris is falling. He or she can take refuge in the cab, or a fire department ambulance can be parked and staged next to the fire engine so the driver can take refuge inside while monitoring the apparatus pump.

Second- and Third-In Engines

Depending on the situation, the second-in engine can charge the standpipe on the opposite side of the building from a position outside the area where debris might fall. This assignment could also be given to the third-in engine. All the procedures listed above should be followed. An interconnected standpipe FDC should be supplied by a second pumper on a separate hydrant source and preferably a second water main. Whether there is a second FDC or just a single one, the forward first-in engine should also be supported by a tandem engine spotted at the next hydrant down the street **FIGURE 15-17**. A single or double (2) LDH supply should be laid to the first engine. Every port off the hydrant and intake into the second pumper should be utilized to maximize water flow. Setting up this tandem pumping configuration also provides a redundant water supply should any mechanical malfunction occur with the first-in engine. If falling glass or burning debris begins to rain down on the first-in engine, the pump can be left running and the driver can retreat to an area of refuge at the second engine. This in essence turns the forward engine into an unattended manifold. Any fire engines pumping into an FDC should be supported by an additional fire engine pumping in tandem series from another hydrant into that engine.

Water demands may be great throughout the incident, and a myriad of problems may develop. At some point, an engine officer should be designated as a water control officer and coordinate with a representative from the water department to ensure that municipal water main supplies are boosted.

Damaged or Blocked FDCs

On older buildings, FDCs may not be well maintained, and they could be damaged. In high-density

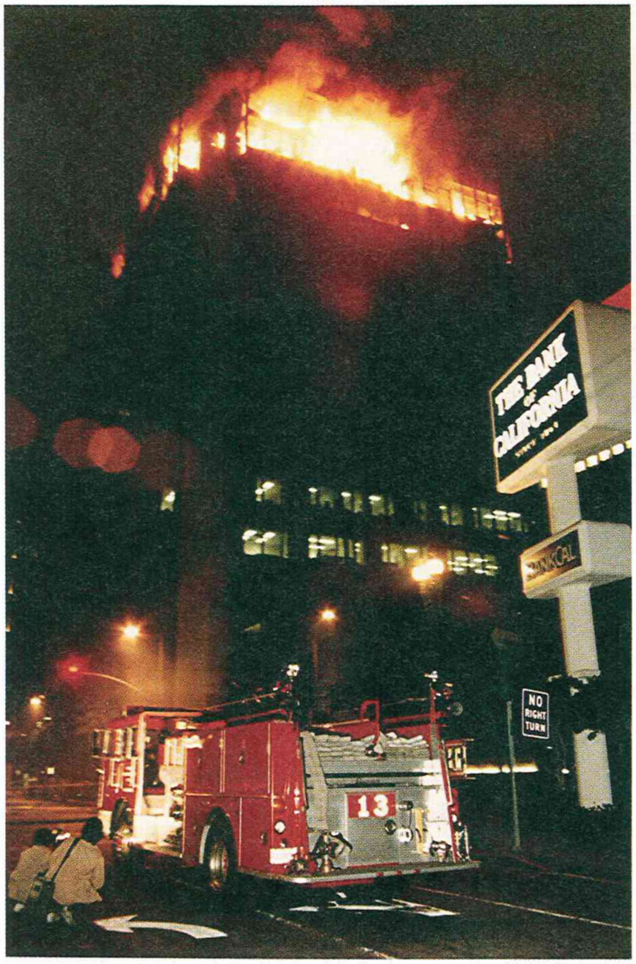


FIGURE 15-17 The forward first-in engine should be supported by a tandem series engine spotted at the next hydrant down the street.

Courtesy of Rick McClure (LAFD ret.).

downtown areas and alleys, the Siamese FDC can also be blocked by cars or delivery trucks. A solution to charge the standpipe when a supply line cannot be connected to the FDC intake is to lay a 2½-inch supply line into the building to the first floor stairway entrance, and connect the hose to the standpipe outlet valve using a 2½-inch double-female coupling on the first floor landing **FIGURE 15-18**. Whenever possible, a 2½-inch Siamese should be installed on the discharge valve using a double-female coupling so that two 2½-inch supply lines can be used to deliver water into the discharge valve outlet from the pumper. Before using LDH to charge the standpipe, ensure that it can withstand higher pumping pressures. For supplying a wet system, the supply line to the standpipe discharge valve should be hooked up and charged before the discharge valve on floor 1 is opened. This prevents water in the standpipe from running back into the supply line and possibly impeding the operation.

If a pressure reducing valve is attached to the outlet, this method will not be possible. PRVs are one-way

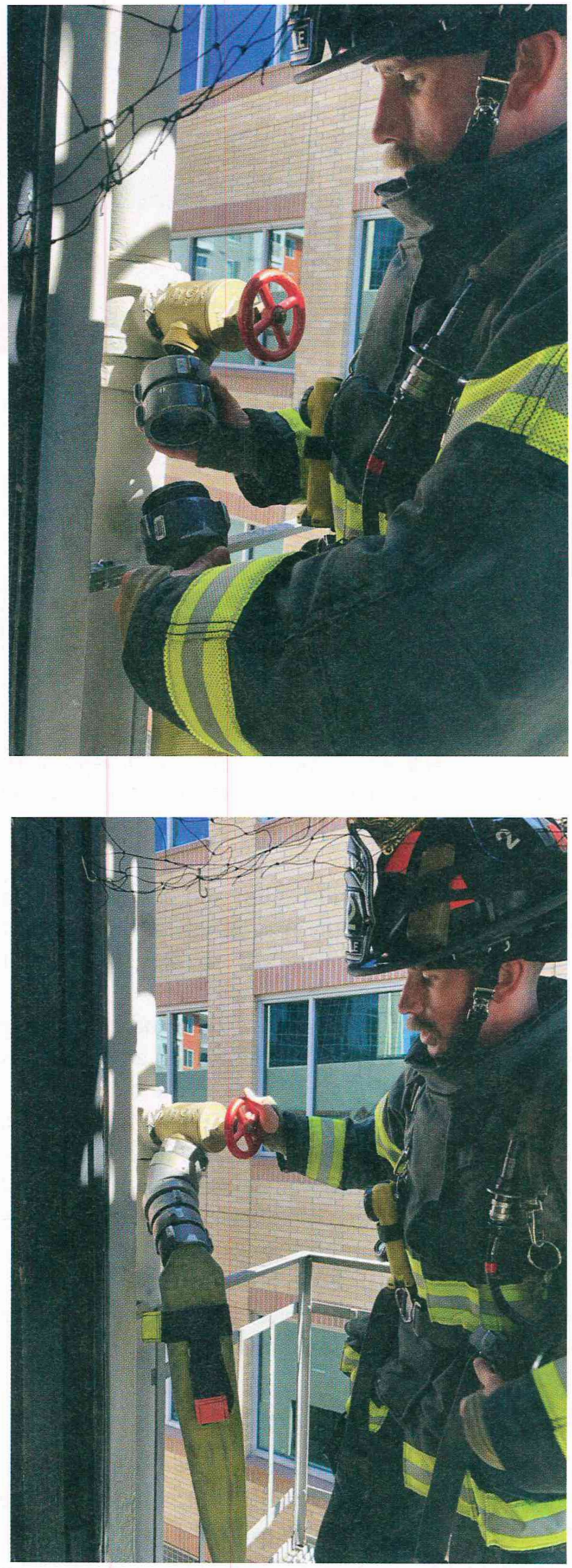


FIGURE 15-18 A solution to charging the standpipe when the FDC is blocked or damaged is to connect a 2½-inch supply line using a 2½-inch double-female coupling to the discharge outlet on the first floor.

A: Photo by Capt. Steve Baer; **B:** Photo by Capt. Steve Baer.

discharge valves; you cannot backflow water into a standpipe through a PRV. You will have to lay a supply line up the stairs—a labor-intensive operation consisting of two or three companies to establish a supply in the stairway to the lowest floor without a PRV or to the floor below the fire.

As a last resort, an aerial ladder or the waterway of a tower ladder can be used to create a temporary standpipe or to advance a hose line to upper floors or even the roof in low-rise buildings. However, this tactic should not become a preferred method or used in lieu of a perfectly functional standpipe. Aerial ladders and tower ladders are a limited specialized resource. Some departments have only one or two, and some departments don't have any. Using a million-dollar piece of apparatus to establish a temporary standpipe commits the ladder to supporting the attack and renders it useless for aerial rescues and elevated master streams—the designed purpose of this fire truck.

Stairwell Support Group

Fire department SOPs vary on the initial use of elevators for high-rise firefighting. If a department does not use elevators, a stairway support group needs to be set up immediately for the transfer of SCBA air cylinders and equipment to the staging floor. Next to an adequate water supply, the demand for air is paramount for firefighters. The need to stock the staging floor with fresh air cylinders as soon as possible cannot be overemphasized. The physical demands on firefighters limits them to approximately 20 minutes before they need a fresh bottle. Extra alarms need to be called for this task alone. The company officer assigned to stairway support must figure out the most effective relay system to move extra air cylinders from parked apparatus to staging. At the First Interstate Fire, over 600 air cylinders were hand-carried to the tenth floor.

In the initial stages, one firefighter can shuttle air cylinders and equipment two floors, but fatigue quickly becomes a factor if the stairway is hot and/or smoky; the summer stack effect can push smoke down to lower floors. Ideally, the relay should be one firefighter per floor. It also depends on what floor the staging is on. Having five companies or more assigned to stairwell support is not unreasonable. Stairwell support firefighters also need to be rotated to catch their breath. If the stairway is pressurized and clear of smoke, the group supervisor and the safety officer can make the decision to allow firefighters to remove SCBA, helmets, and coats during this operation. They can keep their PPE on their assigned floor landing at the ready. Ladder companies usually set up PPV fans at the base of the stairwell to assist in maintaining stair-shaft pressurization, which is also helpful in keeping the stairway support group cool.

In addition to shuttling air cylinders, the stairwell support group may be asked to establish a water supply or a secondary standpipe in the stairway using fire hose and shuttle equipment, and provide drinking water, flashlight batteries, medical supplies, and anything else that is needed in staging. At the DeWitt-Chestnut Fire in Chicago, Illinois, staging was on floor 34. At the One Meridian Plaza Fire in Philadelphia, Pennsylvania, staging was on floor 20. Due to the PRVs and complete failure of the fire pumps, the Philadelphia firefighters had to lay a 5-inch supply line up to the twenty-second floor, which took the stairwell support group about an hour to establish. Manually establishing a water supply in a stairwell is a physically taxing endeavor. To ensure enough hose is laid, it is best to carry rolled hose sections to the floor below the fire and unroll the hose down the stairwell. Using gravity to unroll hose is the fastest way.

Use of Elevators

The Empire State Building in New York City has 102 floors. The Willis Tower in Chicago, Illinois, has 110 floors. The round iconic US Bank skyscraper in Los Angeles, California, has 73 floors, and many high-rise buildings range between 40 to 60 stories. The use of elevators is essential in high-rise firefighting in order to get water to the fire as soon as possible. Even with high-speed elevators traveling at 1,200 feet/minute (366 meters/minute), getting water to a fire on the upper floors can take at least 15 to 20 minutes—if everything goes right. Consider how long it would take and how much physical energy firefighters would have left if they had to hike all the way up the stairs. We need to use the mechanical advantage of elevators to move firefighters and equipment to the staging floor whenever possible to prevent fatiguing firefighters before the fire attack even begins. Fire departments must have written SOGs that address the use of elevators during a high-rise incident. The main concerns are smoke in the hoistways or elevator shafts and water entering the hoistway; these can lead to electrical shorts and mechanical failures. These large vertical shafts are a primary route for heat and smoke spread. In newer buildings, pressurization fans are designed to pressurize the hoistways and thus keep them clear of smoke for firefighting operations, but not all HVAC systems pressurize the elevator shafts. This needs to be identified during the prefire review. In older buildings without hoistway pressurization, vertical ventilation of the hoistway at rooftop level can reduce the accumulation of smoke and heat on upper floors.

Elevators should not be used for fires below the fourth floor. Staging is set up two floors below the fire, and not much is gained by riding an elevator one or two floors. And the company doesn't lose a member to run the elevator car when all firefighters can use the stairs. The initial IC should consider the logic in resisting the use of elevators below the eighth floor but using elevators to the thirty-eighth floor. The benefits are obvious, and the accepted risk is the same, so why not use the mechanical advantage and save the strength of your firefighters for the battle? They're going to need it. It is interesting to note that in the NFPA high-rise study, the majority of high-rise fires in all the property classes started on floors no higher than the sixth floor, or below grade. Elevators should also not be used for fires on lower floors below the main entrance of a building for the same reason you shouldn't hook up to below-grade standpipe discharge connections. The fire is already below you. If smoke enters the elevator shaft, it can trap firefighters by filling the car with smoke.

There are two basic types of elevators: electric traction and hydraulic. Hydraulic elevators are usually found in low-rise or non-high-rise buildings. In this instance, the elevator mechanical room is in the basement. Electric traction elevators are used in actual high-rise buildings. These elevators use the giant hoist cables wrapped around drums along with cables attached to counterweights. The hoist motors and mechanical room are usually on the roof or the top floor of the building, although in modern high-rise buildings, elevator mechanical rooms can be located almost anywhere adjacent to the hoistway. There may be a low-rise bank elevator serving the lower floors; a mid-rise bank that serves only the middle floors; a high-rise bank, including express elevators to the uppermost floors, that serves only the upper floors; and freight elevators that typically serve nearly all floors of the skyscraper.

In high-rise fire situations, the elevators and stairways are managed by the company assigned to lobby control. With multiple elevators, there should be one designated as the up elevator and another as the down elevator. Between runs, the up elevator returns to the lobby, and the down elevator returns to the staging floor. The rest of the elevators should be shut down unless they are needed by the fire department. All members must understand and follow the elevator protocol for Phase I and Phase II operations. The IC must take special precautions and conduct a risk-benefit analysis before allowing firefighters to use a freight elevator in a fire situation because some freight elevators have manually operated doors and do not have Phase I or Phase II safety features. A firefighter would have to know how to operate a freight elevator manually. If they do have Phase II features, however, freight elevators can carry more weight than passenger elevators, and they can be beneficial in quickly transporting SCBA cylinders and equipment to the staging floor. Many freight elevators do not have an enclosed car design, and the elevating platform and guardrails are open to the hoistway, which is most likely not pressurized. The firefighter assigned to operating this type of elevator must check the shaft constantly for the presence of smoke.

Phase I elevator operation is tied to the building automatic fire alarm (AFA) system and occurs automatically if the alarm is set off by a smoke detector or pull station in elevator lobbies, shafts, elevator machinery rooms, or other system-designated areas. These elevator cars are automatically recalled to the main lobby. If they are not recalled, all elevators should be manually recalled, accounted for, searched, then shut off. The swift movement of the elevator car within the hoistway moves considerable air within the shaft, often bringing an odor of smoke when the car reaches the lobby. This may be your first physical indication that you actually have a fire. Phase I disables all floor buttons in the car and all call buttons on every floor so that the elevators cannot be used by any occupants. People who are in the elevator at the time of the alarm are carried down to the main lobby. If the alarm activation occurs in the main lobby, the elevators are recalled to an alternate designated floor, usually below the main lobby. This alternate floor recall is sometimes referred to as Phase III. The doors to the elevator car remain open on the ground floor until Phase II is initiated or the alarm is cleared, and the elevators are reset by the fire department to normal operations. Closing doors on unused elevators on the ground floor ensures optimization of shaft pressurization.

Phase II elevator operation occurs when the fire department actually takes control of the elevator car. The 3502 fire service key or barrel key should open the red elevator key box next to the floor 1 or main lobby elevator. Master access keys, keycards, or fobs may be kept in a Knox-Box next to the elevator or at the FCC of the building. The firefighter assigned to run the elevator should be equipped with full PPE, portable radio, fire phone to the FCC, and SCBA. In addition, this firefighter should keep a set of irons or at least a Halligan tool to force the car doors open in case of a power outage or emergency, a high-powered battle lantern to check the elevator shaft for smoke, a water-pressurized fire extinguisher, a spare SCBA cylinder, a hand-held multi-gas detector, and a baby ladder to reach the emergency hatch on the roof of the elevator car to escape if it stalls between floors.

Operating in Phase II

The firefighter assigned to run the elevator car in Phase II should check to make sure that all the command functions work with the appropriate buttons. In newer buildings, the elevator electronic eye or sensor should be disabled automatically so that unexpected smoke does not block or prevent the doors from closing. Opening and closing the car door works only with the manual buttons operated by the firefighter. A test run to the floor above the lobby should verify that Phase II is operating properly. The operator should note the maximum weight limitation of the car and avoid overcrowding the car with firefighters and equipment. Extra trips to carry firefighters and equipment to the staging floor is quicker than dealing with an elevator that stalls because the weight limit has been exceeded. Not only could you have an entire company stuck in an elevator, but valuable time and resources will have to be diverted from firefighting to deal with this embarrassing problem.

If time allows, the operator should stop the elevator a few floors below staging to point out the layout of the hallway or the floor, as well as the exits to additional stairways. This should take less than a minute and may be the only time crews get the chance to get their bearings. Some elevator operators may draw a floor plan on the interior of the elevator door as a reference to point out stairwells, fire locations, or other important features. Firefighters can expect to be ordered off the elevator two floors below the fire, then use the stairway from the floor below to hook up hose and gain entry to the fire floor.

It is extremely important that the elevator operator know which floor the fire alarm is on because he or she is the one manually operating the elevator car. Any confusion can have disastrous consequences because this firefighter could unintentionally take the car directly to the fire floor. An elevator should never be taken to the fire floor or any floor above the fire, and fire department personnel should not be allowed to break this rule. If the elevator is taken to the fire floor, the firefighters in the elevator could be exposed to flames, excessive heat, and/or toxic smoke when the door opens. This type of event occurred on February 8, 1978, at 04:36 hours at the Grosvenor House Fire in Seattle, Washington, when three firefighters took the elevator to the sixth floor of this 18-story residential high-rise. The fire began when an intoxicated occupant, who was heating some baked beans, fell asleep. When the alarm sounded, he made a feeble attempt to extinguish the fire in the kitchen, then left, leaving the front door to his apartment open. As the occupants evacuated, he met the fire department on the ground floor and stated to the battalion chief that the fire was in his unit but there was "no emergency . . . all is well." Dropping their guard, the three firefighters took the elevator to floor 6. When the doors opened, the thick smoke was down to the floor. In 1978, the existing fire code did not have language to deactivate the electronic eye while the building was in alarm. The thick smoke interrupted the sensor, keeping the doors from closing. All three firefighters, who were not wearing SCBA, quickly became disoriented and succumbed to the effects of carbon monoxide (CO). One firefighter dragged his partner and sought refuge in an unlocked apartment. The third firefighter, who was unconscious in the hallway needed to be dragged out by a rescue team. All three survived but suffered severe smoke inhalation.

The operator should check the shaft periodically for any smoke. The movement of the elevator car up and down the shaft can push around or draw in residual smoke. If smoke is detected or is noticeably increasing, stop the elevator at the nearest floor and get everyone out. Turn the elevator back to Phase I, which returns the elevator to the lobby. Note that the elevator shaft can allow CO or other nonvisible gases to drop down the hoistway. There have been cases when the elevator operator and lobby control personnel received significant doses of CO in or near the elevator shaft.

Firefighters should become completely familiar with the elevators in buildings to which they typically respond. New elevator security features that require fobs or security keycards, in addition to the elevator key, are being installed in high-rise buildings. The fire code is changing, making Phase I and Phase II elevator operations a little more complicated. In fact, in buildings with different elevator banks, not all cars return to the lobby in Phase I but may go to a different floor that is designated a safe refuge. Some buildings with more than one elevator in the same shaft create a challenge because the uppermost elevator must be recalled to the lobby and the lower elevator may not be able to access the uppermost floors. These features should be identified within the prefire plan. Company officers need to stay up to date on these building industry and fire code changes and understand that almost no new code requirements are retroactive to existing elevators.

Fire service access elevators (FSAEs) is a term for newly approved, "hardened," post–September 11 elevators designed for firefighter use, occupant evacuation, and high-rise firefighting and will become more common as new taller buildings are constructed. The cars and hoistways are built with reinforced construction that is not subject to the normal problems associated with regular elevator operations during a fire. The concrete shafts are pressurized, and the electrical operating components are insulated from smoke, heat, and water damage. These elevators have remote heat and smoke monitoring for all floor lobbies.

Many hospitals have specialized code blue elevators to move patients quickly between floors, much like a medical Phase II elevator operation. Whether these elevators are recalled or work independently of the automatic fire alarm system, or if the fire department has the ability to override a code blue elevator needs to be determined during prefire planning. An occupant evacuation operation (OEO) is a newer requirement in building codes that specifically provides ongoing elevator operations during an emergency for disabled occupants who cannot use stairs.

Expect the unexpected because sometimes you get a curve ball. An AFA came in for a new, partially occupied, residential high-rise building in downtown Seattle, Washington. The engine officer, who took lobby control, verified the alarm was on the rooftop (RT) level of this 40-story high-rise. However, none of the express elevators capable of traveling above floor 20 would return to the lobby; only the cars for floors 1 to 20 were operating. After troubleshooting all his options, he was getting ready to pull the trigger on the decision for his company to start climbing the 21 floors from 20 to 41 when the building manager showed up and explained that technicians were working on the RT display vent system. The manager had cell phone contact with the workers to verify that there was no fire and that the AFA system was probably set off by dust. The officer accepted the explanation but still needed a firefighter to verify it; however, the explanation provided by the building manager would not have solved his dilemma if there actually had been a fire on RT or a fire on another floor between 22 and 40 because the building was partially occupied. The building manager inadvertently offered that he turned the express elevators to off at night because he didn't want people going to the upper floors for security reasons. In this example, turning the cars to off disabled the Phase I and Phase II mode **FIGURE 15-19**. This situation had to be followed up with the involvement of the fire marshal. The point is that one would expect, when a new building goes into alarm, everything should work according to design, and the company officer should be able to carry out his or her responsibilities according to department policy. The takeaway is that not all

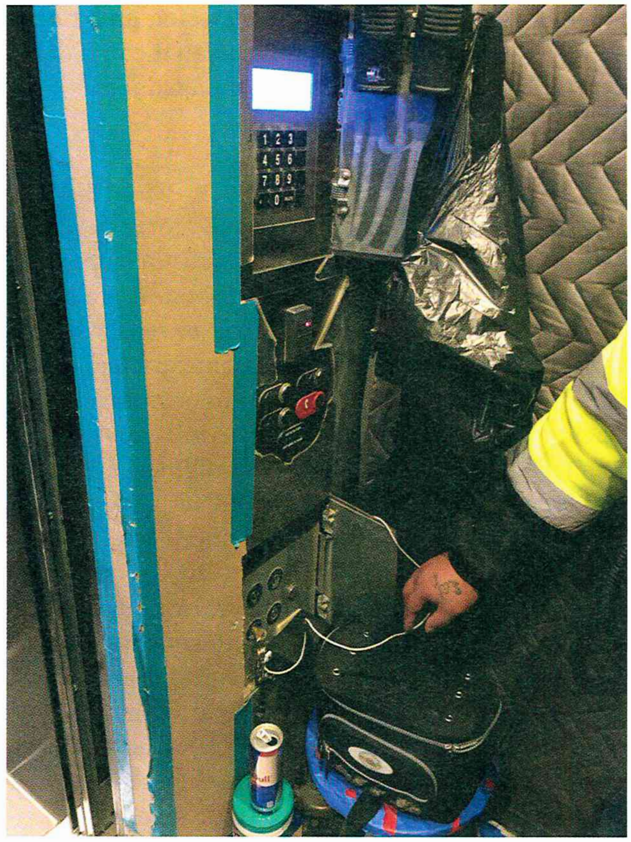


FIGURE 15-19 This elevator serving the upper floors of a high-rise building was routinely shut off at night for security reasons, which disabled the Phase I and Phase II features in the occupied building.

Photo by Captain Steve Baer.

civilian authorities are on the same page as the fire department. The actions of individuals can seriously interfere with or stall fire department operations.

An elevator service technician from the elevator company should be summoned to respond to the command post during a major high-rise fire, but this person should also be consulted for regular hands-on training for accurate information and procedures on the proper operation of an elevator's system during a fire incident. Phase II operations can be utilized during medical calls. This legitimate use of Phase II develops confidence for use during a fire incident.

The Staging Floor

Typically, the staging floor, or staging, is set up two floors below the fire. If the fire is on floor 20, staging is on floor 18. All personnel coming up the stairway or from the elevator report first to staging for assignments. This is the forward gathering place for firefighters and equipment. All firefighting operations are launched from this area. Crews are also rotated and rehabbed on the staging floor. Experience has shown that the demands placed on the staging officer are great. A single engine company can be quickly overwhelmed, and it is recommended that two companies, if not three, be assigned to the staging floor—another reason to call quickly for additional alarms at a confirmed high-rise fire.

Hose, Nozzles, and Equipment

The first hose line into the building should be at least 200 feet long and of a diameter dictated by the size and intensity of the fire. The hose line should be able to reach any portion of the fire floor. Determine during pre-incident planning if longer hose lays are required. Only equipment that is absolutely necessary for the initial attack should be brought into the building by the first firefighters. There are various high-rise hose packs and hose carries for predetermined lengths and diameters of hose. Nozzle types and sizes vary. Hose can be shoulder-loaded (flaked), double-rolled, or donut-rolled. The most common are the pre-bundled, pre-tied, 50-foot sections with smooth-bore nozzles that are draped in a horseshoe bend over the SCBA cylinder of the firefighter.

Standpipe Bags

The following is a list of recommended equipment that should be placed in a standpipe bag:

- 2½-inch in-line pressure gauge
- 2½-inch 60° elbow (2)
- Spanner wrench (2)
- 18-inch pipe wrench
- Vice grips
- Wire brush
- Spare operating handwheel and handwheel wrench
- Reducers or increasers
- Webbing

The spare handwheel and wrench is used to open the standpipe valve if the handle is missing or if the valve cannot be opened by hand. Some departments use a 10- to 12-foot pigtail section of 2½- or 3-inch hose. **FIGURE 15-20** shows an assortment of standpipe equipment and firefighters carrying the horseshoe hose bundles. Each department should select the tools that work best for its members. All hose, tools, and appliances should be lightweight.

Hose Diameters

Hose lines that are 1¾ inches are effective on most apartment high-rise fires with the typical household furnishings because the room size is compartmentalized by internal walls. However, a 2½-inch hose should also be available for backup in case the smaller hose lines are inadequate for controlling the fire or if the fire extends into the hallway. As in all firefighting operations, if the 1¾-inch hand line isn't knocking down and controlling the fire in less than a minute, the 2½-inch backup hose should be used immediately. Two-and-half-inch hand lines should be anticipated for fighting fires in open-space office buildings and commercial skyscrapers, and in high-rise buildings that are not sprinklered. Many fire departments are opting for 2-inch attack hose. This is a happy medium, especially for departments with limited staffing. It flows more water than the 1¾-inch hose line but isn't as hard to handle as a 2½-inch hose. A 2-inch hose with a $\frac{15}{16}$-inch smooth-bore tip operating at 75 psi yields

A B

FIGURE 15-20 A. An assortment of standpipe equipment. B. Pre-bundled, 50-foot sections of hose with smooth-bore nozzles are draped in a horseshoe bend over the SCBA cylinders of firefighters.

A & B: Coutresy of Bernard J. Klaene.

approximately 230 gpm. A 2-inch hose with a smooth-bore 11⁄16-inch tip flows 212 gpm at 40 psi, 237 gpm at 50 psi, and 260 gpm at 60 psi.

Lightweight High-Rise Fire Hose

The North American Fire Hose Corporation has manufactured a new lightweight hose specially designed for high-rise firefighting. The Dura-Flow 800™ hose series has a thermoplastic, urethane inner core lining covered with an inner and outer woven Nylon 6-6 jacket. This advancement in fire hose technology reduces friction loss, which improves nozzle performance, and makes this hose lighter than regular structural firefighting hose. Reduced coil diameter makes the hose more flexible, so it can be packed in tighter folds. It also takes up less compartment space on the apparatus and is easier to carry. The woven Nylon 6-6 double jacket is abrasion-, cut-, and kink-resistant, and gives the hose its strength to maintain a 400-psi service test pressure. The nylon makes the charged hose slide more smoothly around bends, corners, and stair treads, so it is easier to advance **FIGURE 15-21**. Note the following comparisons:

- A 50-foot (15.2-m) length of 1¾-inch Dura-Flow 800™ hose weighs 14 pounds (6.4 kg) compared to its rubber-lined counterpart, which weighs 17 pounds (7.8 kg).
- A 50-foot section of 2-inch Dura-Flow 800™ hose weighs 17 pounds (7.8 kg) compared to its rubber-lined counterpart, which weighs 22 pounds (10 kg).
- A 50-foot length of 2½-inch Dura-Flow 800™ hose weighs 21 pounds (9.6 kg) compared to its rubber-lined counterpart, which weighs 26 pounds (11.8kg).

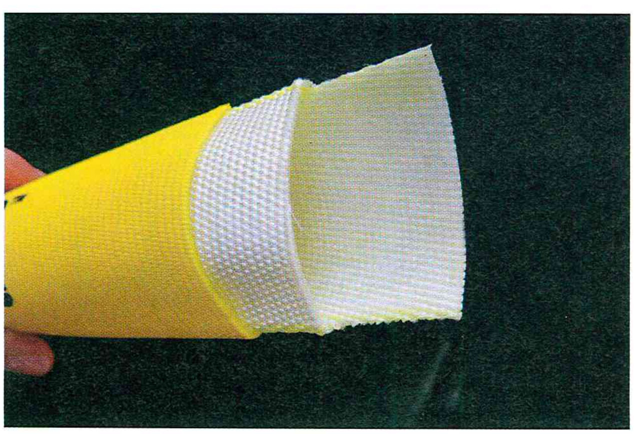


FIGURE 15-21 The Dura-Flow 800™ lightweight high-rise firefighting hose weighs significantly less than regular, rubber-lined, structural firefighting hose.

Photo by Mike Peterson, North American Fire Hose Corp.

If the fire attack team is carrying 200 feet of 2½-inch hose line, that's a weight-saving difference of 20 pounds!

Nozzles

The use of solid-stream, smooth-bore nozzles is often considered for high-rise fire attack because of their lower operating pressures. They can operate on low-pressure standpipe systems with a tip pressure of 50 psi. They have excellent penetration and good reach when they can hit the seat of the fire. Their disadvantage is they do not produce an efficient fog stream without gating down the shutoff, which reduces gpm flow. The closer the smooth-bore tip orifice gets to the diameter of the hose line, the less velocity the water stream has at the same flow rate. A trick of the trade is to remember that no nozzle should have a tip orifice opening greater than one-half (½) the diameter of its hose. So, a 2½-inch hose line should have a smooth-bore tip no greater than 1¼-inch, and a 1¾-inch hose line should have a smooth-bore tip no greater than 15⁄16-inch.

Standpipe outlet pressures vary by location and can range between 50 psi and 205 psi. If smooth-bore nozzles are used for fire attack, and standpipe pressures are adequate for low-pressure combination fog nozzles (75 psi), the combination fog nozzle should be used for the backup line and for the RIT line to protect firefighters. This anticipates conditions worsening. The entrained air from a fog pattern can move the flames away from the attack team as well as spray them down, keeping them cool as they back out. The fog spray can also act like a sprinkler head to cool overhead gases. Experience has shown that, when extreme fire conditions develop because of the wind, smooth-bore fire teams are not able to hold their ground because the solid stream doesn't absorb the radiant heat or push flames away from firefighters.

In many fire departments, there is resistance to using a combination fog nozzle in high-rise firefighting. A smooth-bore tip shoots a solid stream that doesn't easily break up. But consider that the solid stream is intentionally bounced off the walls or ceilings to extinguish the fire more effectively. Thus, one needs to ask, "Doesn't bouncing a solid stream off the walls, ceilings, or a solid object defeat the purpose of the stream they want maintain? Isn't breaking up a solid stream the function of a combination nozzle?"

Combination fog nozzles, including automatic and selectable gallonage nozzles, have an operating tip pressure between 75 and 100 psi. They have good penetration and reach with a straight stream, as well as an effective fog pattern when they're properly

A B

FIGURE 15-22 TFT *Flip-Tip* nozzle: **A**. the combination fog nozzle and **B**. the smooth-bore tip.
Photos courtesy of Task Force Tips.

supplied, but they can have problems with PRVs and can be ineffective with low-pressure standpipes below 75 psi. Nozzle selection should be based in part on the building's minimum standpipe outlet pressures to deliver the desired gpm and reach. The selection is also based on how much flow and nozzle reaction can be controlled by the available firefighters and their ability to move the hose line (combat mobility).

Modern low-pressure, break-apart, high-rise nozzles are an excellent choice for both combination and smooth bore applications where the nozzle assembly includes a low-pressure (75 psi) combination spray nozzle with a rated discharge of 150 gpm coupled with a 15/16-inch solid-bore tip (50 psi) rated at 185 gpm. An example in new nozzle technology is the TFT *Flip-Tip* nozzle that provides all the features and benefits of the smooth-bore and spray tips by combining them into one. This nozzle assembly allows firefighters a choice of a spray nozzle or a solid smooth-bore nozzle for combatting a fire. The combination selection provides a single nozzle that offers fixed, selectable, or automatic gallonage into the tip that can be adjusted from straight stream to a wide fog pattern. It performs all the functions and features of any other combination nozzle because it is a genuine combination nozzle. If the fire situation warrants a harder-hitting, deeper-penetrating straight stream from a smooth-bore tip, the locking ring has a single-twist, push-down release. The combination tip is flipped down with a push of the palm, and the pivot-lock secures it in the down position. The nozzle is hinged in the middle, exposing the smooth-bore tip. There are nozzles for 1¾-inch and 2½-inch hose lines. Smooth-bore tips range from ⅞, 15/16, 1⅛, 1¼, to 1⅜ inches. This allows for flows of 50 to 300 gpm **FIGURE 15-22**.

In large open-floor areas, firefighters must be prepared to use master stream appliances for interior attack. A single- or two-inlet lightweight deluge set, made of modern aluminum alloys and equipped with a solid-bore tip, has proved most effective for such operations. Another new innovation in nozzle technology is the TFT *Blitzfire*. The *Blitzfire* is a 2½-inch lightweight, single-operator portable master stream that is ideal for initial interior attack. The master stream nozzle can flow up to 500 gpm (2,000 L/min). The monitor is compact and lightweight. The base model is designed for low-angle interior attack. The 10° to 46° elevation is perfect for directing a fire stream into any door or hallway of a high-rise during an initial attack **FIGURE 15-23**. The high-elevation (HE) version provides an even higher 86° elevation angle for tactical advantages, such as the ability to place a high-volume stream directly into an overhead or to shoot deep into the open floor space of a high-rise. Both models can be equipped with a unique water-driven turbine that drives the oscillating unit in a selectable 20°, 30°, or 40° sweeping motion. Both models can accommodate a 2½-inch combination spray nozzle tip or stacked smooth-bore tips. The *Blitzfire* portable

FIGURE 15-23 The lightweight, single-operator TFT *Blitzfire* portable monitor.
Photo courtesy of Task Force Tips.

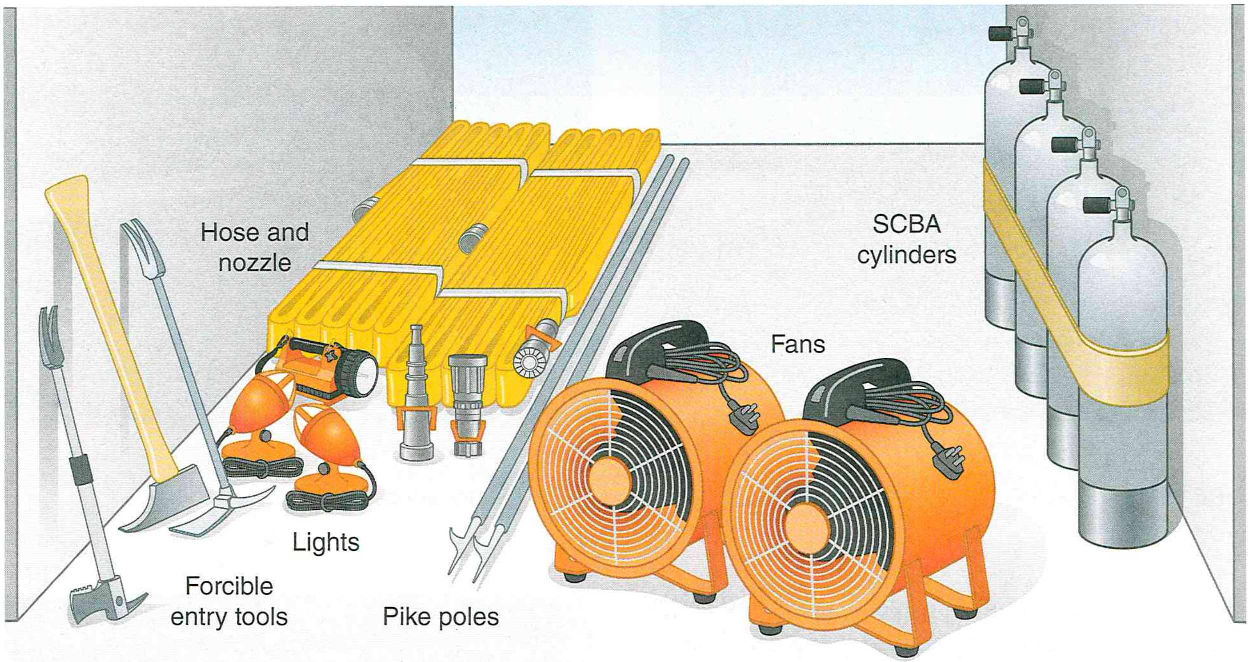


FIGURE 15-24 The equipment cache is set up in staging.

monitor has carbide-tip ground spikes along with two wide-leg stabilizers. The single 2½-inch female intake is low at the base, which keeps the supply hose low to the ground. These three components securely anchor the monitor, which absorbs the 250-pound nozzle reaction while flowing 500 gpm. There is little, if any, nozzle reaction for the firefighter to wrestle with or brace against, making this portable monitor excellent for offensive high-rise interior attacks. Once set, the monitor can be left unattended.

Equipment Cache

As firefighters report to staging, they must carry in hoses, extra SCBA cylinders, nozzles, search ropes, pickhead axes, TICs, and forcible entry tools. Conducting a primary search, attacking the fire, checking for fire extension, and performing other tasks may require firefighters to force their way into locked apartments, offices, or other secured areas of the building.

Other tools and equipment are eventually needed inside the building to support and assist in firefighting operations and should be placed in the equipment cache area of staging **FIGURE 15-24**. Pickhead axes are the most effective tool for taking out high-rise windows. Pike poles and drywall hooks are needed for checking the overhead, the plenum spaces, and overhaul. Gas and electric PPV fans and smoke ejectors are needed in setting up horizontal and vertical ventilation within the building after the fire is extinguished. Extra flashlight batteries and portable lighting may be necessary to illuminate smoke-filled or windowless areas of the building. Portable generators may be needed in case of electrical power failure. As additional companies arrive, a large supply of full SCBA cylinders will be needed for air exchange more than any other piece of equipment. Every member should bring at least one if not two extra SCBA cylinders when she or he reports to staging. Looping webbing around the cylinder stems and throwing it over a shoulder is an easy way to carry two bottles.

A medical area must also be set up in staging, or possibly three floors below the fire for a cleaner environment. In addition to a gurney and all the medical equipment needed by paramedics, a water canteen, jug, or cases of water bottles should be provided—the first thing firefighters need after being rotated out is clean drinking water. The physical condition of firefighters must be maintained during the incident, and firefighters engaged in firefighting activities need to be rotated, rehabbed, and medically monitored in a timely manner. Members must be rehabbed after working through two SCBA air cylinders. NFPA 1584, *Standard on the Rehabilitation Process for Members During Emergency Operations and Training Exercises*, defines the process for firefighter rehab. Additional alarms should be called early to ensure an adequate number of firefighters are onsite for rotating crews. There should be one crew in standby for every two crews assigned to a high-rise task.

Connecting to Standpipe Discharge Outlets

Standpipes provide a significant tactical advantage for quick and efficient direct attack evolutions and getting fast water to an elevated incipient and growth stage fire, as well as some fully developed fires, using 1¾-inch and 2½-inch hand lines. Other fully developed fires that will need more than 300 gpm to knock down and extinguish require the use of multiple hand lines or a lightweight portable master stream monitor or *Blitzfire* nozzle, both of which need to be supplied from the standpipe.

The discharge valve (outlet) is where firefighters hook up the hose to the standpipe, either directly onto the outlet or by first attaching a 2½-inch or 1½-inch wye. It is recommended that an inline pressure gauge be connected before the hose is attached **FIGURE 15-25**. Starting with the first floor, there is a 2½-inch discharge valve coming off the standpipe on every floor landing in the stairwell. Sometimes they are located on the half landing between floors. Every standpipe has a rooftop discharge manifold valve on the roof equal to the required flow to attack roof fires, roof deck and patio fires, and fires in rooftop machinery rooms, and for flowing water down the exterior sides of high-rise buildings to prevent autoextension and lapping. If not on the roof, the discharge valve will be located just inside the top stair landing at roof level. If the stairway continues down into a basement or lower multilevel parking garages, there will be additional below-grade discharge valves.

FIGURE 15-25 It is recommended that an inline pressure gauge be connected to the standpipe outlet before the hose is attached.

Photo by Captain Steve Baer.

Pressure-Reducing Valves (PRVs)

Pressure-reducing devices prevent dangerously high discharge pressures from the standpipe hose outlets. Two types of pressure-reducing devices can be installed on standpipes: flow-restricting devices and PRVs. A flow-restricting device controls the discharge pressure by restricting the flow through a reduced orifice plate. The specific pressure and discharge rate are determined when the standpipe is initially installed and flow-tested for certification. Flow-restricting devices do not reduce the static pressure (pressure with no water flowing). When water is flowing at the higher pressure, the flow rate is reduced because the water is passing through a smaller-diameter orifice plate within the valve.

PRVs limit the pressure on the downstream side at all flow rates. The PRV is set to deliver a specific pressure that will not be exceeded under any flow condition. Static and residual pressures remain set. These valves are often installed on the connections between the standpipe risers and the automatic sprinklers' sectional valves on the individual floors as well as on discharge hose outlets.

In super-high-rise buildings, the head pressure on lower floors can be tremendous. NFPA 13, *Standard for the Installation of Sprinkler Systems* deals with PRVs for sprinkler sectional valves. For standpipes and hose connections, NFPA 14, 7.2.3.2 states, "[W]here the static pressure at a 2½-inch (65-mm) hose connection exceeds 175 psi (12.1 bar), a listed pressure reducing device shall be provided to limit the static and residual pressure at the hose connection to no more than 175 psi." If flow pressures exceed 100 psi, then NFPA 14 requires that an approved device be installed at the discharge outlet to reduce pressures to a maximum of 100 psi (unless approved by the fire department, which may require a minimum pressure of 125 psi or more and a maximum pressure of up to 200 or more psi). Lower floor outlets have a higher static pressure, so expect PRVs to be installed with the higher setting to restrict the flow. Pressure settings decrease as the standpipe ascends to upper floors, which may have regular hose outlets without PRVs because of reduced inlet pressure due to the elevation. The determination about which pressure adjustments are required per floor is made during the system acceptance tests after the standpipe system is initially installed.

The 2½-inch outlets have the flow-restriction device or the PRV within the outlet housing or on the outside of the outlet housing. Most are set at the factory and cannot be adjusted in the field. Most of the time, PRVs operate as designed and do not present a problem in firefighting operations, but after the One Meridian Plaza Fire in Philadelphia, Pennsylvania, a failure to even recognize their existence became a national training concern. At the One Meridian Plaza Fire, human error resulted in deadly disaster. The PRVs were adjusted too high at the time of installation, and the discharge pressure was restricted to less than 60 psi, a pressure too low to provide an effective or functional stream for 1¾-inch or 2½-inch hand lines. The miscalibrated PRVs made it impossible for Philadelphia firefighters to launch an effective attack or for fire department pumpers to override the pressure restriction in the valves.

Adjusting a PRV is not a typical task for which firefighters train, and it is not part of the Firefighter I and II curriculum. Although some textbooks suggest adjusting or removing PRVs when necessary, this textbook does not. The methods for adjusting PRVs require specialized training and shouldn't be attempted by untrained personnel during an emergency incident. There are too many variables within a flowing standpipe system, and dismantling these valves may cause other problems with overpressurization. At the First Interstate Fire in Los Angeles, California, some of the PRVs failed and allowed pressures estimated at 500 psi to reach hand lines. Some hose lines ruptured, and others were nearly impossible to manage safely. Other alternative solutions should be implemented using fire department supply hose as a temporary standpipe.

The best way to find out if PRVs will be a problem during the fire attack is for the hose crew to flow the nozzle onto the floor below the fire after hooking up to the standpipe. In a relatively smoke-free environment, the company officer can check the volume, pressure, quality, and reach of the stream before entering the immediately dangerous to life or health (IDLH) area of the fire floor. If there is a problem with the PRVs, it will become apparent right here, before anyone gets hurt or killed. Fire department members, or at least company officers stationed in the downtown districts of major cities, should have some knowledge and experience on this subject, but part of any major high-rise incident management plan is to have a building engineer on site at the command post to help resolve such problems. If PRVs need to be adjusted, the adjustment should be coordinated with the building engineers.

Connecting to Below-Grade Standpipe Discharge Outlets

With fires in lower-level floors below the main entrance, hose lines should be laid down the stairs from the apparatus, even though there may be additional below-grade standpipe discharge connections. The reason for this is that the fire is already below you; heat and smoke may be pushing up the stairway as you're working your way down. If conditions change for the worse, you need the ability to back up and out of the stairway with a charged hose line to protect the attack team and to protect the stairway if rescues or evacuations are in progress. Head pressure is working in your favor when you are advancing below grade, so a combination fog nozzle is a better choice to protect firefighters and occupants. Additional firefighters on the main floor can assist in pulling the hose line back up the stairs, and this will not be possible if the hose line is connected to a below-grade discharge outlet. According to the NFPA *High-Rise Building Fires* report, 10% of all office and hotel high-rise fires start below grade—the common location for service areas.

Sometimes a below-grade standpipe connection may be the best choice. For example, some underground parking garages can go six levels below grade. A recon size-up and risk-benefit analysis needs to be conducted for vehicle fires occurring on these lower levels. Due to the amount of hose that may be required, these types of incidents warrant connecting to below-grade standpipe connections in the stairway.

House Lines and Fire Cabinets

With Class II standpipes, engine company personnel should not rely on house lines intended for use by the building occupants for fire attack. They should always use fire department hose. House lines should be tested at least once every 5 years but are often poorly maintained and not always actually tested. As a result, hose can be found partially charged, snarled, or in disarray in the cabinet or hose rack. Hose or nozzles could also be missing from the standpipe location. Unlined hose may be rotted. Valves that are never used or tested can be rusted and difficult to open by hand, or the handwheel may be missing. The only exceptions to this rule are for firefighters assigned to recon and searching for the seat of the fire, or those assigned to search, evacuation, and rescue above the fire floor who may be without the support of a fire department hand line. If for some reason they discover the fire, come across fire extension, or need the protection of a hose line, grabbing the house line makes sense and is better than doing nothing, but such an action should be followed up with a radio call for a hose line and crew. Experience has shown that ladder companies assigned to recon have used these house lines to provide fast water in extinguishing room fires before the engine company was able to get a hose line into operation. Such a case occurred at the Gateway Apartments and Townhouse Fire in San Francisco, California.

Dangers in the Firefighting Stairway

Many officers face the dilemma of whether to open the roof access door at the top of the stairway for vertical ventilation or leave it closed. Common sense says that it should be opened to let the pressurized heat and smoke out of the building. In a nonpressurized stairway, that may be the best tactic. In buildings that have pressurization fans for the stairway, it is not. In order for stairway pressurization to be maintained, the roof access door and the doors to each floor within the stairway need to remain closed. Modern pressurization systems can maintain a positive pressure with two and even three doors open in a stairwell; after that, system pressurization may not be effective in keeping smoke out of the stairwell. Occupants and residents propping hallway doors open on upper floors for convenience or air circulation, especially in summer months, is a common problem.

When firefighters make entry into the hallway from the stairway, the officer needs to watch what the smoke does. If pressure is sufficient within the stairwell, it may hold back the smoke, but conditions can change rapidly with any window failure or too many doors being opened within the firefighting stairwell. Thus, door control at the fire floor must be practiced to avoid allowing the air pressure in the stairway to decrease. PPV fans can be set up on lower levels of the stairway to help maintain stairway pressurization **FIGURE 15-26**. As soon as the offensive attack is initiated on the fire floor, you must understand that conditions in the stairway change quickly if stairway pressurization is not sufficient or maintained and if fire and smoke have entered the hallway. Flames, heat, and smoke immediately travel out the door and rise up the stairway to top floors. The stairway becomes a giant chimney with a lid **FIGURE 15-27**. Without door control, the stairway becomes an efficient high-low flow path when the roof access door is opened. Rapid movement of heat and smoke begins to develop **FIGURE 15-28**. If the fire has self-vented through a window, a wind-driven fire can push the flames, heat, and smoke up the stairwell, making it an extremely efficient high-low flow path with blowtorch force **FIGURE 15-29**. Having the rooftop door

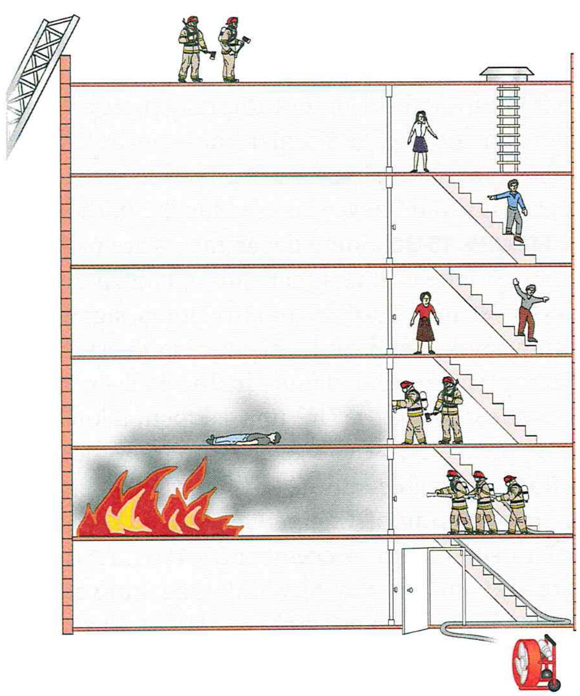


FIGURE 15-26 In pressurized stairways, the roof access and hallway doors within the stairway must remain closed to maintain pressurization until the attack stairway is cleared of occupants. PPV fans at floor level help maintain stairway pressurization.

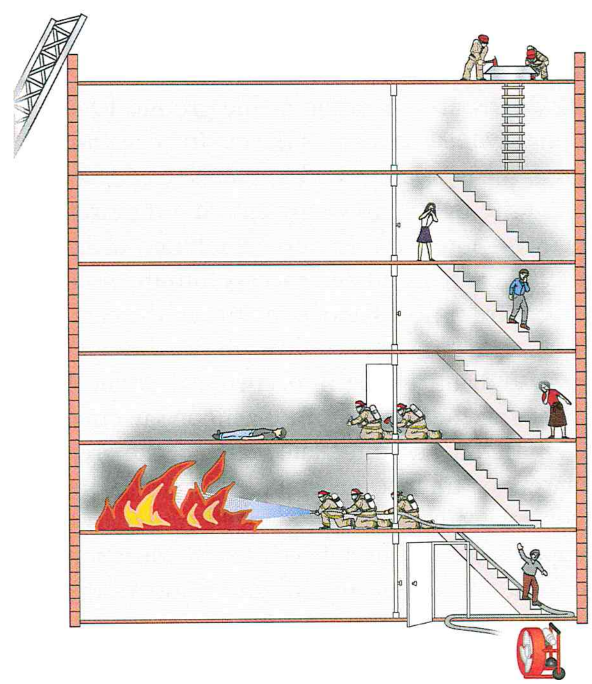


FIGURE 15-27 In a nonpressurized stairwell, or if pressurization is lost due to numerous open doors to the hallways, conditions in the stairway change quickly when fire attack is initiated. Heat and smoke immediately travels out the door and rises up the stairway to top floors.

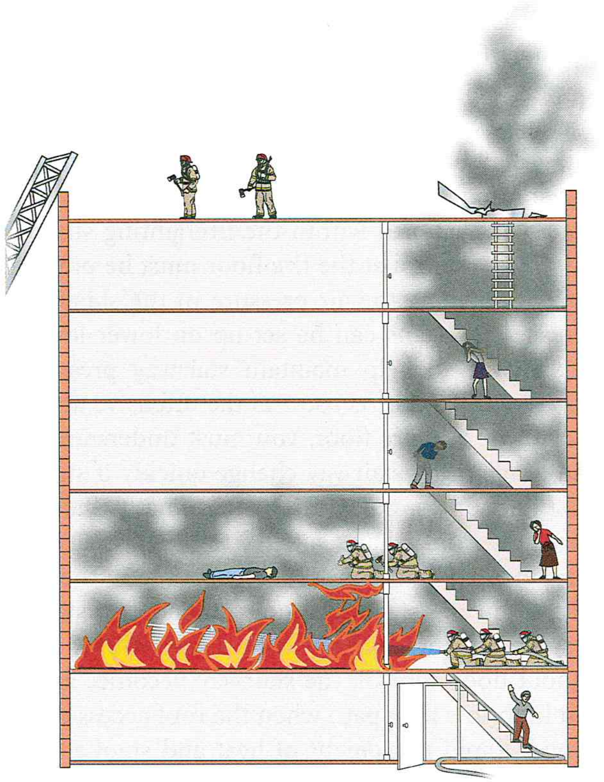


FIGURE 15-28 When the roof access door is opened, the stairwell leading to it becomes a rapid and efficient high-low flow path for heat and smoke.

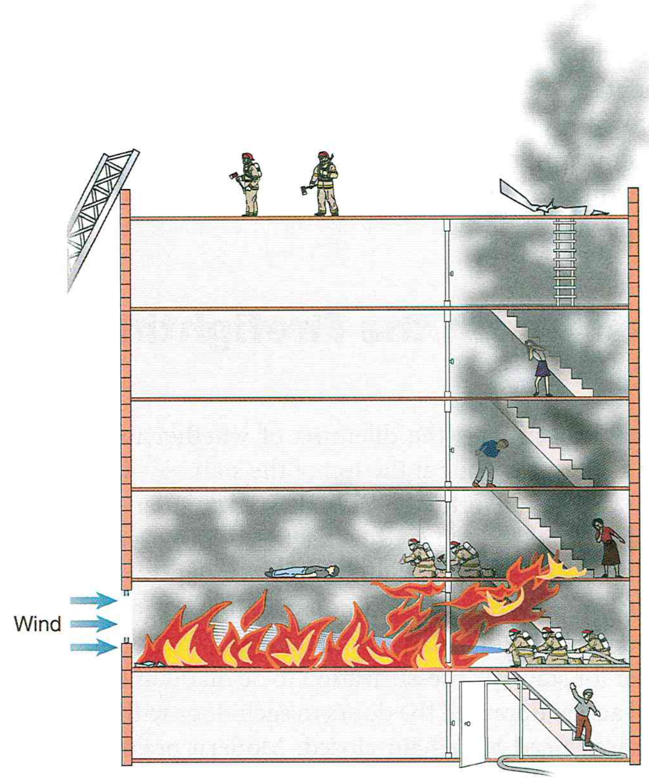


FIGURE 15-29 If the fire self-vents through a window, a wind-driven fire can push the flames, heat, and smoke up the stairwell, making it an extremely efficient high-low flow path with blowtorch force.

open increases the speed of the flow path, especially if PPV fans are operating at the ground-level entry. *But the primary concern is the ability for occupants to enter the "stairwell-turned-chimney."* Occupants fleeing the fire by unknowingly entering the firefighting stairway—now the chimney—combined with our inability to control and deny access into the firefighting stairway from floors above the fire in the early stages of the incident is the deadly problem. Company officers should anticipate this occurrence. Other than extinguishing the fire, no other actions save more lives than initiating an immediate search of the firefighting stairway for trapped occupants before the fire attack is commenced and implementing strategies to keep occupants out of the stairwell for the duration of the fire. At a minimum, the first five floors of the attack stairwell must be checked for occupants by an engine crew member before the hallway door is opened to the fire floor.

Unless the entire fire attack stairwell can remain pressurized, connecting hose lines on the fire floor and above the fire floor landing should be avoided. If the attack line is taken off the fire floor and the stairway landing becomes untenable, control of the standpipe discharge valve is lost. Once the fire is sufficiently knocked down and thermal energy is taken away from the fire, additional lines can be taken off the fire floor standpipe for a backup line or for overhaul, but it should never be used for the initial fire attack **FIGURE 15-30**. Some departments are now using portable smoke curtains that can be quickly installed in doors between stairway and fire floors, significantly limiting smoke and heat from entering the stairwell.

Heavy smoke and flames in the hallway usually means the door to the fire unit is open, allowing the fire to spread. This can make the stairway above the fire floor untenable and deadly. New York City Firefighter John King of Engine Company 23 was killed in such a situation on December 27, 1961. As the crew was ready to make entry, he was flaking the excess hose on the stairs above, a practice we all use today to make it easier to advance the hose line onto the fire floor **FIGURE 15-31**. When the hallway door was opened, smoke and flames trapped Firefighter King on the stairs above the fire floor, killing him. On December 24, 1998, in New York City, four civilians died in a superheated, smoke-filled stairway. The fire started on floor 19, and the victims were found in the firefighting

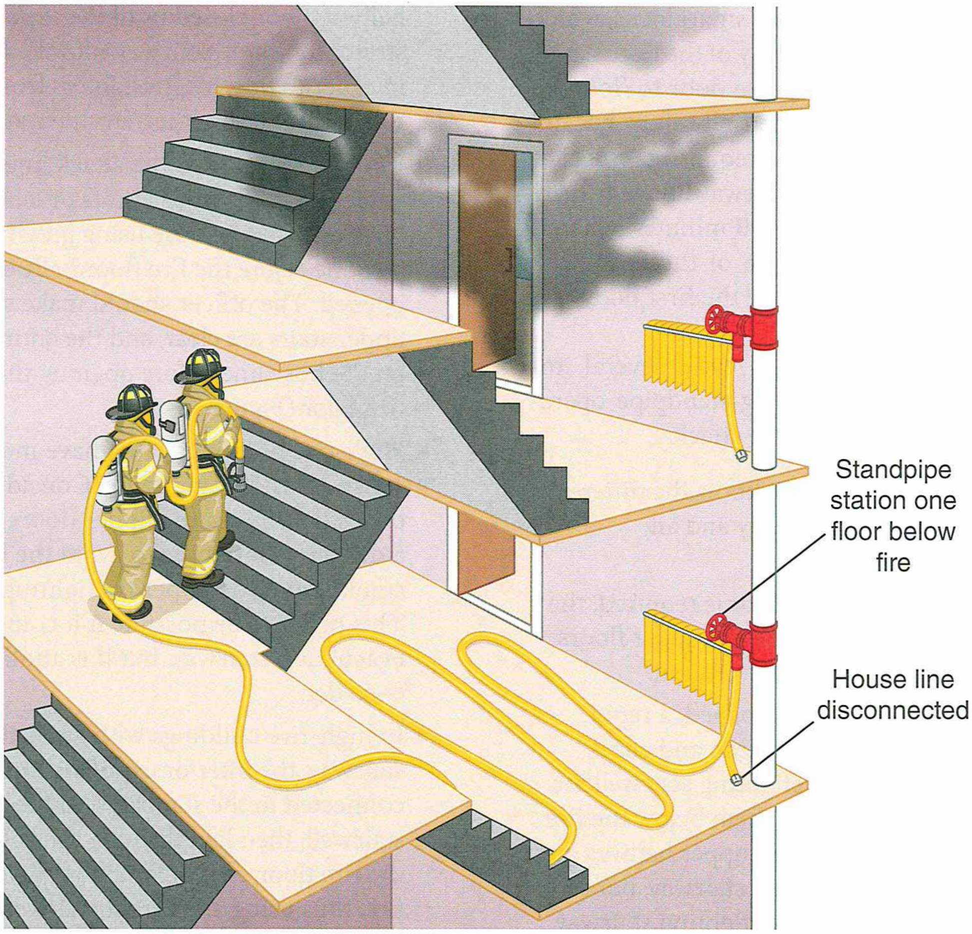


FIGURE 15-30 The first attack line should be connected to the standpipe discharge outlet one floor below the fire.

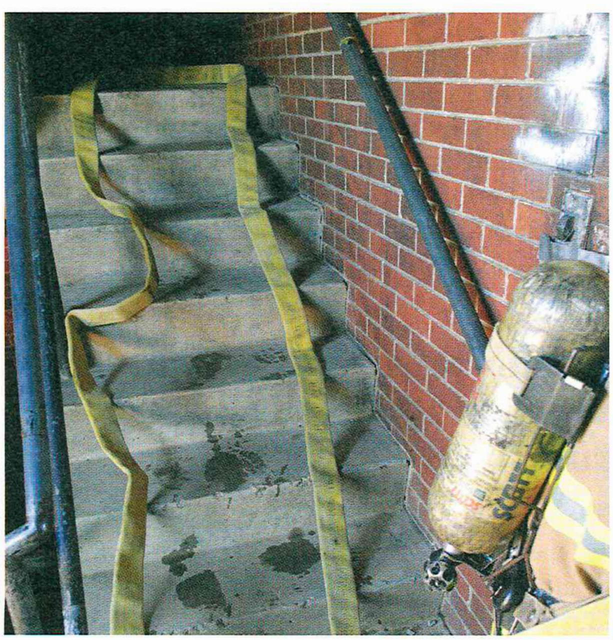


FIGURE 15-31 If the excess hose of the attack line is coiled or stretched to the upper stairs or landing, the officer should make sure that the entire crew is back on the hose line before opening the door to the fire floor.

stairwell on floors 27 and 29. On January 6, 2014, again in New York City, one man was killed, and another critically injured when they tried to escape a fire in their high-rise apartment. The fire started on floor 20. The two men unknowingly entered the firefighting stairwell on floor 38. As the firefighters opened the hallway door to advance to the fire floor, heat and smoke filled the upper stairwell: the men only made it down to floor 31.

The most tragic example was the Cook County Administration Building Fire on October 17, 2003, in Chicago, Illinois. A relatively small fire started in a supply room on floor 12 of this 35-story nonsprinklered high-rise. The supply room was directly adjacent to one of the two stairways. The fire started at 17:00. Within 3 minutes, smoke was visible from the exterior of the building. By 17:06, the windows had failed, and flames were visible from the street before the Chicago Fire Department arrived on scene. The 54-minute-long fire attack started at 17:16, and as the attack crew made its way onto floor 12, smoke and heat from the fire floor charged the attack stairway, trapping 13 civilians who were trying to escape. The stairway was not pressurized, nor did it have any smart locks, which would have allowed reentry into any of the floors. Fortunately, someone blocked open the door to floor 27, which allowed seven occupants to find refuge but not without smoke inhalation injuries requiring resuscitation. The other six died in the stairway above the fire floor. Unfortunately, it took over 90 minutes, when it was decided that the entire length of the fire attack stairway should be checked, before the first body was discovered.

These examples illustrate and reveal several important actions to consider during standpipe operations before initiating the offensive attack:

- Building occupants may not know the difference between a firefighting stairway and an evacuation stairway.
- If forcible entry to the fire floor is required, the door must be controlled until the upper floors of the firefighting stairway are cleared.
- Before the fire floor door is opened, a rapid ascent team (RAT) should search and check the upper levels in the firefighting stairwell for evacuees and quickly move them below the fire floor or move them inside an upper hallway and direct them to the evacuation stairway, but they must be moved out of the firefighting stairway before the attack begins. This understandably poses a dilemma when there are several floors above the fire. At minimum, the first five floors above the fire floor should be immediately checked for evacuees.
- The PA system located at the fire alarm panel should be used to clear the stairway and direct occupants to the evacuation stairway or direct them to remain in their rooms to shelter in place.
- Protect and shelter in place is the primary strategy for search teams. Rather than risk bringing occupants through an IDLH atmosphere, search teams should direct occupants back into their rooms.
- If a large number of occupants are flooding down the firefighting stairway, they have effectively stalled the fire attack. The company officer cannot initiate the attack by opening the door to the fire floor hallway without endangering the evacuees. They must wait for the stairwell above the fire to clear or look for another way to attack the fire.
- If an exposure line is needed on the floor above the fire, the firefighters involved in the fire attack might have to wait with the fire floor hallway door closed until the exposure line is stretched up the stairway into the hallway above in order to prevent firefighters from getting caught in the superheated stairway/chimney.
- If the excess hose of the attack line is coiled or stretched to the upper stairs or landing to assist in advancing the hose using gravity, this should be done *before* the fire floor hallway door is opened. The officer should make sure that the upper stairs are clear, and the entire crew is back on the hose line before opening the door to the fire floor (Figure 15-31).
- High-rise buildings often have more than one stairway with a standpipe. Consider taking the exposure lines to the upper floors and using a different standpipe to avoid the heat and smoke from the upper firefighting stairway. This may not be possible if it compromises the evacuation stairway, but it is another option to consider.
- In high-rise buildings with more than one stairway, the interior exposure line can be connected to the standpipe in the firefighting stairwell, then laid through the hallway below the fire floor, and then up to the floor above the fire, thus using a different stairwell and staying clear of the smoke and heat rising above the fire floor in the firefighting stairway. Although this tactic requires more hose, the lay should be fast because there is no smoke or heat to deal with. In this scenario, the hose can remain uncharged until it's time to make entry.
- Another option is to lay another 2½-inch hose line connected three or four floors below the fire floor and stretched up to the floor below the fire with a 2½-inch wye attached to it. Once charged, it provides two other standpipe outlets to connect to.

Initial Hose Operations in Residential High-Rise Buildings

This section of the chapter covers a variety of strategies and tactics to consider when executing the initial fire attack in residential high-rise buildings.

Beginning the Direct Attack

Hose lines that are 1¾ inches are effective on most apartment high-rise fires with the typical household furnishings; however, a 2½-inch hose should also be

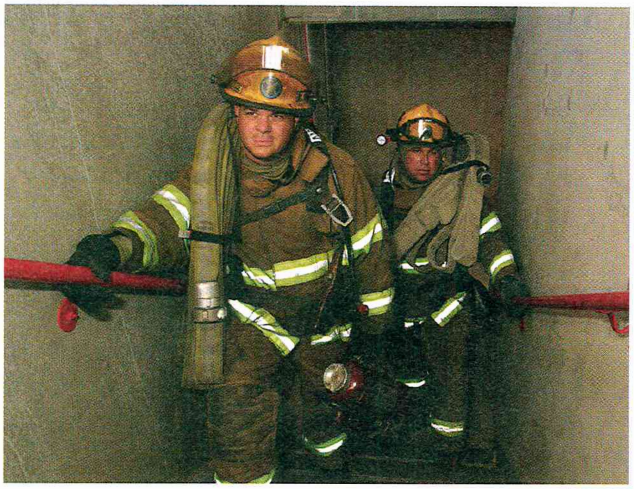


FIGURE 15-32 As firefighters ascend the stairwell, they should ensure that all standpipe discharge valves on the lower floors are closed.

available for backup in case the smaller hose lines are inadequate for controlling the fire or if the fire extends into the hallway. As in all firefighting operations, if the 1¾-inch hand line isn't knocking down the fire in 1 minute, the 2½-inch backup hose should be used immediately. Backup lines should be equal to or greater than the hose diameter of the attack line utilizing a combination nozzle.

Ascending the Stairs

If firefighters ascend up the stairwell to the floor below the fire instead of using the elevators, it is a good (proactive) practice as they pass each landing to check that all standpipe discharge valves on the lower floors are closed **FIGURE 15-32**. If water is cascading down the stairway after the standpipe is charged, it is an indication that there are open discharge valves somewhere in the stairway, thus robbing water from the fire area on upper floors. If there is unexpected low pressure before the fire attack begins, it is another indication that lower floor valves are left open. One firefighter may have to run down the entire length of the stairway to make this check to close them, which wastes valuable time. After this check is made, the firefighter should take the elevator back up to staging, which is two floors below the fire floor, and rejoin the crew.

If elevators were used to take firefighters to the staging area two floors below the fire, the firefighters should advance by stairway to the fire floor. The first hose line must be connected to a standpipe discharge outlet in the enclosed stairwell, one floor below the fire. The hose should be coiled or spread out and up the stairs before it is charged. When charged, coiled hose is easy to advance and means less congestion in the stairway of the fire floor as the attack gets under way **FIGURE 15-33**. If 1¾-inch hose lines are to be used for initial attack, a wye can be placed on the outlet or attached to a short length of 2½-inch hose, and two attack lines can be hooked to it. If the hose connection is needed in the hallway with a Class II standpipe for firefighting, the house line and reducer coupling should be removed. Only in extreme rescue circumstances during a high-rise fire attack should the engine crew use the tenant hose found on the outlet instead of fire department hose. *Use your own hose.* Keep in mind that the flow and pressure in the house line outlet is typically much lower than that in firefighter standpipe outlets; therefore, attempting to operate fire hose from a house line outlet can result in inadequate flows and pressure.

FIGURE 15-33 When charged, coiled hose is easy to advance and means less congestion in the stairway of the fire floor.

Photo by Lt. Kevin O'Donnell.

Tactical Objectives

The tactical objectives on the fire floor of a high-rise building remain the same as in a one-story building:

- Forcible entry: access
- Fire attack line (first hose line)
- Backup line (second hose line also acts as initial RIT)

- Exposure line to floor above (third hose line)
- Rapid intervention line (fourth hose line)
- SER and evacuation
- Ventilation
- Salvage and overhaul

At a minimum, the four hose lines mentioned above must be deployed. Additional attack lines, backup lines, and interior exposure lines may be needed on the fire floor, and additional exposure lines may be needed on the floor or floors above the fire. Speed and maneuverability with the available personnel are extremely important for controlling fires in high-rise buildings. The size of the hand lines and nozzles still depend on the application of one of the two fire flow formulas, Royer/Nelson Iowa State University or National Fire Academy (NFA), but more than likely, 2½-inch hand lines should be anticipated for backup lines in fighting fires in high-rise buildings.

In most cases, not all hose lines operate simultaneously, but if 2½-inch lines are used and the standpipe is 4 inches in diameter, recognize that the combination of an attack line, backup line, exposure line, and RIT operating simultaneously might exceed the flow capacity of the standpipe. Most important, if three lines are flowing and the fourth line is opened, the pressure on all lines could drop, thus endangering the attack line crews and crews assigned to SER.

Rapid Intervention Teams (RITs)

There needs to be some clarification about when the RIT (or rapid intervention crew [RIC]) is assigned on the fire floor. Many feel that making RIT the second assignment after the initial attack team is a waste of firefighter resources early in the incident, when every firefighter should be utilized in getting sufficient water to the fire. If the backup line is the second assignment, and the exposure line is the third assignment, properly supporting the attack strategy should prevent a firefighter emergency that would require a RIT deployment. On the surface, this reasoning may sound logical, but there is an assumption that the RIT is standing around simply waiting for an emergency to happen while the attack crew is struggling on its own to get a line in position to attack the fire. Chapter 8 of NFPA 1500, *Standard on Fire Department Occupational Safety, Health, and Wellness Program* has a section, specifically section 8.8, called Rapid Intervention for Rescue of Members. Every fire officer should carefully study this section; it is the law. After an occupational fatality or line-of-duty death (LODD), our actions will be scrutinized for compliance to this standard and, without a doubt, we will be held accountable for willful noncompliance.

- Section 8.8.2 states: "In the initial stages of an incident where only one crew is operating in the hazardous area at a working structural fire, a minimum of four individuals shall be required, consisting of two members working as a crew in the hazard area and two standby members present outside the hazard area available for assistance or rescue at emergency operations where entry into the danger area is required." (This is the two in/two out rule that also applies to high-rise firefighting.)
- Section 8.8.2.9 states: "Once a second crew is assigned or operating in the hazard area, the incident shall no longer be considered in the 'initial stage' and at least one rapid intervention crew shall be deployed that complies with the requirements of 8.8.2."
- Section 8.8.2.5.1 states: "No one shall be permitted to serve as a standby member of the firefighting crew when other activities in which the firefighter is engaged inhibit the firefighter's ability to assist in or perform rescue, if necessary, or are of such importance that they cannot be abandoned without placing other firefighters in danger."
- Section 8.8.4 states: "A rapid intervention crew shall consist of at least two members and shall be available for immediate rescue of a member or a crew."
- Section 8.8.6 states: "The composition and structure of a rapid intervention crew shall be permitted to be flexible based on the type of incident and the size and complexity of the incident."

What does this all mean? In actuality, the NFPA standard gives you options with a tremendous amount of flexibility. The RIT needs to be viewed as supporting the attack. The standard never states that the RIT has to be a crew of four. It never states that they have to have a hose line. In fact, the only required equipment, in addition to full PPE with SCBA, is a universal air connection (UAC) to a supplied air source. RIT standby members (two minimum) can include the officer assigned to the floor division. The standard never states that they can't help. They can help lay the hose in the stairway, connect to the standpipe, bleed the air in the standpipe and the hose line, remove kinks, pull hose up the stairs, and help advance the charged line into the hallway from the stairway. They merely have to remain outside the hazard area but in close proximity, where they can drop whatever they're doing and immediately assist or rescue members who are operating inside the hazard area.

In a NIST experiment, a video was shot capturing the speed of fire development of commercial office furnishings provided in a typical office space. Within 20 seconds, thick black smoke was banking down one-quarter of the way from the ceiling. In 5 minutes, most of the furnishings were on fire, and thick black smoke was banked halfway down. In 7 minutes, flashover had occurred, and the room was completely involved in fire, with a zero survivability profile. Experience and case studies have already revealed that it takes between 15 and 20 minutes to get the first hose line in operation on upper floors after the arrival of the fire department. At the First Interstate Fire in Los Angeles, California; the One Meridian Plaza Fire in Philadelphia, Pennsylvania; and the Cook County Administration Building Fire in Chicago, Illinois, smoke and flames were already blowing out the windows when their respective fire departments arrived on scene. From arrival, it took Los Angeles firefighters 29 minutes to get the first line into operation on the twelfth floor. In other words, the first attack team may be entering a hazard area that is heavily involved in fire and they may require the immediate assistance of a rescue team in the first few minutes. Why would you hesitate to establish a RIT immediately after their entry and wait for the time it will take for the fourth company in the sequence to arrive on the fire floor before establishing a designated rescue team?

Consider the following evolutions for the first company assigned to fire attack. It can only be accomplished with 1¾-inch or 2-inch hose. Two firefighters cannot realistically advance and operate a 2½-inch hose line down an interior hallway and into a compartment in smoke, heat, and fire conditions. The fire attack crew must have a crew of four to enter the hazard area. If they connect on the floor below and bring a single attack line of 200 feet, the nozzle firefighter and his or her partner can make entry into the hallway or fire floor while the officer and the fourth firefighter remain on the landing and thus become the initial RIT. The officer becomes the fire floor division supervisor and the two in/two out rule is met.

If this crew of four can manage to bring two hose lines of 200 feet each, the attack line can be connected and charged from the floor below the fire while the second line, which is designated the RIT line, can be connected on the fire floor, coiled on the landing above the fire floor while all hallway doors remain closed, and charged, and the nozzle section can be brought down to the stairs just above the fire floor landing in a ready position. Then two firefighters enter the hazard area on the attack line while the officer and the fourth firefighter become the initial RIT; this time, however, they have a hose line for protection and for cooling members who may be rapidly exiting the fire floor. The two in/two out rule is met.

When the next company of four arrives, they can be given the backup line assignment to the attack crew. With more personnel, the 2½-inch line can enter the evolution. With two officers available, one remains division supervisor while the other enters the hazard area with the backup team. The arrival of the second company ends the initial stage of the incident, so a designated RIT company of two members minimum needs to be assigned. With six members now on the landing, the teams can be split two different ways depending on the hose:

1. One officer remains the division supervisor, with two firefighters on the backup line and three firefighters on the RIT line, *or*
2. One officer remains the division supervisor, with three firefighters on the backup line and two firefighters on the RIT line.

As more crews arrive, the RIT size can increase or be substituted for a ladder company or rescue company. A designated RIT hose line is not required by the NFPA 1500 standard, but if you're going into a hostile thermal environment to assist or rescue firefighters, wouldn't you want to protect yourself? It is doubtful that you would be able to even make entry without the protection of a hose line. The same rationale applies to ladder company members assigned to SER. There is no rule preventing firefighters assigned to SER from taking a hose line with them for protection and the protection of occupants. If there are no civilians on the fire floor, the only remaining unprotected occupants are the firefighters themselves. We must shift our mindset to operate with the greatest margin of safety and with the protection of charged hose lines rather than risk thermal assault without hose protection because that's how it was done in the past.

Hooking Up Below the Fire Floor

The firefighter hooking up to the standpipe hose outlet should open the valve before connecting the hose. This tactic quickly bleeds out the air in the standpipe and flushes any debris between the FDC and the outlet. Once water is flowing, the firefighter can close the valve and connect the in-line pressure gauge, then the hose. While the crew is hooking up to the standpipe and laying out the hose up to the fire floor landing, the company officer should look into the floor below the fire to get as much information as possible about the layout of the office/commercial open-floor space or the layout of the residential hallway. The officer should check for:

- Locations of other exits and stairways
- Location of the elevator lobby
- The number of rooms that are on the right
- The number of rooms that are on the left
- The length and height of the hallway
- Floor construction (industrial carpet, tile, or concrete)
- The existence of a plenum
- Door construction: wooden doors are easier to force than metal doors
- Direction in which doors swing (right or left, in or out)
- Wall construction, for example, gypsum board (Sheetrock) or concrete (wall breaching and reaching through for the door handle might be the easiest way to access a hallway or room)
- Open or closed floor plan
- The existence of a service room or utility closet (a common source of fires)
- The existence of cubicles
- The existence of wall partitions that will deflect hose streams or fall over from hose streams
- The existence of glass partitions and windows

A quick look inside a unit (apartment or office) would be even better because the layout in the fire unit will most likely be identical and aid in keeping you and your crew oriented. This survey can be quick and completed in less than a minute, or at least in the same time it takes the crew to connect to the standpipe and lay out the hose. It's worth the time because the floor plan of the fire floor may be the same. A quick scan of the hallway helps you remain oriented on the fire floor as well as plan for a secondary means of escape. If time allows, the entire crew should scan the floor as well. This opportunity can give some peace of mind as well as develop self-confidence before the firefighters enter a smoky hot environment with little or no visibility. The fire code requires buildings to have an evacuation floor map posted in elevator lobbies, but sometimes they are also posted in the stairway landings by the door. If so, they include a diagram of the floor plan **FIGURE 15-34**. This may mean taking the extra time to check out the floor plan map in the elevator lobby on the staging floor or the floor below the fire, but the time is worth it before proceeding to the fire floor.

Finally, before the nozzle section is stretched to the fire floor, the officer should have the attack team flow the nozzle and check the stream on the floor below the fire. Do not worry about water damage, which is the least of your worries. This tactic allows firefighters to bleed the line of air; flush the hose; and check the reach, flow, shape, and quality of the stream in a smoke-cleared hallway. Most important, if there is any problem with a PRV, it will present itself right here instead of on the fire floor, where crews may be caught in a hostile thermal environment with an inadequate stream. This is a very important safety check before starting the attack. When the crew is ready to make entry, the officer should announce on the radio, "Commencing fire attack." Not only is this a time mark for the IC, it is a warning that conditions in the attack stairwell are about to change.

1½-inch and 2½-inch Gated Wyes

The attack line and backup line can be connected to the standpipe on the floor below the fire using a 1½-inch or a 2½-inch gated wye. This gives the company officer options. Depending on the occupancy, whether the floors are compartmentalized, the fire load, the size of the fire, and if the building is fully sprinklered, a 1¾-inch attack line with a 1¾-inch backup line will sometimes be sufficient. For example, consider the fire load and square footage of a fire in a unit in a high-rise hotel that is sprinklered. There's one room with one or two beds, a nightstand, lamps, a TV, an easy chair, a desk or small table with a chair, chest of drawers and curtains—that's about it. This fire does not need a 2½-inch line for the initial attack. Two engine companies can manage a 1¾-inch attack line and backup line coming off a 1½-inch gated wye and handle this fire fairly quickly.

Using a 2½-inch gated wye can yield a number of combinations:

- Two 2½-inch attack lines
- One 2½-inch attack line and one 2½-inch backup line
- One 2½-inch line and two 1¾-inch lines coming off a 1½-inch gated wye
- Four 1¾-inch lines coming off two 1½-inch gated wyes for exposure protection to floors above
- Two 2½-inch lines to supply a portable monitor or *Blitzfire* master stream nozzle

These wye configurations add a tremendous amount of cantilevered weight to the standpipe discharge outlet and should be supported with webbing

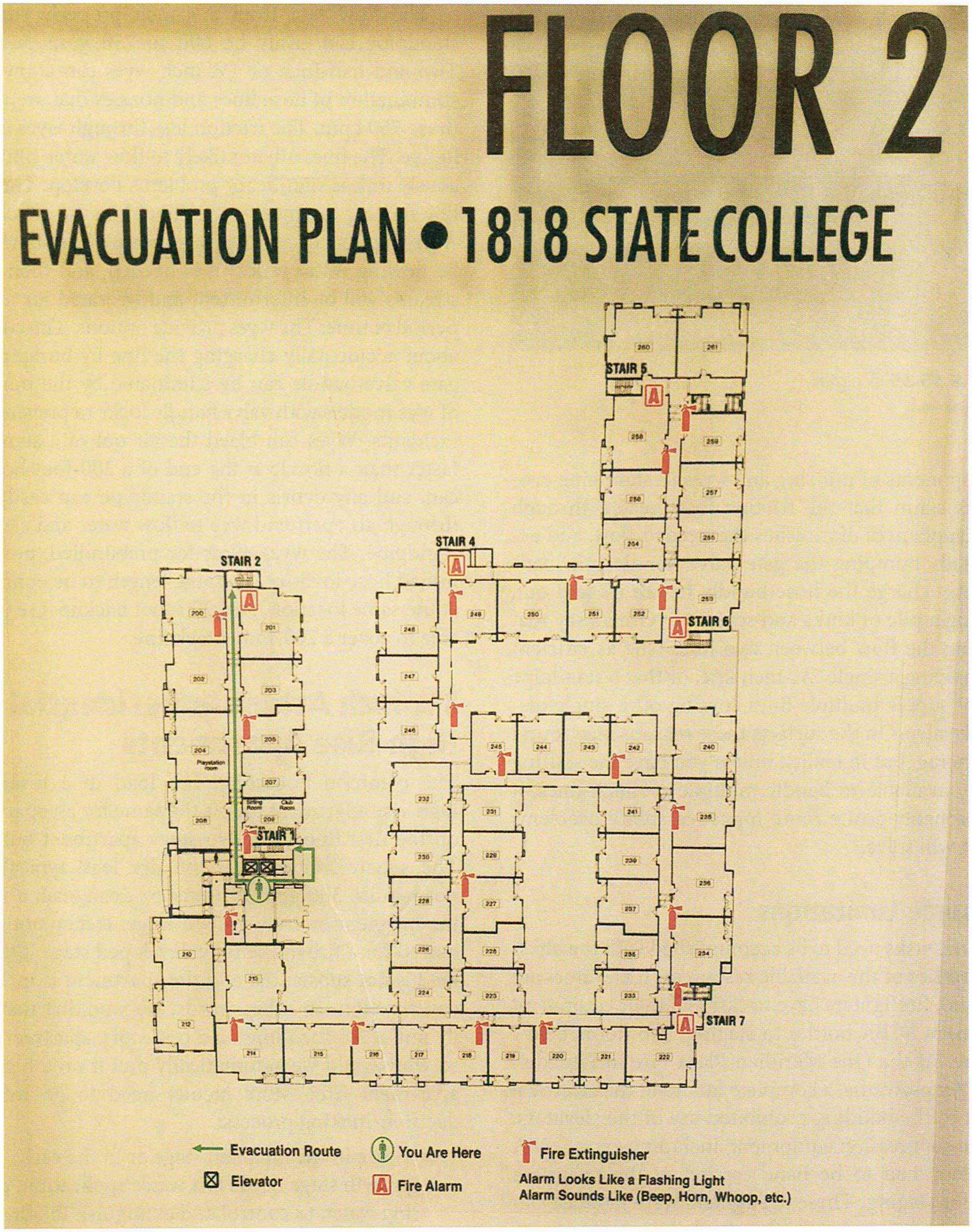


FIGURE 15-34 Evacuation maps include the floor plan and are posted in the elevator lobbies and sometimes in stairway landings.

Courtesy of Raul Angulo.

tied to the standpipe bracket. A better solution that many fire departments have implemented is to have what is called a pigtail: a 10- to 12-foot section of 2½-inch hose line that connects to the standpipe discharge valve, and then wyes, the in-line pressure gauge, or attack hose lines are connected to the male end of the pigtail. This relieves practically all the weight on the discharge valve and transfers it to the floor **FIGURE 15-35**. The pigtail also allows the hose connections to be moved to a corner of the floor landing, so all the connections aren't blocking the door and don't become an obstacle for firefighters.

FIGURE 15-35 A pigtail.
Courtesy of Raul Angulo.

Opponents of utilizing any wyes in standpipe evolutions claim that the friction loss created through these appliances diminishes the needed flow, and accidentally bumping the gate valve handle can inadvertently charge the hose bundle before it's laid out, creating a pile of kinks and spaghetti. Others say that splitting the flow between two lines isn't as efficient as supplying a single 2½-inch line, or that a standpipe cannot supply multiple lines coming off a single discharge valve. On the surface, these reasons may sound convincing, but in reality, unless you have the staffing readily available to handle multiple 2½-inch lines, it will probably create more maneuverability problems than it will solve.

Resource Limitations

Essential tasks need to be accomplished with the physical abilities of the available resources. If elevators are not used, firefighters have to carry all their equipment with extra SCBA bottles to staging, two floors below the fire. At the One Meridian Plaza Fire in Philadelphia, Pennsylvania, a complete failure of the electrical power to the building prohibited use of the elevators. All the suppression equipment, including extra SCBA cylinders, had to be hand-carried to the twentieth floor for staging. These firefighters were fatigued before they even started the fire attack. It is unreasonable to expect that all firefighters have the physical stamina to manage the weight of a charged 2½-inch hand line with the additional assault of smoke and heat after such a hike. You have to be flexible and allow the use of 1¾-inch lines. In Philadelphia, 1¾-inch hand lines were the initial attack lines. The inability to control the fire was due to the miscalibrated PRVs, not because firefighters selected 1¾-inch hand lines. They were flowing less than 60 psi, which is insufficient for some 2½-inch hose lays and nozzles as well.

The flow rate from a 4-inch properly supplied standpipe can easily be 600 to 750 gpm or more. Two-and-half-inch or 1½-inch wyes can allow for a combination of hose lines and nozzles that are within those 750 gpm. The friction loss through wyes is negligible. The lines are not likely to flow water simultaneously unless significant problems develop. The hose line flowing the most water should be the attack line. A backup line or an interior exposure line should not be flowing water unless it is needed, and then those streams will be intermittent and operated for a short period of time. The wyes provide options. The concern about accidentally charging the line by bumping the gate valve handle can be eliminated by the purchase of wye models with valve handle locks to prevent such incidents. Wyes can bleed the air out of a standpipe faster than a nozzle at the end of a 200-foot hose lay can, and any debris in the standpipe can easily pass through an open-end wye to flow water and clear the standpipe. The wyes allow for prebundled, predetermined hose loads of the same length to be connected at the same location, so a 200-foot backup line will be able to cover a 200-foot attack line.

1¾-inch Attack in Residential High-Rise Apartments

The common household fire load in a residential high-rise apartment unit is the same for an apartment on the first floor of a two-story apartment building. The square footage and the fire load typically do not require 300 gpm of water to extinguish a fire in the incipient or early growth stage. It may not be required for a fire in the fully developed stage if the fire load is not substantial and the apartment is in Type I construction. In other words, we wouldn't necessarily pull a 2½-inch line on a one-story apartment fire, so why would we automatically pull it on a high-rise apartment fire? More factors need to go into the decision-making process:

- A fire in the incipient stage or in the early growth stage needs fast water application, not big water, to control and extinguish the fire. This is the theory behind sprinklers, that is, small volumes of water applied quickly.
- Although the rapid deployment of a 1¾-inch hand line can get fast water on the fire, it should be backed up with a 2½-inch line.
- Residential high-rise units are compartmentalized and can often contain the fire to the room of origin.
- Getting quick water into a residential unit without opening the front door to accelerate

the fire can be accomplished by making a hole in the front door or the exterior Sheetrock wall within the hallway just large enough to insert and operate a nozzle.

- Residential high-rise fires behave differently than a fire in a wide area, open-space floor plan.
- Residential units often do not have a plenum.
- Modern high-rise insulated windows are very strong, with some being triple-paned. Unless they are exposed to direct flame contact or a wind-driven fire, they can retain the heat generated by household fire loads for a greater period of time than regular residential windows can.
- Everything hinges on wind conditions. Whether the winds are strong, light, or nonexistent must be determined. In high-rise fires, wind is the game-changer.
- Determine the direction of the wind. Is the fire on the windward side or leeward side of the building? Will the wind work in your favor or against you?
- In a decay fire, the tactic of making a hole through the front door or through the Sheetrock exterior wall of the hallway just large enough to insert and operate a nozzle can safely reduce the chance of a smoke explosion or the sudden rush of fresh air to reignite a smoldering fire.

While acknowledging the dangerous potential for fire spread in a residential high-rise, we must also acknowledge the tactical advantage gained with the speed and mobility afforded firefighters when using 1¾-inch lines. These hose lines provide the required gpm to extinguish the fire. Planning for the worst-case scenario doesn't mean we have to execute the tactics for one; you can have overkill even in a high-rise fire. These points are best illustrated in a high-rise apartment fire that occurred in San Francisco, California, and that is described in the next section.

Gateway Apartments and Townhomes Fire in San Francisco, California

On October 22, 2018, at 5:15 p.m., a three-alarm high-rise apartment fire occurred at the Gateway Apartments and Townhomes in the Financial District of San Francisco. The fire started in a corner unit on floor 12 and burned every corner unit above it, up to the sixteenth floor, primarily from autoexposure **FIGURE 15-36**. The Gateway is a 25-story, nonsprinklered, high-rise building that was built in

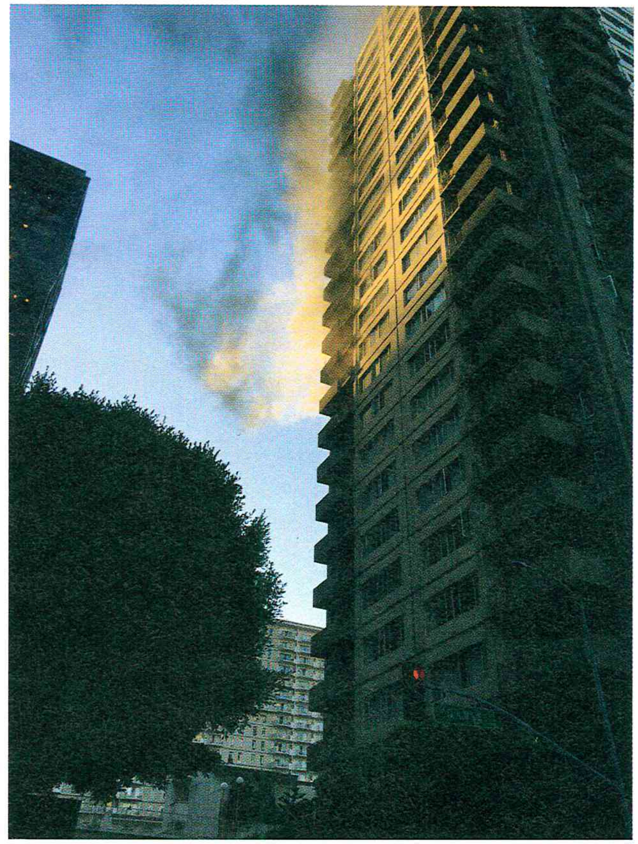


FIGURE 15-36 The Gateway fire started in a corner unit on floor 12 and burned every corner unit above it to the sixteenth floor.

Photo courtesy of Jonathan Baxter, San Francisco Fire Department.

1965 and contains 196 residential units, with eight apartments per floor. At the time of the fire, the building was approximately 25% occupied because many of the residents had not come home from work yet. There was approximately a 10–15 mph prevailing wind.

As mentioned, the fire started in a corner unit on floor 12. The fire alarm sounded in the building, and many occupants evacuated, although some disabled and elderly tenants in wheelchairs were unable to. Others decided to shelter in place and stay in their units. The corner units had balconies with a glass sliding door in addition to adjacent wall windows to maximize the view. Once the flames broke out the glass on floor 12, the fire started lapping to the floor above. The flames were so high, they made direct contact with the windows above, and these windows failed quickly. It didn't appear that the wind was working against the firefighters, and although conditions could change, it was not a wind-driven situation where flames would be pushed back onto the attack team. Instead, it was blowing lightly, sideways, counterclockwise around the exterior perimeter of the building **FIGURE 15-37**. This breeze pushed the lapping flames under the overhang of the balcony above. It was speculated that the balcony overhangs were enough of a horizontal

FIGURE 15-37 Although exterior windows failed in the Gateway Apartments and Townhomes Fire, the prevailing winds were light. A perfect scenario for a wind-driven fire was averted.

Photo courtesy of Jonathan Baxter, San Francisco Fire Department.

barrier for the flames that radiated heat and convected currents were allowed to accumulate at the top of the door, contributing to early failure of the glass sliders to the balcony. This theory makes sense. And so it went, unit-by-unit, floor-by floor, up to floor 16.

When the fire department arrived, firefighters charged the Class II standpipe (rated at 750 gpm), then climbed with all their equipment to the eleventh floor. The first attack team connected a 1¾-inch hand line with a smooth-bore tip to the standpipe on floor 11 and proceeded to floor 12. The building PA system was used to identify and direct occupants to the evacuation stairway, but the attack was delayed because occupants used the firefighting stairwell anyway. The company officer knew that opening the fire floor hallway could result in thick smoke and heat rushing up the stairway, endangering or injuring occupants, and thus did not open the door. After the upper stairway was cleared of fleeing residents, the firefighters made entry into the hallway for a direct attack on the fire. A second 1¾-inch hand line was taken off the wye and laid up to floor 13 for an exposure line above the fire. It was confirmed to all units that this building did have a thirteenth floor.

An SAR team was assigned to start on floor 12 where occupants were in the most danger and work its way up. When the team made it to the corner unit on floor 14 above the fire, the flames from autoexposure had reached the balcony. Without a hose line, they made a quick decision to go back into the hallway and grab the house line from the hose cabinet. The house line is a 100-foot single-jacket section of 1½-inch hose with an attached spray nozzle that is part of the Class II standpipe system. It is intended for occupant use (called first-aid use), and many texts state that it should never be used by fire department personnel for firefighting, but firefighters should also use common sense. Engine companies should not use these lines in lieu of fire department hose, but if ladder companies find themselves in a position of needing fast water for fire attack or protection, then by all means use the house line. That's what it's for! As it turned out, due to the actions of these quick-thinking firefighters and the use of the house line, the corner unit on floor 14, except for the balcony, was the only unit not damaged by the flames. However, the fire continued to lap up and extend to floor 15.

Because the wind wasn't working against the firefighters, smoke and heat conditions in the firefighting stairwell were tenable, and firefighters were able to quickly stretch 1¾-inch hand lines to floors 14, 15, and 16. With direct fire attacks happening simultaneously in the hallways and inside the fire units, the fires on all floors were extinguished in 45 minutes. The second-alarm companies were assigned to stretch 2½-inch backup lines to the five floors, but none of the 2½-inch lines were used in fighting the fire. The attacks were successful using 1¾-inch hand lines. Again, because the wind was working in their favor, horizontal cross-ventilation using the prevailing winds was effective and sufficient.

A rare but not unusual fireground hazard was discovered after the fires were knocked down: some of the glass windows that failed during the fire were curtain-wall windows that ran from floor to ceiling. The failure of these windows created an unobstructed opening and a severe and dangerous fall hazard to any unsuspecting firefighter performing an interior perimeter wall search or being unaware of their surroundings during overhaul. This illustrates the ever-present dangers on the elevated fireground. After extinguishment and before overhaul begins, a scene-safety survey, and a risk-benefit analysis needs to be conducted of the immediate fire area, and hazards like unobstructed openings should be cordoned off. Wooden studs, or fire-damaged furniture, like tables or sofas, can be used to fence off an open wall or windows with low sills. Fire scene tape should be used to flag the area, and all firefighters must be made aware of these severe fall hazards.

The Gateway Apartments and Townhomes Fire confirms some strategic and tactical points:

- Based on the common household fire loads, even in high-rise apartments, and the square footage and compartmentation of residential units, 1¾-inch hand lines are effective for combating residential high-rise fires when these lines are properly supplied.
- The speed and mobility of moving charged 1¾-inch hand lines made it possible for firefighters to stop autoexposure quickly and attack fires on five different floors. These actions would not have been so easy if 2½-inch hose lines were used because they would have required more flow from the standpipe and a lot more personnel and resources.
- The standpipe supplied the water flows for five separate 1¾-inch hand lines operating simultaneously.
- Two-and-a-half-inch hand lines were laid to back up the 1¾-inch lines; although they were never used, this is a sound tactic.
- Even though the PA system was used to direct residents to the evacuation stairway, occupants still evacuated using the firefighting stairway, a situation we must expect in any evacuation situation.
- The firefighters who saved the fourteenth-floor unit by using the house line should dispel the notion that fire personnel should never use a house line for fire attack. Use common sense.
- First-in companies hiked up the stairway with all their equipment to the eleventh floor, which was the floor below the fire. Elevators were not used until it was confirmed that there was no smoke in the hoistways and that the elevators operated properly. Then Phase II operations shuttled equipment to the staging floor.

Miraculously, there were no injuries, and only 30 units in the Gateway Apartments were unable to be reoccupied. This was a textbook example in residential high-rise firefighting where everything went right. The fact that the fires on five different floors were extinguished in 45 minutes with 1¾-inch hand lines is incredible. The extra time and personnel that would have been required to perform this same evolution with 2½-inch hand lines exclusively could have meant that the situation would have turned out much differently had the fire occurred in the middle of the night when the building was fully occupied and residents were asleep.

Single-Hose Method (2½-inch)

The method for taking a single 2½-inch hose line per floor can be an effective fire attack if sufficient firefighters are on hand to help advance the charged hose line. If not, this method can complicate the attack or cause it to fail. Consider the hose lines that need to be laid up the stairs and that you must allow 50 feet of hose per floor; the 200-foot attack line is connected on the floor below the fire. If the exposure line is needed on the floor above, it may need to be connected before the backup line to get that crew out of the firefighting stairway and into the hallway. That hose must connect two floors below the fire and needs to lay up to the floor above the fire; that is 150 feet of hose just for the stairs. The backup line must connect to the standpipe three floors below the fire and also requires 150 feet of hose for the stairs, plus an additional 150 feet to be able to reach the attack nozzle; that's 300 feet of charged 2½-inch hose—and moving it is not an easy task. The RIT line must be connected four floors below the fire, or perhaps from another standpipe. You can see how this situation can get complicated. Plus, you would need a sufficient number of companies to manage this much hose and weight **FIGURE 15-38**.

Some buildings, especially older ones, have a wide open well between floors within the stairway. Hose lines can be stretched vertically between landings in lieu of laying hose over the stairs. This method is essentially creating a vertical standpipe. It is quick and uses less hose but needs to be tied off at intervals to a

FIGURE 15-38 Moving charged 2½-inch hose lines up a stairway is extremely difficult without sufficient staffing. It's even harder with heat- and smoke-filled stairways and if the stairwell already has charged lines.

Courtesy of Michael Gala.

banister or railing to support the weight of the charged hose and couplings. Some wells are narrow, which may work with 1¾-inch hose lines, but might be too narrow for 2½-inch lines. There is a risk that the narrow well may act as a hose clamp when the hose is charged, restricting the water flow and preventing this line from advancing.

Another effective solution for the single-hose method to limit the amount of hose used in the stairway is connecting a 2½-inch hose line to the standpipe outlet four floors below the fire, laying that line up to the floor below the fire, and connecting a 2½-inch wye to the male end. Essentially, the officer creates a second standpipe in the firefighting stairway with two additional 2½-inch discharge ports, which gives the engine officer more options and helps avert problems encountered with hose layering within the stairway **FIGURE 15-39**. The RIT line is often the fourth hose laid. Connecting the RIT line to this wye is a good use for this hose lay; it brings the RIT line connection up to the floor below the fire and allows firefighters to use the same amount of hose as the attack line because it isn't being used up in the stairway.

Hose Layering

Hose layering also needs to be considered. We have all seen hose lays forcefully expand when the line is charged. Three charged 2½-inch lines in a single stairwell are unmanageable **FIGURE 15-40**. The first line laid, the hose on the bottom, is the attack line. A 50-foot section of charged 2½-inch hose weighs about 105 pounds (48 kg) and 200 feet of charged 2½-inch hose weighs about 420 pounds (181 kg). When the 2½-inch backup line and the 2½-inch exposure lines are charged, the weight of these two hoses and the friction against the jackets make it impossible for the attack line to advance **FIGURE 15-41**, which can be disastrous. If this fire cannot be extinguished with the firefighters available to position and maneuver two 2½-inch hoses effectively, a direct attack will most likely fail. You need the options and flexibility, as well as the speed and maneuverability, to use 1¾-inch hose lines in addition to the 2½-inch lines. Therefore, you need the wyes.

FIGURE 15-39 To limit the lengths of hose connected in the firefighting stairwell, a 2½-inch hose line can be connected to the standpipe outlet four floors below the fire. This creates a second standpipe in the firefighting stairway.

Courtesy of Raul Angulo.

FIGURE 15-40 Three charged 2½-inch lines in a single stairwell are unmanageable.

Courtesy of John Odegard.

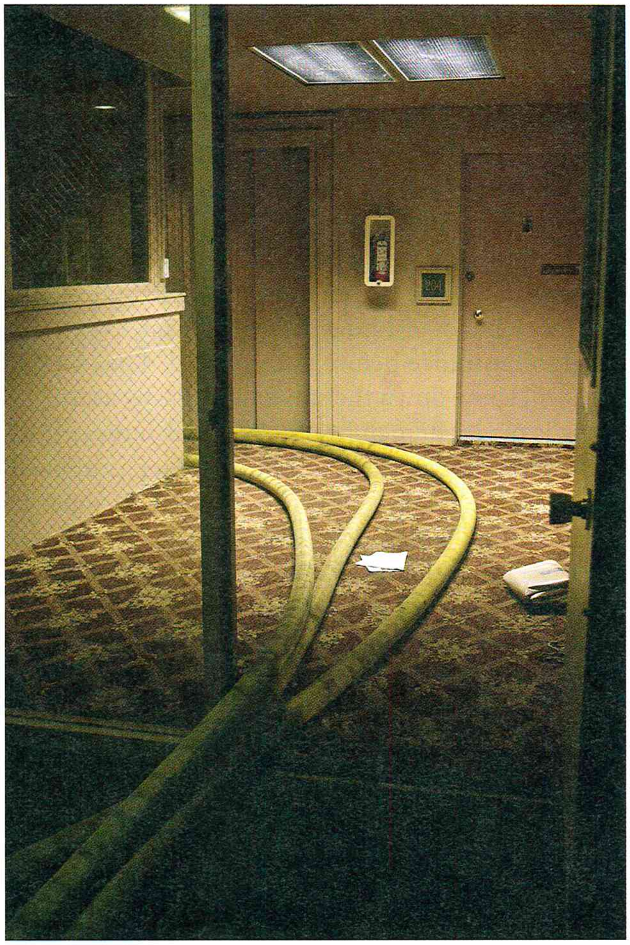


FIGURE 15-41 The hose on the right is the attack line. This hose is on the bottom, indicating that it was the first line laid, and it is buried by the weight and friction of two additional 2½-inch lines. It will be extremely difficult if not impossible to advance without an army of firefighters.
Courtesy of John Odegard.

At the First Interstate Fire in Los Angeles, California, four stairwells were in the center core, each with a standpipe and one 2½-inch discharge valve per floor. All four standpipes were utilized to attack the fires on floors 12 through 16. In total, there were 20 hand lines in operation by 32 companies on five involved floors. Attack-line diameters were a combination of 1¾-inch, 2-inch, and 2½-inch hose, with a combined estimated flow of approximately 2,400 gpm. You can't perform this type of operation without using wyes.

New Standpipes

In newer high-rise buildings, architects and fire protection engineers have recognized the need to take multiple lines off the standpipe on a single floor. These new standpipes now have two separate 2½-inch discharge connections with handwheel gated valves permanently affixed to the standpipe. In essence, they have created a 2½-inch gated wye **FIGURE 15-42**. This

FIGURE 15-42 New standpipes have two separate 2½-inch discharge connections on each floor permanently affixed to the standpipe, thus creating a 2½-inch gated wye.
Photo by Capt. Steve Baer.

is now part of the City of Seattle Fire Code; other fire codes may follow this trend, thus ending any debate about the use of wyes. As for the proponents of using wyes, these new standpipes provide additional options for the use of multiple hand lines (not all hose lines flow simultaneously).

Hallway Corridor Standpipe Connections

In some high-rise buildings, the standpipe discharge valves were designed and placed in the hallway corridors on each floor. They are located just inside the entry from the stairway landing. There may be an additional hose outlet in the middle of long hallways supplied by an interior mid-riser. An additional standpipe may or may not be in the stairwell. The theory behind this design was that if all the firefighting operations were confined inside the hallway, it would prevent smoke from entering the stairwell because firefighters would not have to open the door from the stairs when making entry to the fire floor, thus keeping the stairs smoke-free for safe evacuation. Their theory is correct; unfortunately, no one included discussions with the fire department because we would have given them all the reasons why we do not connect attack lines on the fire floor. This design would actually be deadly in a wind-driven fire because firefighters would have no way to retreat without abandoning their hose line, and the hallway, along with the control of the water source for the attack hose connection, would become untenable. In one Los Angeles high-rise fire, the extreme heat in the hallway caused these hallway standpipe outlets to fail, in turn causing water problems throughout the building, including a cascade of water onto the staging floor.

If smoke or fire is encountered on the fire floor, hose lines should be stretched from a standpipe connection in the stairway and not from a standpipe connection in the hallway. If hallway standpipe outlets are all that are available, it should be taken from the floor below. This means that the door to the floor below the fire has to remain partially open for the hose, and the door to the fire floor is open so the attack team can advance, which totally defeats the original purpose of this design. Connecting additional lines to other floors will most likely contribute to the loss of adequate pressurization in the stairwell. Minimizing the draft of air in and the smoke exhausted out into the stairwell is the reason that door control is emphasized. Note that the hallway outlets use 2½-inch supply pipe, so there is additional friction loss in this connection, unlike that from a standpipe outlet connected directly from a 4- or 6-inch standpipe.

On the flip side, hallway corridor standpipe connections are excellent for connecting exposure lines to the floors above the fire. Although a building's architects were probably not designing this feature to protect exposure floors, it does allow for the safe connection of these hose lines without the exposure teams being inside the firefighting stairwell above the fire. Crews can bring their hose and equipment in from another stairway and safely set up the exposure operations and protect the search teams without being affected adversely by the direct attack in the firefighting stairway.

Although the control of the water source is still on the same floor, the margin of safety is acceptable because crews should be ahead of the fire. If the situation deteriorates and the floor is lost, it is because the fire below is gaining headway. All crews on the floor above the original fire must retreat to the evacuation stairwell, not the firefighting stairwell. Hose lines may have to be abandoned. Companies will have to regroup and go up to the next floor with new hose lines.

Stretching Hose from the Standpipe

The initial attack hose line must be connected to the standpipe discharge outlet in the stairwell one floor below the fire floor. The excess hose could be coiled at the mid-landing above the fire floor, or it could be pulled up the stairway past the fire floor toward the next floor landing, then reversed, making a large horseshoe bend, bringing the nozzle back toward the fire floor entrance before it is charged. The charged hose will come down the stairs more easily as the advance is made. Remember to accomplish these tasks *before* the hallway door to the fire floor is opened. If the hose is thrown down a stairway, it must be worked, or pulled up, after it is charged, which is not an easy task if this is 2½-inch hose. Use gravity to your advantage, especially with 2½-inch hose.

If the hallway is clear of smoke and the door to the fire unit is closed, the uncharged 2½-inch hose line should be stretched quickly down the corridor past the fire unit. Then make a large horseshoe bend and bring it back to the front door of the fire unit before the attack line is charged. This makes the advance into the fire unit easier. A V-split stretch also works. Care must be taken to ensure the uncharged hose line doesn't get pulled underneath the door between the threshold and the bottom rail. Again, when the hose line is charged, the threshold and the bottom of the door will act as a hose clamp restricting the flow or stopping it completely. Even worse, if the door closes over an uncharged hose line, once it is charged, it can effectively wedge the door in the closed position, trapping firefighters on the opposite side without water.

Making Entry and Attacking the Fire

If part of the hallway corridor is involved in fire, the hose line should be charged before it is advanced from the stairwell into the corridor. The engine officer should announce over the radio that the fire attack is commencing as a warning because atmospheric conditions are about to change. The nozzle and hose line should be worked to utilize the reach of the straight stream while the officer scans the area with the thermal-imaging camera (TIC) to get thermal readings. Maintaining the thermal balance aids in searching in poor visibility for any victims or locating the seat of the fire; however, if the intensity of the flames is growing and temperatures are climbing, the ceiling area must be cooled by deflecting the stream off the ceiling to prevent flashover.

Ideally, the seat of the fire should be hit with a straight stream, but if the room is involved, the Z-, T-, or clockwise-O-spray patterns should be used to cover all areas of the room, including the floor. Avoid rapid movements or whipping the nozzle around. Such movement entrains air towards the fire, increasing intensity, and the higher pressure created could send hot gases back on the attack team. Like any interior fire, if the fire isn't knocked down after 60 seconds of water application with a 1¾-inch hand line, bring up the 2½-inch backup line, and bring in an additional 2½-inch backup line or portable master stream.

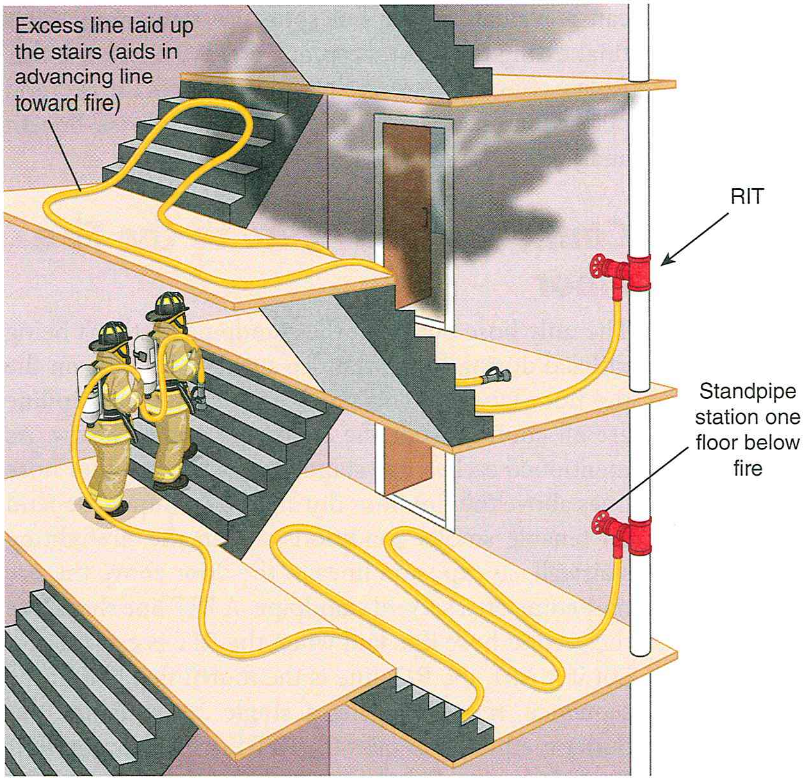
Firefighters should always be prepared to fight their way into the corridor from the stairwell. When a long corridor is completely involved in fire, the hose line should operate from the hallway threshold and use a straight stream to reach as far into the hallway as possible. This cannot be done during wind-driven fires. The officer using the TIC can help the nozzle firefighter aim the stream precisely at the seat of the fire. The company officer must know if this condition is caused by a wind-driven fire. If extreme heat isn't driving the company out of the hallway, the IC or pump operator can be asked via portable radio to confirm visually if this fire has self-vented through the window. Flames will be visible from the exterior of the building. If they are visible, the crew must be pulled back to the safety of the stairwell. History and experience have demonstrated that even two 2½-inch hose lines with straight streams are ineffective against wind-driven fires. ***A note of warning:*** The fire must be sufficiently knocked down, if not extinguished, before windows are opened with a key or taken out in order to prevent a wind-driven fire from developing. The fire attack occurs without ventilation on fire floors, and ventilation doesn't commence until the fire is knocked down or extinguished. Water first, then vent.

Once the fire is knocked down in high-rise apartments or hotels, a straight stream at midlevel between the floor and ceiling might blow out any windows that were subjected to high heat, aiding in horizontal and hydraulic ventilation. But high-rise glass is strong; it may not work but it's worth a try because horizontal ventilation is challenging. It is best to ventilate to the outside from the room of origin. Once this exhaust portal is created, PPV fans can be used to bring in fresh air and accelerate the ventilation of smoke and fire gases. As conditions improve, all shards of glass should be removed to the inside of the fire room so that the window opening is totally clear. After knockdown, shut the line down and allow the smoke and steam to vent. Perform a primary search of the area and then follow with a secondary search by a different crew. The officer can reevaluate where hot spots are remaining. After final extinguishment, keep one crew to check the fire. Rotate crews; try to determine the cause of the fire; and perform a new size-up, safety survey, and risk-benefit analysis before salvage and overhaul begins.

Connect the RIT Line to the Fire Floor

The only hose outlet on the standpipe that isn't being utilized during the initial fire attack is the one on the fire floor landing. The attack line and the backup line are all coming from the standpipe outlets below. As mentioned earlier, any standpipe outlets used for hose lines above the fire floor during the fire attack depend on tenable smoke conditions within the firefighting stairwell, so exposure lines to the floor above the fire may come off a second standpipe. A RIT line should be the second hose line laid when the RIT is established, but if it isn't, the RIT line is the fourth line laid in the sequence. If you're using a single 2½-inch line per outlet method, that puts the RIT line connection four floors below the fire. A better solution is to connect the RIT line on the fire floor and coil the hose on the first stairway landing above the fire. This would depend on tenable conditions in the firefighting stairway with the hallway door closed as tightly as possible until the hose can be coiled and charged. The firefighter needs to stay low during this fast evolution. The charged nozzle could then be brought down to the first or second stair tread above the fire floor landing and left in a ready position unattended **FIGURE 15-43**. The RIT would stage in the hallway below the fire attack to stay out of the way. If a Mayday is called and the RIT is deployed, the team members can grab the charged hose line and enter the fire floor. Since this line is being advanced over (on top of) the existing hose lines, the RIT line will not be hampered by hose layering.

The RIT hose line doesn't necessarily have to enter the fire area to protect or save firefighters from death or injury. The first RIT can enter the hazard area and utilize the backup line to wet down and cool firefighters during a rescue. The line on the stairway can become the new backup line to support the rescue with a newly established second RIT. Consider the following scenario: If conditions suddenly change on the fire floor or extreme fire behavior starts to develop and the firefighters must bail out of the fire floor hallway without their hose line, it's because they're burning. They're trained to follow their hose line out, so these firefighters will be exiting to the fire floor stairway landing. This RIT line is in a ready position to protect their egress and flow water to cool them down—two good



A

B

FIGURE 15-43 The RIT line can be connected on the fire floor hose outlet and coiled on the stairway landing above the fire floor. The combination nozzle can be left unattended in a state of readiness. The door to the fire floor should be closed as tightly as possible.

A: © Jones & Bartlett Learning; B: Photo by Lt. Kevin O'Donnell.

reasons to have a combination nozzle on the RIT line. A RIT firefighter simply needs to grab this hose line and assist the firefighters in clearing the threshold to safety **FIGURE 15-44**. Once the fire is extinguished and firefighters are no longer in danger of getting trapped, there is no reason that this hose can't be used for other overhaul activities.

FIGURE 15-44 The charged hose in the ready position for the RIT firefighter to protect a rapid egress of the attack crew.

Photo by Lt. Kevin O'Donnell.

Wind-Driven Fires in Residential High-Rises

Of the five property classifications in high-rise buildings, the ones that are least sprinklered are older residential high-rises. A wind-driven fire can be deadly in a residential high-rise. This scenario is created when the fire self-vents by breaking out a window on the windward side, or when a window is left open at the time of the fire. The wind, along with the fire, pressurizes the unit. As long as the front door of the unit remains closed, the flames, smoke, and gases pulsate while trying to escape against the wind through the open window. As soon as firefighters attempt to make a direct attack through the front door, a high-pressure to low-pressure flow path is created. Remember that high pressure always seeks the path of least resistance and moves toward the low pressure in an attempt to equalize. But in this scenario, the wind drives the flow path currents with extreme speed and temperatures well over 1,200°F (538°C). This creates a situation known as extreme fire behavior caused by a wind-driven fire. Firefighters cannot survive this event if they are caught in the flow path. This is the scenario that killed three New York City (FDNY) firefighters at the Vandalia Avenue Fire on December 18, 1998, in Brooklyn.

On December 10, 2009, in Chicago, Illinois, a fire started on floor 36 of the 43-story DeWitt-Chestnut Apartments. The female occupant of the fire unit was killed, and 12 others were injured. The occupant, who was trying to escape, collapsed at her front door. She blocked it open, which allowed the smoke and flames to enter the hallway. While Engine 98 was hooking up to the standpipe, the officer ran up to the fire floor to check fire conditions. As he entered the hallway, the door behind him shut. The ceiling temperatures were so hot that they started to warp the door. Conditions were rapidly changing for the worse, and the officer had to retreat quickly, but he could not open the hallway door through which he had entered. He ran as fast as he could to the opposite stairway and miraculously escaped without injury. The officer rejoined his crew on the floor below to initiate the fire attack. By this time, the hallway door was so warped that the firefighters needed forcible entry tools to pry it open. Engine 98 attempted to make entry to the fire floor but the firefighters were pushed back numerous times by high heat. Opening the door created a flow path that allowed a wind-driven fire to develop. They never got more than 10 feet (3 meters) into the hallway before bailing out. The convected heat currents flowing up the firefighting stairwell were estimated at well over 2,000°F. The fire on floor 36 completely melted the stairway identification placard on the floor 37 landing (Figure 15-7). These high-temperature convected currents were released every time the firefighters opened the hallway to attempt entry. Any firefighter or civilian in the stairway would have been killed. **FIGURE 15-45** shows the extent of the heat damage on floor 36. The floor-level temperatures were so hot that the shutoff bail on the nozzle of the abandoned hose line melted completely.

Before making entry into the hallway from the firefighting stairwell, the officer must determine smoke conditions in the hallway. This is easy if there is a wired glass window in the hallway fire door. A simple look can determine if the hallway is relatively clear of smoke or charged with smoke. The officer should check the edges around the door while it is closed for pressurized smoke pushing through the door jamb. Otherwise, the officer can open the door slowly to

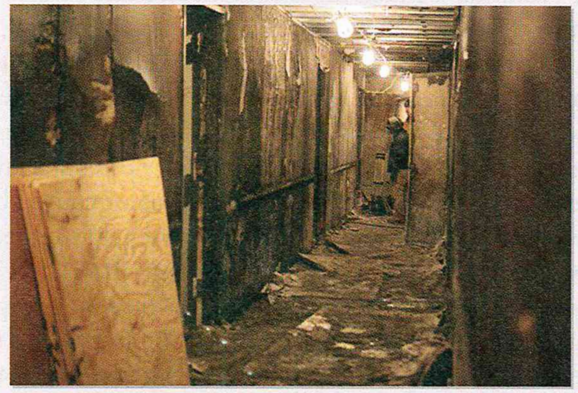


FIGURE 15-45 Floor 36 of the DeWitt-Chestnut Fire in Chicago, Illinois.

Photo By Battalion Chief Michael Wielgat, Chicago Fire Department.

check hallway conditions, but she or he must be prepared to close the door quickly. Thick smoke in the hallway may be your only sign that the entry door into the fire unit has been left open. High heat and thick smoke under pressure are the first signs that the window in the fire room has self-vented.

On commercial buildings where windows cannot be opened, crews on the exterior of the building can confirm if the window has self-vented. In residential buildings, a crew above the fire floor can open a window and visually check fire conditions below from a safe location. A driver on the outside perimeter, a spotter from an adjacent high-rise, or the IC at an exterior command post can also confirm, and relay via radio, if the fire has already self-vented through the window. Each of these personnel may be able to note a change in fire behavior and flame direction when the hallway door is opened. This may be the only way to determine if a wind-driven fire will be created when the hose team initiates a direct attack. If the spotter confirms that the fire has self-vented and the hallway is filled with smoke, the engine officer should not attempt to make entry into the hallway. The fire will have to be attacked from below, or a fire curtain will have to be deployed from the floor above the fire. You also cannot rule out arson, in which leaving the front door open to the unit is a deliberate attempt to spread the fire.

Fire Curtains

A fire curtain is basically a big, heavy, fire-resistant tarp. There are small 6-foot × 8-foot curtains and larger 10-foot × 12-foot curtains called fire blankets. The 6-foot × 8-foot fire curtain was designed for windows in residential occupancies. The 10-foot × 12-foot fire blanket can work on exterior glass curtain walls of commercial and office high-rise buildings, but the evolution is much more complicated and rarely attempted, even in New York City.

The purpose of this tool is to cover the exterior window of a fire room that has self-vented or was left open on the windward side of the building. The fire curtain covers the inlet portal of the flow path and prevents or stops the extreme fire behavior caused by a wind-driven fire. The window, in essence is closed, stopping the unlimited source of fresh air. This will lower the intensity of the flames and reduce the energy output, reducing the temperature. If the front door to the fire unit is closed, the attack crew should be able to enter the unit without the danger of a wind-driven fire developing. If the front door to the fire unit was left open, the curtain should stop the blowtorch flow path that exists in the hallway. Fire crews can advance into the fire unit from the hallway.

The fire curtain is heavy, so this is not a fast operation. A ladder crew has to gain access to deploy the curtain from the floor above or from the roof. It also requires another crew to stage in the unit below the fire. The ladder crew from above needs to drop two guide ropes attached to the fire curtain to the crew below. Then the tarp is dropped into place, suspended by two guide ropes from the top. The two crews work together to place the curtain in front of the window by pulling the respective ropes. Then the ropes are tensioned and tied off.

In a drill, this can be accomplished fairly quickly. In real-world conditions, strong winds can blow the ropes any which way, and the curtain can become like a sail in the wind. In high winds, if the ropes are not tensioned properly, the strong wind tends to push the curtain into the window. The crew working in the window below the fire may be struck by falling glass while the curtain is being shimmied into place. The crew working in the window above the fire or on the roof may end up in a thermal column. Nevertheless, a fire curtain is an effective solution to consider in combating a wind-driven fire in a residential high-rise where the fire has self-vented through a window. Once the fire is extinguished, the curtain can be removed to aid in horizontal ventilation by establishing an exhaust portal somewhere else on the fire floor—or into, up, and out of the stairwell.

The curtain doesn't work with balconies. The balcony railing and any patio furniture obstructs and prevents the curtain from creating a seal against a glass sliding door and the balcony ceiling overhangs prevent the curtain from being lowered or secured.

Residential High-Rise Nozzles

The high-rise nozzle, also called a floor-below nozzle, and the HydroVent nozzle are other methods for attacking a residential high-rise fire from the unit below when conditions for a wind-driven fire exist. The high-rise nozzle is an 8-foot (2.4 m) long, 1½-inch (3.8 cm) diameter aluminum pipe whose tip is bent back on itself approximately 68°. This bent-pipe J-configuration has a 1⅛-inch smooth-bore tip connected to the end and can flow approximately 250 gpm. The pipe is supplied by a single 2½-inch hose line taken off the standpipe. It has a ball-valve shutoff, so the hose can be moved to adjacent windows as needed. The nozzle is pushed out the window, and the straight stream is aimed into the fire window above. Rolling the nozzle back and forth covers the window area and shoots the straight stream across the ceiling. Deflecting the stream off the window header or ceiling knocks the fire down, and a spotter from the outside can confirm the proper positioning and effectiveness. Then the nozzle is shut down, and crews can make entry into the fire unit from the hallway for final extinguishment.

The HydroVent is a dual-attack suppression and ventilation nozzle that sprays water into the ceiling with one nozzle and hydraulically ventilates the fire simultaneously through a second nozzle, both attached to a single pipe. The nozzle is meant to be swung up and hung on the windowsill of the fire room by a single firefighter working at the window from inside the room below the fire. Once set and charged, the HydroVent nozzle can be left unattended. The suppression part of the nozzle is a round nozzle with four smooth-bore discharge holes that flow approximately 95 gpm toward the top of the heated compartment. This creates a sprinkler-type system in which the water converts to steam 1,700 times its volume. The water application knocks down the fire quickly and takes away the thermal energy, reducing interior temperatures. Operating simultaneously is the ventilation 95-gpm combination tip. By design, this part of the nozzle is already positioned on the pipe at the windowsill, aimed toward the outside for hydraulic ventilation and capable of pulling thousands of cubic feet per minute (cfm) of smoke, steam, and other gases of combustion out of the room, thus reducing interior temperatures even further. If the wind is too strong for ventilation to occur, it will still push all the spray and moisture along the flow path, cooling and extinguishing fire as it goes. An exterior spotter can confirm when the fire is knocked down, and crews can enter the fire unit from the hallway for final extinguishment.

The two nozzles are safer and faster than the fire curtain evolution because water application significantly cools the interior temperature of the fire room before the attack crew makes entry for final extinguishment.

Indirect Flanking Attack

If it is confirmed by observers on the exterior of the high-rise apartment that the fire room has self-vented and flames are exiting the window, and the engine officer has determined that the fire floor hallway is relatively clear of smoke with little if any heat, the officer can conclude that the front door to the fire unit is closed. However, a direct attack into the unit could create a wind-driven fire as soon as the firefighters open the door and the flow path reverses.

The safest method to attack this type of fire successfully is with an indirect attack that includes cutting a small hole just large enough to insert and operate the nozzle through the front door or the Sheetrock exterior wall of the unit from the hallway. If the decision is made to preserve the integrity of the door, the indirect attack can be made from the adjoining residential units. The first point is to ensure that the front door to the fire unit remains closed. Attack lines should be laid into both adjoining exposure units—to the right and to the left of the fire unit. A TIC can help determine which wall has the highest heat readings, and the indirect attack should be concentrated on that particular wall. Then, using piercing nozzles, an indirect attack can commence into the fire unit. Another indirect attack method is to breach the walls into the fire unit with holes just large enough to accommodate combination nozzles set to a medium fog, or distributor nozzles. This indirect attack is like introducing a giant sprinkler system into the unit. Backup lines should be laid to the exposure units to support the attack team because the nozzles will be through the wall, leaving the firefighters vulnerable should something happen.

The two factors that make this type of fire difficult to fight is the wind and the elevation. The fire load and the residential square footage require water flow rates similar to a one-story apartment or condominium. Therefore, multiple handlines, or even portable monitors operating from the adjoining units, should be able to flow the required gpm to extinguish this fire. Firefighters serving as observers from adjacent buildings or rooftops can let the attack crews know when the indirect attack has knocked down the fire. Then attack lines and backup lines can be repositioned for a direct attack and final extinguishment. Multiple PPV fans can also be set up in the hallway and at the entry of the fire unit to keep the wind at the back of the fire crew while the crew members overhaul the fire.

Indirect Attack from Above

If the ceiling of the fire room and the floor decking to the unit above the fire room are not concrete (for example, they are constructed of wood trusses), the fire can also be attacked indirectly from the unit above the fire room using piercing nozzles or distributor nozzles—tactics similar to those used on a basement fire. The ceiling and floor construction can be confirmed by pre-incident plans or by opening the ceiling in the hallway with a pike pole. A chainsaw can quickly make access holes from the floor above the fire, then the nozzles can be dropped in.

Commercial High-Rise Fire Attack

This section of the chapter contains firefighting strategies and tactics to be considered in Type I construction office and commercial spaces with large floor or open floor plans. High-rise buildings with a center- or side-core design have cores that contain the elevators, the elevator lobby, at least two stairwells, bathrooms, kitchen, breakroom, and utility closets. A labyrinth of office cubicles and offices surround the center core. The fire load of paper products, computers, office accessories, office furniture, and so on, are made of plastic and hydrocarbon-based synthetics, which provide a greater modern fuel load capacity with tremendous British thermal unit (BTU) heat release energy potential than other property classes. Other than the supporting columns, the floor space is wide open. Floor space can easily range from 20,000 ft^2 (1,858 m^2) to over 200,000 $feet^2$ (18,581 m^2). Unless controlled by automatic sprinklers, this open space provides ample oxygen for the fire to grow to a significant size before it even starts to become ventilation-limited—if it ever will. The fuel will probably be consumed (fuel-limited) before these fires run out of oxygen. Serious fires, causing death and injury to firefighters and occupants, have occurred in such buildings in the United States and elsewhere.

High-rise fires should be attacked as quickly as possible but, by their nature, getting the attack line to the seat of the fire can be difficult and time consuming, especially with fires in upper stories. Firefighters would be lucky to get a hose line in operation within 15 minutes of arrival, and 20 minutes is more realistic. Type I, fire-resistive construction is designed to contain a fire for an extended period of time. The maximum interior operational period is in Type I buildings.

The most unpredictable aspect in high-rise firefighting is the wind. Smoke movement within the building is determined by many factors, such as HVAC systems, summer and winter stack effect, prevailing winds, and others. It is a complicated subject, and few experts can predict with accuracy the causes and effects of firefighting actions.

Exterior Recon

A major problem in fighting high-rise fires is that firefighters cannot see the exterior upper perimeter when they are in a hallway corridor on the inside. They need eyes on the outside.

Perhaps it is time to introduce a new tactic in high-rise firefighting: sending a high-rise recon team equipped with binoculars into an adjoining high-rise building to the same floor so they have the closest line-of-sight horizontal perspective of the fire conditions across from them. It is similar to the important tactic of having the IC observe the C-side rear of a single-story structure fire. If visibility allows, the high-rise recon team can observe and immediately report via radio the fire and smoke conditions, wind and flame intensity, interior exposures, and fire load; confirm sprinkler operation; and, most important, coordinate with the fire attack team the cause and effect of fire behavior with their current actions. The high-rise recon team would also have the best vantage point to report the effectiveness of the attack as well as notify exposure teams on the floor above if the fire is being contained to the floor of origin or if and where it is spreading to the floor above. The high-rise recon team may also be able to locate visible trapped occupants in windows on the fire floor and floors above the fire. This new tactic makes sense and should be considered as a regular assignment at high-rise fires.

The photo in **FIGURE 15-46** was taken from floor 11 of an adjacent high-rise building at the First Interstate Fire. It clearly shows the fire conditions on floor 12. If you look carefully at the three windows to the right on floor 11 below the fire, it appears that a person is in the center window shrouded by smoke. The high temperature on May 4, 1988, in Los Angeles was 73°F (23°C). It is possible that a summer stack effect pushed smoke down below the fire floor. This picture was shot with 35-mm film and was not developed until the incident was over. The photographer did not realize what he had captured.

Direct Attack

If the fire department can set up and be ready to advance to the fire floor while the fire is in the growth stage, there is a good chance that the fire can be extinguished with one or two 2½-inch lines. A 2½-inch line equipped with a 1⅛-inch smooth-bore tip can flow 250 gpm, and the stream has about a 50-foot reach. This line should be able to extinguish about 2,500 square feet of fire.

Before making the attack on the fire floor, the company officer must again confirm the status of the firefighting stairwell above the fire. Occupants coming down the stairs can effectively stall the attack until they get below the fire. Do not open the stairwell door with civilians in the stairwell above the fire. Once the stairwell is clear, initiate the attack. The officer should check the door for pressurized smoke and be prepared to close it. Smoke pulsating around the edge of the door indicates a window has failed on the fire floor **FIGURE 15-47**. If the door is opened to the fire floor, the firefighting stairwell will be charged with smoke and heat. Pay attention to the smoke velocity and the density. Fast smoke movement reveals the direction of the flow path and which way the fire wants to go. Smoke and fresh air heading into the fire floor when the door is open indicates a fire in the growth stage and that the area isn't pressurized yet from the fire. The pressure in the stairway is greater than in the fire area. Following the path of the smoke and fresh air

FIGURE 15-46 The fire conditions on floor 12 of the First Interstate building are clearly visible. Light smoke is visible on floor 11, with what appears to be a trapped occupant shrouded by smoke.

Photo by Rick McClure, LAFD.

FIGURE 15-47 The officer should check the door for pressurized smoke and be prepared to close it. Smoke pulsating around the edge of the door indicates that a window has failed on the fire floor.

should take you right to the seat of the fire. If smoke is coming out into the stairwell, operate the 2½-inch hose line with a straight stream into the ceiling area. Use the reach of the stream to penetrate deep into the hallway **FIGURE 15-48**.

If the fire is substantial, the smoke and heat will make this stairwell untenable for firefighters trying to stretch an exposure line to the floor above. Taking an exposure line to the floor above via the firefighting stairwell may have to wait until the heat release rate on the fire floor subsides, which occurs after knocking down the fire.

Remember that smoke is fuel. Use a TIC to get heat readings. You have only one chance to knock down the fire with a direct attack. The direct attack can be augmented by operating the second 2½-inch line. Two 2½-inch attack lines are all that is realistic. Moving three or four 2½-inch lines through the hallway door is impossible to manage and advance. If two 2½-inch lines can't do the job, the fire is growing beyond the ability to overwhelm it with hand lines, and portable master streams will have to be utilized.

Pincer or Flank Attack

Another alternative attack is to use the center core of the floor to flank the fire. The center-core walls can shield crews from radiant heat, so one crew can go to the left and one crew can go to the right. They can utilize the reach of the streams to perform a pincer attack, hitting the seat of the fire from two sides without having opposing lines.

The fire may also surround the center core completely, and attacking from opposite stairwells may be necessary and effective without having opposing lines. In the First Interstate Fire, there were four stairways, each equipped with standpipes, and all four standpipes were used to supply the attack on the fire. Because each crew was operating from the center core toward the outer walls in their respective directions, there were no opposing lines.

FIGURE 15-48 If fire is coming into the stairwell, operate the 2½-inch hose line with a straight stream into the ceiling area.

Defensive Interior Attack

Portable Master Streams

Fire showing from numerous windows on a floor indicates that the building is not sprinklered and that the fire has gained substantial headway in large open areas. Time and energy shouldn't be wasted on attempting an attack with 2½-inch hand lines. Two 2½-inch lines require the efforts of six to eight firefighters and can flow only 500 gpm to 600 gpm at best, depending on the nozzle. They can be set up later as backup lines.

Master stream appliances should be put in service right away for the initial attack. The decision to use master streams is your last resort for a full direct attack. Such an attack is actually a defensive interior attack and should be viewed as such. The goal is to flow as many gpm of water as possible. The energy of this fire has to be knocked down to stop the intensity and spread of the fire; otherwise, the radiant heat will be unbearable. Pressurized smoke created on the fire floor seeks every possible vertical space to extend to. Autoexposure, or lapping, is the vertical extension of flames out the windows of a high-rise to the floor above. In this case, master streams have to be supplied from one or more standpipe outlets as required, with 2½-inch lines or LDH **FIGURE 15-49**.

The 500-gpm TFT *Blitzfire* monitor nozzle is an excellent tool for a defensive interior attack. The low-profile nozzle can be carried and placed in service by a single firefighter and, once set, it can be left unattended. It has a hydraulically powered, oscillating feature that gives it the ability to sweep the floor or aim the water stream into the overhead automatically.

If the fire cannot be knocked down with portable master streams, that's it. You're done. The fire has gone beyond your ability to supply sufficient gallonage to overwhelm the fire. It's time to back out and take a defensive posture in the stairway until the fire consumes the available fuel load. Firefighting efforts should now shift to attacking from the floor below and protecting exposures on the floors above. The hose line should cool the fire door to the fire floor entry to prevent warping. The fire rating for fire doors used on a 2-hour wall is 90 minutes. That time can be extended if the door and frame are constantly cooled and protected with a hose line.

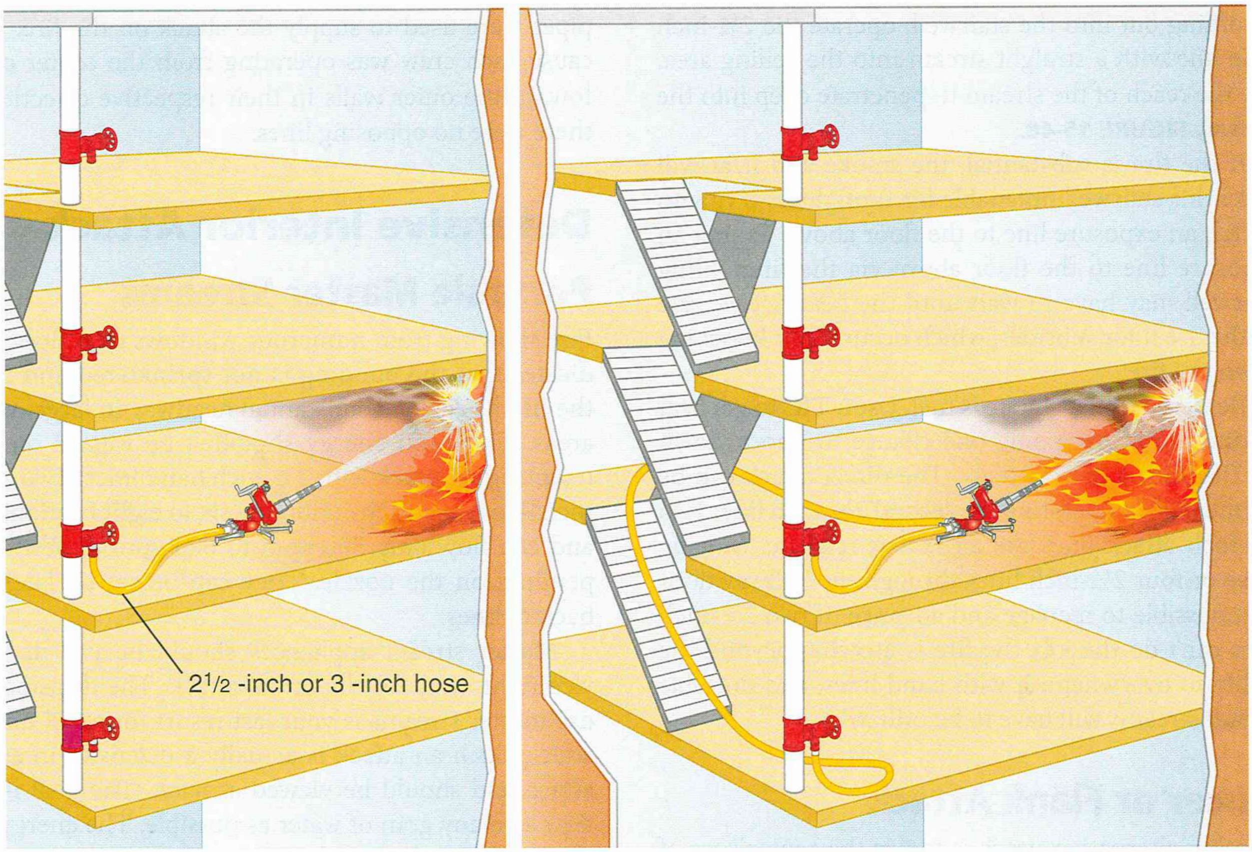


FIGURE 15-49 When a fire has gained considerable headway, a master stream should be used for a defensive interior attack. The monitor must be supplied from one or more standpipe outlets.

Ultimately, the decision to make a direct attack, a pincer or flank attack, or a defensive interior attack with master streams will be very clear. The decision is based on whether the interior heat conditions are tenable or not. If conditions are untenable, your decision should be no attack and let the fire burn itself out. The civilian survivability profile is zero, and there's no reason to risk and punish engine crews who will get burned or injured in an unwinnable attack when the only life hazards are themselves.

Relying on Type I Construction

Type I fire-resistive construction is the strongest construction firefighters encounter. Type I high-rise buildings and the vast array of fire load stuffed into them have to withstand and endure the strongest of natural elements and forces: wind, rain, snow, earthquakes, and fire. These steel structures do not contribute to the fire load and are coated to protect them from the effects of heat, unlike unprotected steel in Type II noncombustible construction. Unprotected steel can soften, elongate, and start to fail when temperatures rise above 1,000°F (538°C).

In Type I construction, the columns have a 4-hour fire rating; the beams are rated for 3 hours; and the floors, ceilings, and shafts have a fire rating of 2 hours. The hallway corridor fire doors are rated for 90 minutes. The fire load in Type I high-rise buildings can be great, as can the potential BTU heat energy production and heat release rate. This potential is designed into the building construction; thus, Type I high-rise office buildings are giant incinerators that can far outlast the burn time of any combustible material occupying the interior space. Let the fire on that floor burn itself out. Think of it as a controlled burn. Efforts should be concentrated on removing occupants above the fire and stopping fire extension.

At the First Interstate building, the fire extended at a rate estimated at 45 minutes per floor and burned intensely for approximately 90 minutes on each level. This resulted in two floors being heavily involved at any point during the fire. After 3 hours and 39 minutes of firefighting, five floors were destroyed by the fire; however, in the following months, structural engineers determined that the Type I fire-resistant building suffered no structural damage from the fire. At the One Meridian Plaza Fire in Philadelphia, Pennsylvania, nine floors were destroyed by fire. After 11 hours of uninterrupted fire in the building, the IC withdrew all crews from the building fearing a structural collapse, but it never happened. One Meridian Plaza was never reoccupied and was eventually demolished 8 years later.

No-Attack Strategy

A new strategy to consider when fire has gained control of a floor in a commercial office space high-rise with limited personnel and resources is the no-attack strategy. Time and effort can be spent on a fire attack only to realize that putting out the fire wasn't possible from the beginning. In a failed direct attack on the fire floor where interior conditions are untenable for firefighters, the civilian survivability profile is zero. Consider the benefits of a no-attack strategy when necessary, often after a failed direct attack. Keep the following points in mind for a no-attack strategy:

- Do not open the hallway corridor door to the fire floor so that the firefighting stairway remains clear of smoke, fire gases, and CO.
- Any occupants in the firefighting stairway are safe from heat and smoke.
- SER teams can move from floor to floor without the danger of being trapped by heat and smoke entering the firefighting stairwell.
- Evacuating occupants from upper floors can be expedited if stairwells stay clear of smoke and heat.
- There is no urgent need to vent the bulkhead at the top of the stairs.
- Any conditions that could create a wind-driven fire will not develop.
- Exposure teams can connect multiple hose lines from the firefighting stairway standpipe to protect the floor above the fire, without smoke or heat from the fire floor.
- PPV fans can assist in keeping the stairwell pressurized.

Once multiple exposure lines are in place on the floor above the fire, or whatever floor is necessary to get ahead of the fire, firefighters are in a position to contain the fire. A hose line needs to be in place to protect the fire doors at the entrances of the fire floor. Then the fire should be allowed to burn down and consume itself, removing the fuel leg of the fire tetrahedron. If there is another way to take the energy out of this fire to prevent extension and autoexposure by attacking from above or below the fire, those strategies and tactics should be implemented.

Attacking from Below the Fire Floor

As mentioned, stack effect can produce unpredictable smoke movement within the building. Although rare, sometimes smoke and fire can move down, so it is helpful to keep this in mind to avoid being surprised.

Let's use the fire behavior example from the First Interstate Fire. If the strategy for the fire floor is no attack, and the windows have self-ventilated, the estimated time for autoextension is 45 minutes per floor, and the burn-down time of the fuel in the fire is 90 minutes; that's a lot of time to try different options for fire attack from below. Attacking from below also allows firefighters to be in the safest atmospheric conditions while getting as close to the seat of the fire as possible.

Falling glass from the floors on fire was a dangerous, ongoing problem at the First Interstate and One Meridian Plaza fires. The film layer that coated and held together many of these large glass panes caught fire, and burning shards came sailing down. If the high-rise nozzle is deployed from below, windows have to be opened or broken. Because conditions should be almost normal below the fire floor, using the key to unlock the windows designed to be opened should prevent additional property damage and decrease the danger of more falling glass. If the glass needs to be broken, however, break it. A trick of the trade is to use a carbon dioxide (CO_2) extinguisher on the glass to freeze it, then shatter it with the point of a pickhead ax. Notify the IC and announce over the radio that selected windows will be broken for fire attack so personnel below can take cover. Include in the radio announcement the side of the building (A, B, C, or D). Wait for an "All clear" from the IC, then break out the windows that you need to break.

The High-Rise Emergency Response Offensive Nozzle (HEROPipe)

The HEROPipe is an 8- to 15-foot (2.4- to 4.6-m) telescopic, waterway high-rise nozzle that gives firefighters another opportunity for an exterior attack when the fire is well beyond the reach of aerial ladders and elevating platforms. The substantial portable monitor weighs about 80 pounds (36 kg) and is stored within a 7¾-foot (2.4-m) wheel-and-track-base unit. It can be wheeled inside any high-rise elevator. This system is designed to be assembled and operated from the safety of the floor below the fire. The unit secures to any Type I fire-resistive construction, including windows, balconies, and or glass curtain walls that extend from floor to ceiling. Many major cities have high-rise companies or squad units that carry special high-rise equipment. The setup time for the HERO-Pipe is negligible compared to the time spent on traditional high-rise tactics. Because firefighters are not battling heat and smoke, visibility is clear, and they may forgo using SCBA. A well-trained team can assemble and put the HEROPipe in service in less than 5 minutes.

The HEROPipe can be supplied by a single 2½-inch hose connected to the standpipe or by two parallel 2½-inch lines connected to a Siamese for additional gpm. The main waterway is a 3½-inch (8.9 cm) internal diameter pipe, and the telescoping extension is a 3-inch (7.6 cm) internal diameter pipe. When water is charged to the control valve, firefighters slide the wheeled waterway along the tracks and the counterweight of the hoses shoots the waterway up into position to the fire floor above.

The tip is an Elkhart Sidewinder EXM water cannon. This monitor tip is a giant combination nozzle that has varying degrees of fog patterns, including straight stream. The monitor is rated for 700 gpm at 80 psi. If a 1½-inch or 1⅞-inch smooth-bore tip is used, the HEROPipe can flow up to 900 gpm, with a penetrating stream reach of 145 feet (44.2 m) **FIGURE 15-50**. Six-inch standpipes with fire pumps, when properly supplied, can deliver anywhere from 500 to 1,000 gpm of water (600 to 750 gpm are more realistic attainable flows for high-rise firefighting). The remote-controlled monitor has a vertical sweep range of 60°, 20° below 0 level, and up vertically to 40°. It has a horizontal sweep range of 40°, 20° to the right, and 20° to the left. When the unit is set to automatic mode, it can be left unattended. The monitor tip oscillates up and down, and right to left simultaneously, within the respective degree ranges. A 2-hour and 4-hour battery pack runs the oscillating motor. The tip assembly can also accommodate a TIC with wireless image transmission to the operator. After the fire is knocked down, the TIC can detect remaining hot spots, and the monitor can be aimed directly to these spots. If the monitor is put into manual mode, the vertical angle can shoot straight up, 90°. The ability to shoot up 90° can be a significant autoexposure control measure for the lapping of flames to upper stories. After a section of the fire floor has been knocked down, the HEROPipe can be repositioned (because the unit is on wheels) to another window to attack the fire from a different position. With sufficient personnel, it can work the entire perimeter of the building.

FIGURE 15-50 With a 1½-inch or 1⅞-inch smooth-bore tip, the HEROPipe can flow up to 900 gpm.
Photo by Battalion Chief Michael Wielgat, Chicago Fire Department.

In a wind-driven fire, a unidirectional intake flow path is created through the fire floor, out through the hallway, and up the stairway, with temperatures reaching close to 2,000°F (1,093°C), and it can kill anything in its path. The HEROPipe can take advantage of the flow path. It is the only nozzle that can place an elevated, 900-gpm, heavy stream beyond aerial reach and into the window intake of the flow path. Wind currents carry and push all the steam and moisture through the flow path, extinguishing fire as it goes **FIGURE 15-51**.

In a wind-driven fire or in a substantial high-rise fire, this may be the quickest and safest tactic for getting water directly on the seat of the fire. Once water hits the fire, everything else gets better. In the DeWitt-Chestnut Fire, Chicago, Illinois, the fire was uncontrolled for over 3.5 hours. Due to the intense heat, firefighters had to wait until the fuel load burned down before they could extinguish it—6 hours after the fire started.

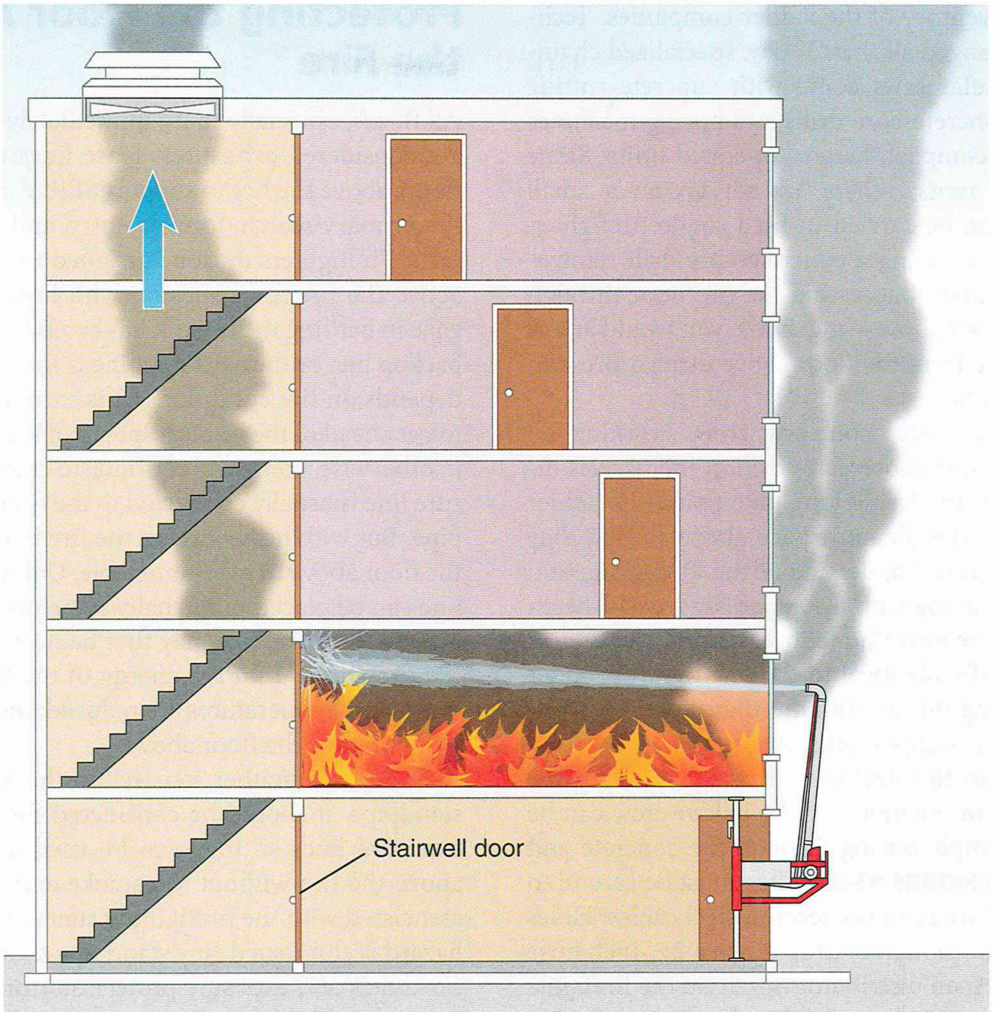


FIGURE 15-51 The HEROPipe has a penetrating stream reach of 145 feet (44.2 m).

The HEROPipe is a major investment for a fire department. Fire chiefs should investigate the possibility of obtaining grants or propose that insurance companies and building owners partner with them and invest in these portable monitors that will help protect their property. The HEROPipe and other high-rise nozzles could be an extension of the required fire protection systems that go into high-rise design for use by the fire department. According to the 2016 NFPA research report on *High-Rise Building Fires,* the property loss due to high-rise fires is, on average, $154 million annually. The property loss at First Interstate was $200 million, and One Meridian Plaza was a total loss. The direct property loss was $100 million, yet the building still had to be demolished, and litigation resulting from the fire amounted to an estimated $4 billion in civil damage claims. We must not settle for incremental half-measures but look to implement advanced nozzle technology that works now. All interested parties must try to adopt advanced nozzle technology that helps solve the problems associated with high-rise firefighting. Fire chiefs must try to adopt advanced nozzle technology that keeps firefighters safe. With a 900 gpm flow capacity, the HEROPipe is the right tool for this job, and it is the only nozzle that currently has the ability to deliver this flow.

Attacking from the Floor Above the Fire

Many previous firefighting textbooks showed a giant concrete-core drilling machine that was used by the FDNY back in the 1970s. This massive piece of equipment looked like a giant cannon and probably should have been set on tracks. It looked very heavy and difficult to put into operation. Although the idea of gaining access through a concrete floor had merit, the impracticability of the drill caused it to be eliminated from the regular inventory of the ladder companies. Technology has changed all that. Today, specialized chainsaws and circular saws come with concrete-cutting blades, and concrete-core drills and boring machines are powerful, compact, battery-operated units. Some are handheld units; others are set up on a small bracket. All can be carried in by a single firefighter. The feasibility of using a concrete-core drill reintroduces the method of accessing the fire floor through the concrete floor above—much like you would attack a basement fire from the floor above using a Bresnan distributor nozzle.

Engine and ladder company crews working on the exposure floor above can position themselves directly over the fire. Using long pike poles, the ladder crew can open the plenum space above so that they can see the exposed underside of the Q-decking and concrete floor, along with the supporting steel I-beam floor joists to the next floor above. The floor joist grid above is typically identical to the one that the ladder crew is standing on. Positioning themselves between the steel grid I-beams marks out the spot they need to drill to avoid the steel members. By checking the grid above them, members of the ladder crew can be sure they're simply boring through the concrete and the Q-decking **FIGURE 15-52**. They must be careful to avoid cutting through post-tension steel cables. Holes have to be large enough to drop down a 2½-inch hose line with a Bresnan distributor nozzle so the firefighters can create a 290-gpm sprinkler head onto the fire floor. This process can be repeated to create as many access holes as needed to drop additional distributor nozzles or cellar pipes. A hose line is required to cool the blade and concrete for all cutting operations, regardless of the cutting tool used.

FIGURE 15-52 By exposing the steel I-beam grid above them, firefighters can place themselves in the right spot to use a concrete-cutting tool on the Q-decking from the floor above the fire, then drop distributor nozzles into the fire area.
Courtesy of Raul Angulo.

Protecting the Floor Above the Fire

All floors, especially those immediately above the fire, are considered exposures. Hose lines need to get to floors above the fire to support SER teams conducting the primary search, forcible entry, and evacuation efforts. Firefighters must be assigned to check the floor above the fire for extension with hose lines and engage in battling the fire if it has extended. Whether the backup line or the exposure line is the second line laid depends on fire conditions. It is extremely important to get ahead of the vertical spread of the fire to contain it; otherwise, crews will continue to chase it. The exposure line is usually connected to the firefighting standpipe. But with heavy fire on the fire floor, the stairs to the floor above may be untenable. Unless the exposure line can be placed in the hallway before the fire attack begins, this hose line may first be needed to augment the fire attack until the energy of the fire is knocked down and temperatures are reduced; then it can be repositioned to the floor above.

If there is another stairwell in the building with a standpipe, it should be considered for supplying the exposure lines so they can be used to access floors above the fire without the smoke and heat problems associated with the firefighting stairwell. Once the life hazard is eliminated, any standpipe should be used for fire attack and exposure protection from any stairwell as needed. At the First Interstate Fire, all four stairways and all four standpipes were used to stop the autoexposure of flames lapping from floor to floor. If interior hallway standpipe discharge outlets are available, exposure hose lines can be connected on the exposure floor instead of the firefighting stairwell. Connecting to hallway standpipe outlets also leaves the evacuation stairway intact.

The First Interstate Fire occurred outside of standard business hours and there were approximately 50 occupants in the building. The need to maintain an evacuation stairwell is the highest priority if the fire occurs during regular business hours when the building is fully occupied. Every effort should be made to protect the evacuation stairway from smoke and heat and to prevent the smoke and heat from contaminating a second stairwell; thus, don't connect to the evacuation stairway standpipe in the early stages of the fire. At some point, the evacuation should be complete or sheltering in place is established, and getting lines above the fire will outweigh other concerns if the fire is to be stopped. At the First Interstate Fire, the concept of maintaining at least one stairway free of smoke so that it could be used for evacuation proved to be ineffective. This concept may be valid for less severe fires, but when the fire reaches the magnitude of the First Interstate Fire, all vertical shafts become potential chimneys. The ventilated vestibule design failed to keep heat and smoke out of the pressurized smoke towers and all the stairwells were charged with smoke.

Once exposure lines are in place and charged, the crews should prepare for the fire to extend vertically from autoexposure, or lapping from window to window **FIGURE 15-53**. Windows should not be broken out to prevent lapping. If they fail due to the fire, however, combination nozzles with a fog pattern must be used to cover the open space, cool the thermal column, and prevent flames from entering the exposure floor. An excellent tactic for controlling autoexposure is to get hose lines to the roof, or on several floors above the fire, and flow water down the exterior sides of the building. A cascading sheet of water down the exterior glass curtain walls keeps the glass cool and wet and effectively stops lapping.

Final Strategy at the First Interstate Fire

The First Interstate and One Meridian Plaza fires were two of the most spectacular towering inferno-type high-rise fires in US history, ranking after those of September 11, 2001. Each fire had its own unique problems. The One Meridian Plaza Fire started on floor 22. It burned for over 19 hours and consumed eight floors. Due to the concern for possible structural collapse, all companies were forced to abandon the building. When the fire reached the thirtieth floor, which had a functioning sprinkler system, 10 sprinkler heads finally controlled and extinguished the fire. The First Interstate Fire was a full-on fire attack. The fire started on floor 12 and destroyed the twelfth to the fifteenth floors in 3 hours and 45 minutes. According to the *USFA Technical Report Series on the First Interstate Fire*, the autoexposure flames were 30 feet high, and it took about 45 minutes for the fire to take hold of the next exposure floor. It was estimated that a total flow of 4,000 gpm was delivered by the standpipe risers, and the total effective fire flow provided by hose lines attacking the fire was approximately 2,400 gpm. With all the efforts of 32 companies operating 20 attack lines from all four stairways, it still wasn't enough to control the fire and put it out. It took about 90 minutes for the fire load to be consumed on each floor (which illustrates the concept behind Type I fire-resistant construction).

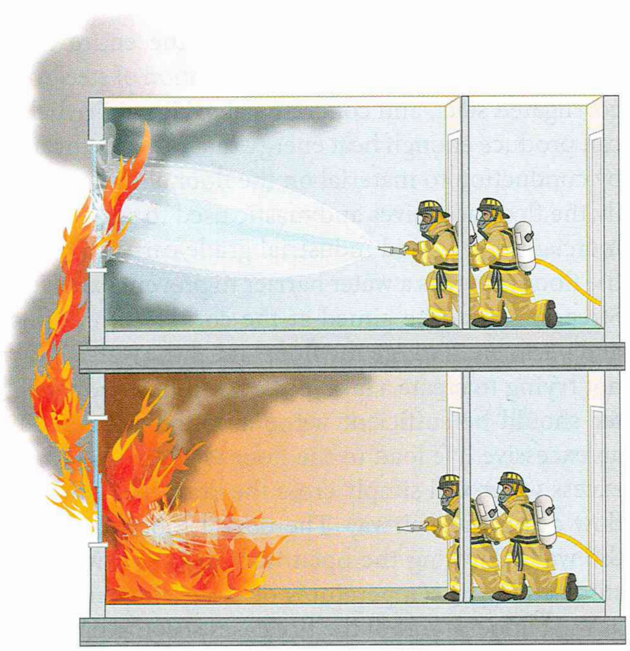


FIGURE 15-53 Firefighters should be assigned to check above the fire floor for fire spreading from window to window.

Once the water source was readied and positioned ahead of the fire in both the First Interstate and the One Meridian Plaza fires, it was controlled with the available water on that floor. Even a 30- to 35-gpm (per head) flow through 10 sprinkler heads in the One Meridian Plaza Fire was sufficient to extinguish the massive fire because extinguishment was ahead of the spread of the fire. The final strategy employed by the LAFD is textbook high-rise firefighting and worth reviewing in detail because it worked; for future fires, it should be implemented sooner rather than later. When it became evident from the exterior that they were going to lose the sixteenth floor, Deputy Chief Don Anthony, the IC, wanted to concentrate a full-out effort to attack the fire on floors 14 and 15 simultaneously to knock down the intense thermal energy and slow the speed of the fire while crews got ahead of the fire and established a defensive position on floor 16. At times, active suppression efforts were underway simultaneously on four levels as crews attempted to push the fire back from the central core to the perimeter of each floor. As more doors were opened, conditions in the stairways deteriorated, with heat and smoke going up and water cascading down. It required extreme effort by crews operating hand lines on heavily involved floors, with as many as four floors burning below them, but crews made it up onto floor 16, operated the attack lines, prepped the room, and flowed the floor. Then they waited for the fire to attack the sixteenth floor. Conceptually, this strategy goes back to the basic fire science covered in Chapter 2 of this text. They had been fighting a massive fire on the fully developed side of the fire time-temperature curve. Chief Anthony needed his firefighters and hose lines to be at the start of the fire time-temperature curve during the incipient and early growth stages on an uninvolved exposure floor. This strategy proved to be successful.

Preparing the Exposure Floor

All combustible material should be removed from around the windows and walls. This may include the entire perimeter of the exposure floor. Move items to the center of the room and away from shafts, ducts, and vertical channels. Combustible items include:

- Curtains, shades, and blinds
- Perimeter ceiling tiles
- Framed photos, artwork, and wall hangings
- Lamps and plants
- Office furniture, including desk chairs, tables, and filing cabinets
- Computers, printers, telephones
- Cubical dividers
- Carpet

Pull the ceiling around the perimeter to expose the plenum and the return-air channels. The perimeter walls should be bare. Open up any knee walls or spandrel panels below the glass, and expose all perimeter walls down to the studs. If possible, floors should be down to the concrete. Buildings with exterior glass curtain walls have a spandrel gap of several inches where the glass curtain walls are anchored to the concrete decking on each floor. These gaps are often left unsealed and are a vertical path for extension at the floor and ceiling level, and contribute to autoexposure. Any curtain wall spacing must be exposed, especially in the area around the floor slabs. Check or expose the window mullions (the vertical rods that join the large windows). At any point where smoke or flames start to show through the floor, flow water. Property conservation is not the concern on the floor above the fire. There are no half-measures here. We are trying to stop the fire, not preserve the floor.

Other vertical avenues for extension of fire include areas in the center core, which can include stairways, elevator shafts, utility shafts, mail chutes, garbage chutes, poke-throughs for communication and electrical lines, and plumbing pipe chases. The pipe chases are in the kitchen area, breakroom, and the men's and women's restrooms. These spaces need to be opened and wetted down. Walls inside utility closets and behind cabinets need to be open and wetted down. Do not rely merely on TIC readings to save a wall. If the fire is stopped, the whole floor will be remodeled, but if the fire extends, half-measures will amount to nothing. Soak everything down thoroughly.

Tools for Protecting the Exposure Floor

In addition to the hose lines, and combination nozzles the following tools are needed:

- TICs
- Pike poles and roof hooks
- Plaster hooks
- Pickhead axes
- Chainsaws and rescue saws
- Irons or forcible entry tools
- Baby ladders or attic ladders
- Spare SCBA bottles
- Portable generator and lights

This demolition work will need to be done on air so bringing spare SCBA cylinders up from staging saves time. Another primary avenue of smoke and fire spread are the HVAC ducts. Vent grates have to be removed. It may be necessary to pull down ductwork. In any case, firefighters need to be able to reach ceiling spaces, so baby ladders or attic ladders will be needed. There may be utility ladders available, but they may not be strong enough to hold the weight of a fully equipped firefighter. Once opened, all areas need to be checked with a TIC, with a hose line at the ready, or the fire may extend. Wet everything down.

Flowing the Floor

While firefighters are performing the above tasks, those assigned to the nozzle should **flow the floor**. Flowing the floor is wetting down the entire floor. High-rise floor systems are a combination of steel rods, corrugated steel, and concrete slabs. Heavy fire below can produce enough heat energy that radiates through by conduction to material on the floor above, primarily the floor adhesives and mastic used to secure commercial flooring and industrial grade carpet. Flowing the floor provides a water barrier to prevent extension. Streams should be aimed at the corners of the floor and perimeters where the floors meet the walls. You're not trying to create a lake, but a pond of standing water should be sufficient without concern for adding an excessive live load to the floor **FIGURE 15-54**. Any excess water will simply cross the door threshold and flow down the stairway. The nozzle should also flow the walls. Flowing the open wall spaces between the studs cools the temperatures of the perimeter as well as the temperatures of the fire gases seeping up. Cooling the glass panels with water should also be done, but the cool water against the hot glass may cause them to fail. Sufficient hose lines with combination nozzles must be in place to fight autoexposure. Broken-out

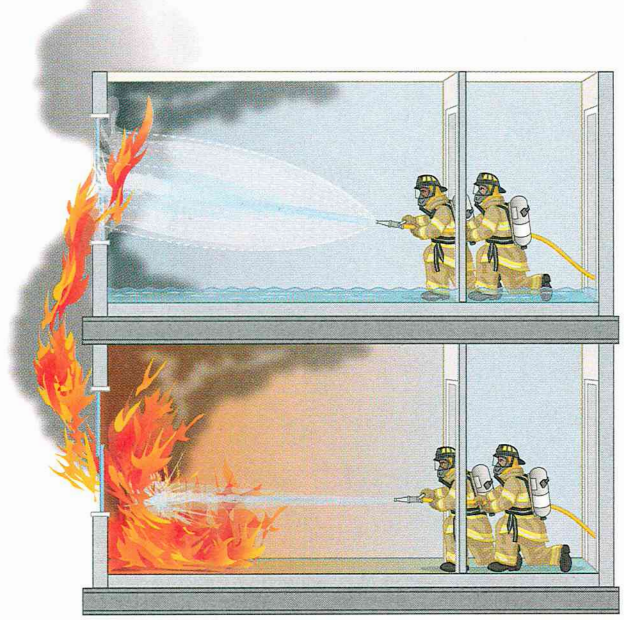


FIGURE 15-54 Flowing the floor is wetting down the entire floor. Standing water is a barrier preventing fire extension.

glass panels may cause additional flow path problems but should also help dissipate the heat and will help later with floor ventilation. A flow path with a wind-driven fire is not a concern yet because there should be no fuel burning on this floor for the wind to fan the flames. The fog patterns are necessary to keep lapping flames out of this area. The only fire load left on the floor is the office furnishings, and other combustible material that was piled in the center of the room. Hose it down. If it's wet, it won't burn. If you look at the One Meridian Plaza Fire case study, you can see that the fire was finally extinguished on the thirtieth floor by 10 sprinkler heads. Once the sprinklers fused, the office furnishings and combustible material were wet, and there was standing water on the floor. In a building without sprinklers, firefighters need to get ahead of the fire and create the conditions described here, which are the only preventative actions available. There are no other manual firefighting methods for protecting the exposure floor.

Checking for Extension Below the Fire Floor

Floors below the fire must also be checked for fire extension. Stack effect produces unpredictable convected air currents, and smoke and heat can actually travel down. If fire is observed below the fire floor, hose lines need to be stretched to these areas for fire control. In addition to fire extending to floors below the fire, property conservation should be considered early in the incident. Depending on their occupancies, high-rise buildings may contain valuable contents. Protecting these valuables, especially from water damage, reduces loss considerably. Property conservation on floors below the fire is usually labor-intensive, and it may be overlooked in the initial stages of the fire because of other tasks being conducted on the fireground. Extension below the fire may force the staging area to be relocated one or two more floors below.

Other Uses for Standpipe Systems

Although designed primarily for interior fire attack, standpipe systems can be used to attack fires in adjoining buildings and for exposure coverage.

Fire Attack in Adjoining Buildings

When fire has gained considerable headway in a building, firefighters may be kept from the fire floor by the intense heat. Under these conditions, if adjoining buildings are close enough to the fire building, hose streams developed from standpipe systems in nearby buildings could be used on the fire **FIGURE 15-55**. The hose streams can be directed across a court, across narrow streets and alleys, or from the roof of the adjoining building into higher floors of the fire building. Either 2½-inch hand lines or master stream appliances may be used for such operations. This tactic was used at the One Meridian Plaza Fire: Hose streams were set up from adjoining high-rise buildings within reach. It could not be used at the First Interstate building.

Exposure Protection

Fire on the roof and in upper floors of closely set buildings presents serious exposure problems. In some cases, aerial fire apparatus can be used for fire attack and exposure protection; however, when the fire is above the reach of aerial devices, almost all operations must depend on the standpipe system of the fire building and adjoining structures for water. Pumpers must be set up to pump into the standpipe systems of both the fire building and exposure buildings. Those of the exposed buildings must be charged to ensure proper water supplies if and when they are needed. This is especially important when only public waterworks supply the systems because the public waterworks pressure could be reduced to the point where attack lines supplied by these standpipes will be

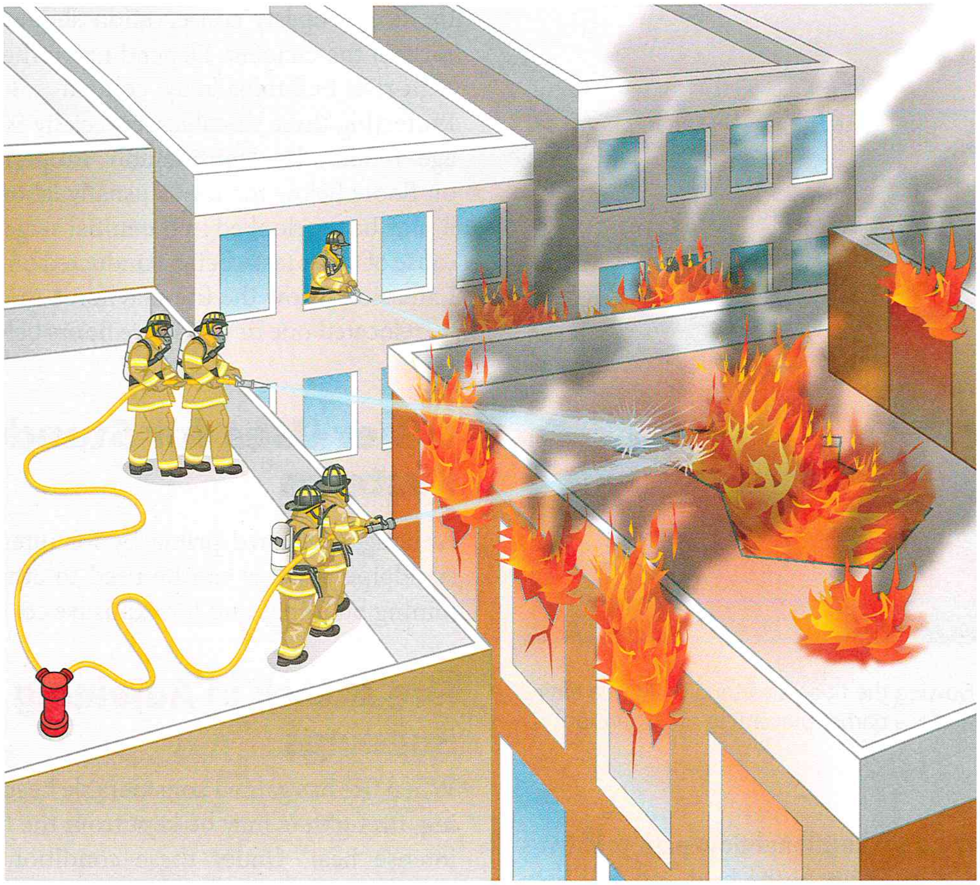


FIGURE 15-55 Standpipe systems may be used for fire attack and exposure protection from adjoining buildings.

ineffective. A simple tactic to protect exposure buildings is for crews to flow hose lines operating from the roofs and flow a cascading sheet of water down the exterior walls of the exposure building to keep them wet. This tactic can be accomplished with low water flows.

Use of Water from Uninvolved Buildings

Water from a gravity tank atop an uninvolved building can be drawn off and used to supply pumpers **FIGURE 15-56**. This is usually a measure of last resort; it is used, for example, when a very large fire requires many pumpers to operate simultaneously and the water main pressure may become dangerously low. To obtain the water, the pumper is parked as close as possible to the ground floor standpipe outlet. The 2½-inch hose or larger supply line is hooked up between the outlet and the pumper intake. The outlet is opened, and the pumper takes water from the gravity tank. Depending on the standpipe system, it could be more efficient to use LDH to support the operation.

Search-Evacuate-Rescue (SER)

Although SER is covered here, toward the end of this chapter, it is by no means a tactic that should wait for all the previously discussed tactics to be accomplished. On the contrary, it is implied that the search starts along with the evacuation, and it is implied that it may be initiated simultaneously with the initial fire attack. It might even be necessary for the engine company to forgo fire attack to concentrate on SER on the fire floor and with evacuation of large open-area floor spaces. Stairways may be congested with fleeing occupants, and the evacuation may be chaotic. There may be numerous disabled occupants who are in danger and who require immediate assistance. These actions may result in a delayed fire attack and an increased spread of the fire, along with additional property damage. It may also require a lot more time and resources to control the fire, but it is the right decision to make. A fast fire attack is important, but you also have the fire-resistive qualities of Type I construction working in your favor.

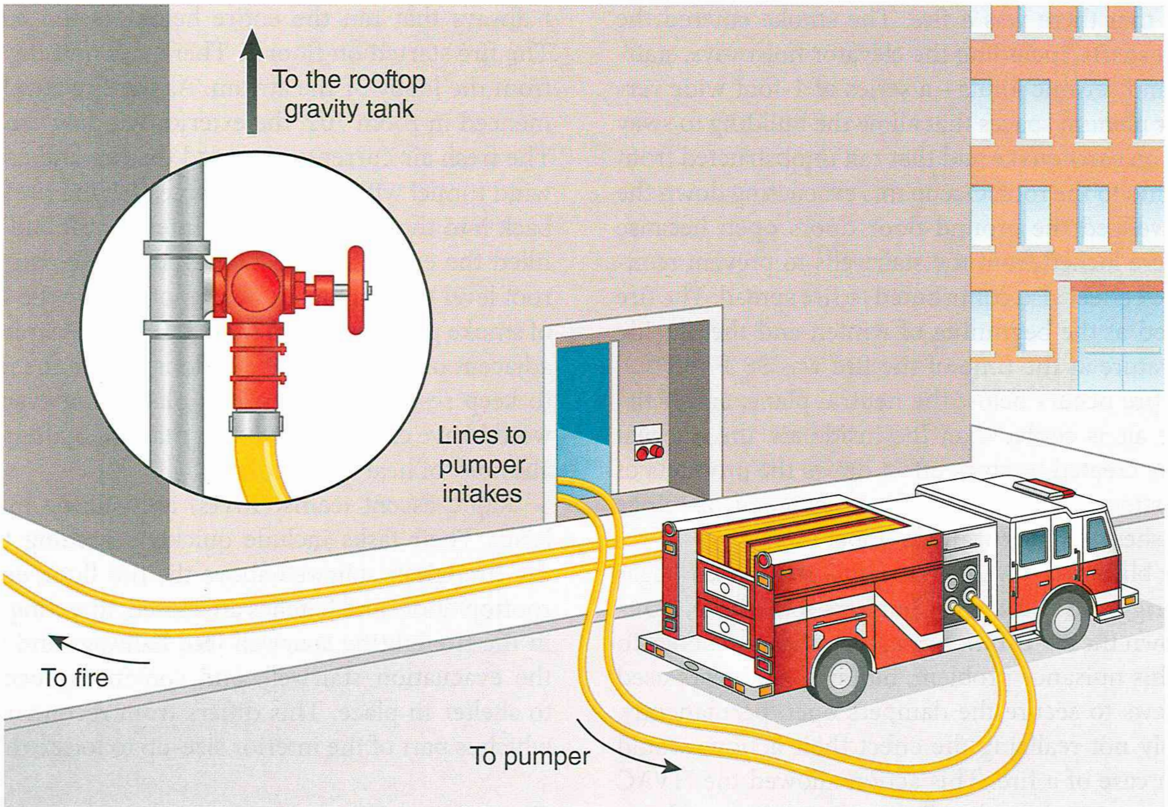


FIGURE 15-56 In water supply emergencies, standpipe gravity tanks from adjacent buildings may be used as a last resort to supply the pumpers.

Search and rescue (SAR) efforts in high-rise fires are different than those in regular structure fires. In a single-family residence, firefighters can expect to rescue one or two people and remove them from the burning structure. In a high-rise, that number can be 10, 20, 30, or perhaps hundreds of people may need assistance. This is why the word *evacuate* (and thus the letter *E*) is added to the common assigned term of SAR to form SER. By no means does this imply that rescues won't be made; they will, but the majority of the occupants need to be evacuated—that's how we rescue them.

Type I fire-resistive construction is the classification that can resist the fire for the longest time. It is designed so the fire load (fuel) is consumed before the building components start to suffer the effects of the fire. Therefore, the strategy for life safety in residential apartments, condominiums, and hotels is to **shelter in place**. This means that the occupants are safer staying in their units than trying to evacuate the building. The hallways and stairs may get charged with smoke. CO, which is colorless, odorless, and tasteless, can overcome an occupant in a hallway or stairwell that may appear to be free of smoke. This was the case at the MGM Grand Hotel Fire on November 21,1980, in Las Vegas, Nevada, where 85 people were killed.

The MGM Grand Hotel was a 26-story hotel with 2,076 rooms; at the time of the fire, 07:07, it was estimated that 5,000 people were in the hotel. The electrical fire started in a restaurant on the ground floor–casino level. Because the casino never closes, and staff members and customers are on the floor 24 hours a day, it was granted a fire code variance to omit sprinklers in the casino. The rationale was that with round-the-clock activity, any fire would be quickly noticed by security and reported to the fire department while trained staff put out the fire with portable fire extinguishers. However, The Deli restaurant was not open yet and there was no one in the immediate vicinity of the restaurant who took notice of the growing fire. Modern fuels, including furniture, decorations, wallpaper, foam padded chairs and booths, PVC pipe, slot machines, gambling equipment, and the flammable glues and adhesives to hold the plastic mirror ceiling tiles above the entire casino, contributed to rapid fire spread throughout the main floor. When flashover occurred, the flames were traveling 15 to 19 feet (4.7 to 5.8 m) per second. Eighteen people were killed in the casino level.

There were no smoke detectors, and the manual alarm pull stations failed or were not pulled. Residents were never notified of the alarm but awoke to the smell of smoke, sirens, commotion, and occupants yelling that there was a fire. The smoke entered the vertical shafts, including the elevator hoistways, stairwells, and seismic joints—a series of 1-foot wide vertical air plenum spaces that allow the building to sway during an earthquake and that ran unobstructed from the casino to the roof. Occupants evacuating down the stairs wedged the ground-floor doors open because they were locked from the stairwells to prevent reentry. Stack effect also contributed to fire spread. The fire occurred at the beginning of winter, and the outside temperature at the time of the fire was 38°F (3.3°C). When fire occurs below the neutral plane, and if the outside air is cooler than the inside air, the internal pressure created by stack effect draws the products of combustion toward any shafts or stairwell openings and pushes them vertically to upper levels.

The blistering summer temperatures of Las Vegas often triggered the smoke dampers to activate, shutting down the air-conditioning system to the hotel. To solve this nuisance problem, building engineers used lag screws to secure the dampers open permanently, probably not realizing the effect their actions would have in case of a fire. This action allowed the HVAC system to spread smoke all the way to the top floors of the hotel and throughout the building. The fire enshrouded the entire building in a massive smoke column that could be seen for miles.

In the end, 85 people died and 650 were injured. Sixty-seven of the deaths occurred in stairwells, stair landings, hallways, and elevator lobbies from floors 16 through 26. Of the 67, 25 occupants died in their rooms from smoke and CO being pushed through the HVAC system, although some showed no signs of smoke inhalation. Ten people died in elevators, and one person jumped and died. The fire never spread past the second level of the casino.

Shelter and Defend in Place

The MGM Grand Hotel Fire is a worse-case scenario, an example of what needs to be done to ensure life safety. Since the September 11 attacks on the World Trade Center and the Pentagon, and the ability to view graphic video footage of any high-rise fire on the Internet, like the Grenfell Tower Fire in London, England, it may be impossible to convince occupants that the safest thing to do is stay in their rooms or work areas. Their natural tendency is to flee. But convincing them is what you need to do to prevent them from inadvertently entering an IDLH atmosphere.

The Polo Club Condominium Fire occurred on October 31, 1991, in Denver, Colorado. The nonsprinklered, 20-story, residential high-rise had an atrium center core with interior balconies and hallways that ran the entire height of the building. The fire started on floor 7. There was nothing visible from the lobby or the atrium. As the fire attack commenced in room 702, the exterior window broke out. The fresh air currents exploded the fire and created a wind tunnel with blowtorch force, driving firefighters back into the atrium hallway. Intense heat and smoke filled the entire atrium. Louvered smoke dampers at roof level were open but could not handle the volume of smoke produced from the fire. The SAR strategy for adjacent units and on all the floors above the fire was to keep residents sheltered in place. Any evacuation would have exposed them to a massive building-wide chimney of heat and smoke.

Rapid ascent teams (RATs) are gaining in popularity. Their tasks include quickly searching the entire firefighter stairwell above the fire floor, ensuring rooftop doors and hatches are closed, directing people in the firefighting stairwell into hallways and toward the evacuation stairwell, and convincing occupants to shelter in place. This differs from reconnaissance, which is part of the interior size-up to locate the fire.

Search-and-Rescue Exterior Recon Team (SERT)

Search-and-rescue exterior recon teams (SERTs) and high-rise exterior recon search teams (HERSTs) are new concepts that should be incorporated into high-rise firefighting SOPs so that one or the other is assigned consistently. The most dangerous floors for trapped occupants are the fire floor and the floor above the fire. As was the case of the First Interstate Fire, stairways above the fire floor were untenable for search teams to climb. They had to wait until the fire was contained and knocked down. When there are exposure buildings of equal or greater height compared to the fire floor, a search recon team can enter these buildings with binoculars to get a line-of-sight view of the fire and smoke conditions, as well as check for trapped occupants visible on the fire floor and floors above. The exposure buildings do not have an IDLH atmosphere, so firefighters do not need a partner or SCBA. In theory, one company can split up and enter four separate exposure buildings to see the four sides of the fire building. The area where flames are visible should be checked first. Cell phone camera zoom capability is extremely detailed, and the IC can see human images that are sent to the command post in real time. Even the division supervisor on the fire floor or other designated positions can have these images available. When you consider how much time it would take for an interior search team to cover two floors, 30,000 square feet each, the time spent for this type of exterior recon is well worth it.

FIGURE 15-57 Person trapped on floor 37 at the DeWitt-Chestnut Fire in Chicago, Illinois.
Courtesy of Michael Wielgat.

FIGURE 15-57 clearly shows a person trapped on floor 37 at the DeWitt-Chestnut Fire in Chicago, Illinois. (Note the Christmas tree.) This person was rescued by Chicago firefighters. Occupants in the apartments below floor 36 sheltered in place. Smoke and fire conditions are also clearly visible in the figure. This photograph was shot with regular film and was not available for viewing at the time of the fire.

Aerial Drones

Drone technology is rapidly coming into play in the fire service. Using a drone to gain a close-up aerial perspective for size-up and exterior recon will become a common tactical tool in the near future. Helicopters can't get as close to a building as a drone can; however, there are still many variables preventing full implementation of drones. For example, how will they operate in inclement weather, high winds, thermal columns, and radiant heat from a fire? The aerial advantage of using helicopters for high-rise fires is obvious, but they also cause problems. At the First Interstate Fire, the constant loud noise of the rotors added to the noise levels within the building, making radio communications extremely difficult to hear. The helicopters also fanned the flames and created turbulent smoke movement around fire crews working in areas where the windows had already broken out.

Fire Dispatchers

The first point of contact with someone trapped in a high-rise is a 911 fire dispatcher. The caller may be able to tell the dispatcher the exact location of the fire as well as what's burning. The dispatcher should calm the caller and gather pertinent information, including the floor number, the room number, and the location of the caller inside the unit (i.e., bedroom, bathroom, closet) and the surrounding fire conditions (i.e., odor only, smoke, fire), then convince the caller that the safest thing to do is stay in her or his room. If the caller is in immediate danger of the fire inside the unit, or he or she lives in the unit above the fire and smoke conditions are getting worse, the caller should try to escape. But if the fire is anywhere else in the building, the caller should stay in the room. The IC must be given the floor and room number of the trapped occupant along with fire and smoke conditions. At the DeWitt-Chestnut Fire in Chicago, it was confirmed that three occupants were trapped on the roof because they called the dispatcher from that location. The dispatcher should reassure the caller that the fire department knows where they are and will come. Based on the information from the dispatcher, the IC should relay the floor and room number, along with the reported fire conditions to the SER team, including if the occupants are young, elderly, or disabled and require special assistance. Although the dispatcher is listening to all the radio communications on the fireground, the IC should make sure to clarify what information and instructions should be relayed to 911 callers by the dispatcher, for example, whether to shelter in place, the location of the evacuation stairway, avoiding the roof, keeping doors closed, opening windows. If the IC wants tenants on the exposure floor to evacuate, the dispatcher should know this information in case those occupants call 911 because then they can be instructed to evacuate to the proper stairway.

Public Address (PA) System

The initial company officer should utilize the building PA system to notify all the occupants to stay in their rooms unless their floor is in alarm. The officer should include the nature of the incident and what the fire department is doing to resolve it. Include any specific instructions for evacuation or to shelter in place. The more reassurance that can be given to occupants, the more they will cooperate. Don't lie or minimize the danger. If you choose to dump the whole building by evacuating all the tenants, then instruct them to the proper evacuation stairwells. A full evacuation may cause more problems than necessary. First, it is time consuming. The evacuation at the MGM Grand Hotel took 4 hours to complete. Next, where will evacuees gather? An outdoor location may be okay on a warm sunny day, but if it is 02:00, 10° F (-12° C), and snowing, you can't just send them out to the parking lot, especially if you're dealing with elderly occupants. Firefighters need to be trained in effective methods for sheltering and defending in place.

The use of handheld, battery-powered megaphones is important for the crews to manage a large evacuation. They should be carried on every fire apparatus, brought up to the equipment cache at staging, and used when directing those exiting the building to a shelter area away from the building. Hallway corridors can be extremely long. This device is an effective way to call occupants to the evacuation stairwell, call to check if anyone is in the hallway, call up and down the stairwells to see if anyone is there, and give instructions to occupants to stay in their rooms. This can be done by a firefighter announcing instructions while walking the hallway. The megaphone-amplified voice should be heard through closed hotel and apartment doors. Occupants can also be directed to turn on the television for complete updates from the PIO working with the local news station. There were 2,076 rooms in the MGM Grand Hotel, and all doors to any high-rise hotel units are locked. It is impractical to search every room with the initial units. And the doors should not be forced. If the message to occupants is that the safest place to remain is in their rooms, why would we force entry to search them? The occupants are most often safe in their rooms or apartments.

Traditional and Nontraditional Search Tools

Multiple master door keys should be obtained for SER units. These keys prevent needless property damage, and they are the fastest way to gain access to locked areas for the primary search and to remove people who cannot self-evacuate from exposure floors. These keys should be in the FCC. Forcible entry tools need to be carried by the SER team. In the MGM Grand Fire, as well as the One Meridian Plaza Fire, the doors in the stairwells were locked to prevent re-entry to the floors. Irons needed to be used to gain access to the floors above the fire. This adds considerable time to a search. One of the fastest and easiest ways to get through a door to a hallway or office is to breach the gypsum board wall, reach through, and open the door. This method uses less energy and causes less property damage than forcing through a heavy-duty fire-rated metal door. Obviously, this method doesn't work when the walls are concrete.

The MGM Grand Hotel Fire sheds light on additional tools that the SER team should consider using. Typically, SER teams are taught to perform a right-handed search and sweep the area with a tool. The scope was different here: although firefighters still needed a tool, the victims in the MGM Grand Hotel weren't hidden. They were found in the common entry egress paths. What these victims immediately needed was fresh air. The RAK is typically used for firefighter rapid intervention incidents, but they can be a valuable rescue tool for civilians.

It's time we start carrying RAKs in high-rise SER operations for civilian use. Bringing spare SCBA units for civilian use accomplishes the same thing. SCBA units would also serve as a backup if one or more SER team members run out of air.

Another tool that SER teams should bring is the handheld multi-gas detector. The smoke column can stratify when particulates cool in the stairwell and vertical shafts, but some fire gases can keep rising. CO is colorless, odorless, and tasteless. Some of the MGM Grand Hotel victims died in their rooms, but they showed no signs of smoke inhalation. They probably died from CO. Seventy-nine of the victims had CO levels that ranged from 25% to 66% saturation. Stairwells and hallways that appear clear can be charged with CO. Firefighters might be tempted to save their air and remove their facepiece, and they might suffer the effects of CO. Semiconscious occupants may appear to be injured, tired, or in shock when they're really suffering from the effects of CO. There is no way to confirm if a clear hallway or stairwell is really clear unless a gas monitor is carried in by the SER team. Again, what these victims of CO poisoning need immediately is fresh air. Lobby and staging areas should also be monitored for CO as both have been found to have high levels of CO due to stack effects.

SER Areas of Emphasis

The primary tactical objectives and areas of emphasis for SER teams are to:

- Check the firefighting stairwell above the fire floor for trapped occupants.
- Check the fire floor, especially isolated rooms where occupants may have sheltered in place.
- Check the rooms on both sides, adjacent to the fire room.
- Check elevator lobbies, starting with the fire floor. Although people shouldn't do so, some may still attempt to use the elevator to escape. Phase I would have recalled the elevators to the main lobby, so occupants may end up unconscious (or dead) waiting for an elevator on the fire floor.
- Check the floor above the fire, starting with the room directly above the fire.
- Check the evacuation stairwell.
- Check the top floors of the building.
- Direct wandering occupants to the evacuation stairwell.

- Direct occupants to stay in their rooms and shelter in place.
- Move wandering occupants into a residential unit for the duration.
- Check all stairways, hallways, corridors, and elevator lobbies on remaining floors above the fire.
- Check bathrooms and other rooms in the central core.
- Check hallway linen closets, utility rooms, and concession areas.
- Direct evacuees to a safe floor of refuge well below the fire floor and firefighting operations.
- Check all elevator cars.
- Check the freight elevators.
- Check the roof.
- Consider referring to a tenant list.

Once the fire is under control, a door-to-door, floor-by-floor inquiry can be made to check on the well-being of occupants. The multiple tasks that are required to perform a proper high-rise search, including carrying all the equipment mentioned above, is more than the typical two-person search team can handle. The IC needs to create a SER group with two or more companies assigned to perform the search in time to make a difference. Call for additional alarms.

SER in Open-Space High-Rise Office Buildings

Of all the property classes, high-rise office and commercial buildings are the most likely to be sprinklered. Their occupancy load is high during the day and low at night. In an open floor plan that is not compartmentalized, trained fire wardens, if they are available, move occupants and employees to a safe refuge area that can be five to ten floors below the fire, clear of fire department operations. Obviously open spaces do not allow you to shelter and defend in place if the floor is close to the fire. But once occupants are moved to safe refuge areas, they can remain there for the duration of the incident if necessary. It is not necessary to evacuate the entire building.

If the civilian fire wardens have cleared the floor, their work should still be verified by fire department personnel. If the floor is clear of smoke, there may be no need to perform a wall search of each office cubicle. Walking the main aisles and side aisles while calling out, perhaps with a handheld megaphone, should be sufficient. Individual offices, supply rooms, photocopy rooms, file rooms, utility closets, breakrooms, kitchens, and bathrooms should all be checked because people may be using earphones and be unable to hear announcements or alarms. Elevator lobbies should also be checked. ***Safety note:*** If an elevator car is found on an upper floor with the doors open, it is a sign of a malfunction. Check the car for occupants but do not enter the car.

Elevator cars are also searched for occupants at lobby level when they are recalled. If smoke is present, individual cubicles need to be searched. Special attention should be paid to making sure that the firefighting stairwell above the fire floor is clear of civilians.

Door Control

In buildings with pressurized stairways, door control during SER is important for maintaining pressurization. Leaving hallway doors open intentionally or unintentionally can reduce the pressure, which can allow smoke to enter the stairways. Some buildings have smart locks that automatically unlock all hallway doors in the stairway when the building goes into alarm, allowing for reentry onto any floor from the stairs. Other systems allow reentry every five floors. Some buildings do not have any reentry doors, and occupants have to exit the building on the ground level. Powerful pressurization fans in modern buildings can maintain pressure even when three doors to the stairway are left open, but that's about it.

It is understandable that firefighters want the ability to enter and reenter the floors from the stairwell, especially if the doors lock. The best tool for the job is the Jeromeo clamp: a simple spring-loaded clamp that can be found at any hardware store. The clamp is strong and inexpensive to replace. The best feature is that, unlike a door wedge, the Jeromeo clamp won't slip. You simply squeeze the clamp onto the edge of the door and let go **FIGURE 15-58**. You can place it at any height, and it won't get kicked loose by other firefighters. Placing the clamp close to the lock side of the door allows the door to close as tightly as possible while still having access. Placing the clamp on the hinge side of the door wedges the door open in case you need to pressurize the stairwell.

Firefighter Air Management

Keep in mind that fresh SCBA bottles are kept in the staging area, two floors below the fire. In the case studies of the MGM Grand Hotel, One Meridian Plaza, and the First Interstate fires, all the stairwells, even the evacuation stairway, became charged with heat and thick smoke. There were no smoke-free stairways. Many of the floors above the fire were also smoke filled.

FIGURE 15-58 The Jeromeo spring-loaded clamp.
Courtesy of Raul Angulo.

When more than one floor is on fire, and fire attack is happening on multiple floors (as was the case at the First Interstate Fire), heat conditions can become so high that all the stairwells are untenable. SER teams cannot access upper floors until the main fire is knocked down and temperatures are reduced. If crews are dropped off on the roof by helicopter, they may not be able to access the stairway because they are at the top of the chimney/thermal column in the stairwells.

SER crews given assignments well above the staging floor will most likely run out of air. The officer needs to monitor the SCBA regulators of all the members. In some conditions, it may be possible for firefighters to remain uncovered until the assigned floor is reached, thus saving their SCBA air supply. In smoke-filled stairways with tenable heat, however, crews may have to hike up several floors and use forcible entry to gain access to the hallways—all while being on air. The physical exertion uses up their air supply and narrows the window to perform the actual search. Some may be tempted to save their air and remove their facepieces. These firefighters run the risk of suffering from the effects of smoke inhalation and CO. The potential for getting too far in a hallway or getting too far up a stairwell, away from staging where the fresh SCBA bottles are stored, can get the SER team in trouble. Air management principles need to be practiced, which includes bringing extra air bottles if the assigned task requires considerable time and takes the crew far away from the staging area. Assign a stairway support company dedicated to the SER group just to bring extra air cylinders up to higher floors. The introduction to this chapter mentioned that, between 1977 and 1996, 16 firefighters died of traumatic injuries in high-rise fires. Nine of those 16 firefighters became disoriented and ran out of air while trying to find their way, ultimately dying of asphyxiation.

Remember, the three firefighters of E11 who died at the One Meridian Plaza Fire were given the task of ascending to the top of the stairway bulkhead to vent the smoke. They had to hike from floor 22 to floor 38, but they never made it before becoming disoriented and running out of air. One of the SAR teams consisting of eight firefighters also became disoriented and all members ran out of air in the mechanical room on floor 38. They were all rescued by the roof team. Like a scuba diver under water, every firefighter has to monitor his or her air consumption. Even the most straightforward tasks can become exhausting for firefighters during or after climbing 10 to 20 stories in heat and smoke. Fatigued firefighters consume more air in a shorter period of time, and it is the responsibility of the team leader or company officer to calculate if the assignment can be accomplished on a single bottle of air. Ideal air management is reaching the objective, performing the task, and returning from the objective with air to spare. But high-rise fires are never ideal. Returning to breathable air may be good enough. If not, taking an extra SCBA bottle may be the most important search tool of all **FIGURE 15-59**.

Air Standpipe Systems

One of the newest technological innovations for high-rise buildings and high-rise firefighting is the air standpipe system. Air standpipes are starting to appear in new high-rise construction around the country. Similar in concept

FIGURE 15-59 SER teams searching upper floors away from staging will most likely run out of air. A dedicated support company should be assigned to the SER group to bring extra air cylinders up to higher floors.

Courtesy of Rescue Air/Mike Gagliano.

FIGURE 15-60 The firefighter air replenishment system (FARS), or the air standpipe, can be supplied by the building's cascade unit.

Courtesy of Rescue Air/Mike Gagliano.

to water standpipes, air standpipes will be supplied by an air cascade system within the building **FIGURE 15-60** or by a fire department mobile air unit **FIGURE 15-61**. With compressed air supplied to the entire system, firefighters will be able to trans-fill their SCBA air cylinders from the air station on designated floors, if not from any floor, without removing the facepiece. This concept is already starting to change the way SER and fire attack is performed in high-rise buildings.

Firefighter Air Replenishment System (FARS)

The following detailed description of the system is from Captain Mike Gagliano (Retired), of the Seattle (Washington) Fire Department:

The physical and logistical challenges for firefighters battling high-rise fires are enormous. Some of the best-trained fire departments in the country have met

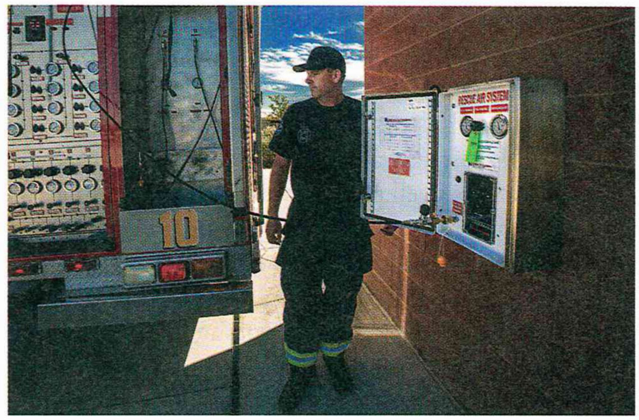


FIGURE 15-61 The FARS air standpipe can also be supplied by a mobile air unit connected to the air standpipe the way a pumper connects to the FDC.

Courtesy of Rescue Air/Mike Gagliano.

their match when the fire is burning high in the sky. The variables of the historic high-rise fires covered in this book are many, but what doesn't change in these buildings is the two essential elements necessary to attack a fire, and rescue those at risk: water and air.

In the first half of the twentieth century, it became clear that new methods needed to be developed for fighting fires with an adequate water supply in tall buildings. Water tanks, standpipes, fire pumps, and sprinklers were designed to get water as quickly as possible to elevated locations. These are now standard systems in high-rise building design.

Unfortunately, the second necessary component has taken some time to catch up. But make no mistake, air is just as critical to effective fire and rescue operations as water. Unless you're planning to fight the fire from the outside, you are going to need lots of air. Air is what allows firefighters to do the work of firefighting and saving lives in superheated, toxic, carcinogenic, and smoke-filled environments. All the water in the world will not translate into success if firefighters don't have enough air to get the water where it needs to be. The best, most progressive air management program available is useless if there is no air to manage. The simple reality for firefighters is this: "You cannot save anyone if you can't breathe."

The answer to this difficult challenge is simple. Using the same delivery model as water standpipes, FARS delivers fresh air directly where it's needed most with no significant delay in the fire attack. FARS is a permanently installed building system that accomplishes rapid air resupply because it includes the following:

1. Air supply is accomplished by a mobile air unit supplying a fire department connection outside the building, or by a cascade air system within the building, or both.

2. Clean air is supplied through a fixed system of half-inch stainless steel piping and pumped to air delivery stations in the stairwell or other designated areas on upper floors.
3. Firefighters get air from a quick-connect panel in the stairwell using trans-fill connections, or from a rupture containment device that is typically placed within utility rooms or closets in the hallways.
4. The air within the self-contained piping distribution system is monitored around the clock for pressure and quality, and the system goes into alarm if any sensor detects a reading below acceptable NFPA standards.

FARS is a game-changer for rapid and efficient fire attack in high-rise buildings. Imagine the difference in your ability to attack the fire aggressively if air is being delivered to upper floors in the same manner as water in the standpipe. Instead of trying to carry cumbersome air bottles up the stairs or pack them into elevators that sometimes fail, the air is waiting for you at the point of attack. Instead of having to retreat and exchange air cylinders at staging, which is likely not even set up in the early stages of the incident, firefighters can move into the stairwell and immediately refill. Refilling at the quick-connect panels can be accomplished while firefighters are covered, without removing SCBA. Refill time takes between 30 seconds to 2 minutes depending on how many refills are occurring, so the fire attack can continue without significant delay. In addition, critical time is not spent using a labor-intensive bottle brigade that must climb the stairs to bring fresh air cylinders and other essential equipment up to staging.

FARS is currently installed in over 500 buildings in 10 states, with amendments to fire codes throughout the United States happening every year. The necessary requirements and recommendations are already part of numerous regulatory codes including:

- Appendix L of the 2018 ICC International Fire Code
- Appendix F of the 2018 Uniform Plumbing Code
- The 2018 National Fire Protection Association, NFPA-1

At the First Interstate Fire, over 600 bottles of air were needed by 383 firefighters while they fought the fire. Old video footage shows scene after scene of exhausted firefighters using hand trucks, carts, and endless lines of personnel carrying bottles to try and provide fresh cylinders for the fire attack. Fireground commanders were unanimous in proclaiming that air supply was a major factor in the firefight, and delays in air resupply slowed their efforts. Sadly, although this fire occurred in 1988, most fire departments do the exact same operations today with the same delays and difficulties. And those departments that cannot readily bring 383 firefighters, like the LAFD can, are in even bigger trouble.

The reality of resupplying air the old way, with bottle brigades and reliance on elevators, results in a very predictable outcome: *Air resupply at large buildings, without FARS, is slow and difficult and occurs at a much later stage in the fire than occurs with the immediate resupply available via FARS.*

When the late Chief Alan Brunacini was presented with the benefits of what FARS could do for his firefighters in the Phoenix (Arizona) Fire Department, he had a very simple answer: *yes*. When the political leaders hesitated, Chief Brunacini asked them simply to hold their breath while they considered his arguments for FARS because that was essentially what they were asking their firefighters to do, hundreds of feet up in the sky, at the biggest fire of their lives, with the delays of manual air resupply currently used. He got FARS for his Phoenix firefighters.

Immediate air delivered right where it is needed most is the reality of FARS. The answer for every fire chief and fire marshal in the United States should simply be "yes."

Ventilation

Ladder companies are traditionally responsible for ventilation, but engine companies may still have to assist with ventilation assignments. Due to the lack of exterior access and elevation, ventilation becomes complicated in high-rise buildings because they cannot be ventilated in the normal manner. The most significant factor facing firefighters is the wind because it cannot be controlled. Venting during a fire attack can create unpredictable air movement that can spread the fire and smoke throughout the fire floor and even the building. Venting can intensify the fire so severely that it creates a wind-driven fire and thus stalls the attack and prevents the search from continuing on the fire floor. Therefore, it is typically not performed until after the fire is substantially knocked down or extinguished.

One of the first assignments for the ventilation company should be to determine the status of the HVAC system. If the system is spreading smoke by the distribution system or the fresh air return shafts are contributing to fire growth, the system should be shut down. However, it is more important to determine if the HVAC system is pressurizing the stairways, the elevator shafts, the fire floor, and the floors above and below the fire. If the system is designed to sandwich the fire with pressurized stairs and floors, the system should be left in operation so it functions as designed. This information can be confirmed by reviewing the prefire plan or consulting face to face with the building engineer or maintenance supervisor.

The next assignment should be to place PPV fans at the base of the stairwells to augment the pressurization of the stairway shaft. If more fans are needed, they can be placed inside the stairway on the landing 10 floors apart or as needed. Another tactic to assist in maintaining stairway pressurization is to place a fan inside a lower floor hallway about 8 to 10 feet from the stairway door with the fan blowing toward the stairway. The hallway door remains open. These two assignments can be accomplished fairly quickly and can improve or maintain favorable conditions for evacuation without causing any negative effects for the fire attack teams.

Ventilation in low-rise commercial and residential buildings, those less than 20 floors, can still be done successfully with PPV fans and using the prevailing winds for horizontal cross-ventilation, but in mid-rise and high-rise buildings, the atmospheric phenomenon known as stack effect comes into play. This is not an easy subject to understand, and very few firefighters do, because it affects the entire building in so many different areas and in so many different ways. The firefighter at the end of the nozzle in a hallway within a 60-story high-rise is not contemplating the stack effect but rather is focused on advancing the line to the seat of the fire.

Stack effect is the vertical air flow within high-rise buildings caused by the temperature-created density differences between the building interior and exterior, or between two interior spaces (NFPA 92). Vincent Dunn defines stack effect as "the natural movement of air in a high-rise caused by the differences in temperature and atmospheric pressure inside and outside a sealed high-rise. Stack effect is responsible for the most forceful movement of smoke in a high-rise, and it is most pronounced in stairways and elevator shafts. Stack effect, when windows are broken out or opened, can create unusual smoke movement." If you've ever passed through the doors to a high-rise lobby or have passed through the doors of an observation deck of a high-rise, you may have experienced very strong wind gusts as you've entered or exited. Often, the wind exerts significant resistance against the door, requiring extra effort to push it open. This gives you a sense of the pressure differentials that exist in high-rise buildings.

Inside the building is an atmospheric column with a neutral plane within the center of the high-rise. This neutral plane is not constant and can fluctuate. When the outside temperature is cooler than the building interior temperatures, the internal pressure created from fires occurring below the neutral plane draws convected air currents, along with the heat and smoke, toward vertical shafts and stairwells. In fires occurring above the neutral plane, the pressure created from the fire moves convected air currents, along with the heat and smoke, away from the vertical shafts and toward the exterior walls of the building. The effects of smoke movement in fires occurring in the neutral plane is minimal, but the neutral plane can move. These effects are reversed depending on the time of year. In winter, the outside air is cold, while the inside of the building is heated; this is normal stack effect. Smoke from fires on lower floors rises **FIGURE 15-62**. In summer, outside temperatures are hot, while air conditioning keeps the interior climate of the building cool; this is reverse stack effect. Smoke from fires on upper floors can travel downward **FIGURE 15-63**. These temperature variables all affect convected air currents and the movement of smoke.

Now that your understanding of stack effect is crystal clear, here is the takeaway for the engine company. Convected air currents, or smoke movement within a high-rise, are unpredictable; there are many variables including:

- The intensity and heat energy of the fire
- The pressure created from the fire to move the smoke
- The condition and setting of the HVAC system, and whether it is shut down or contributing to the movement of smoke
- Outside temperature/inside temperature
- The wind
- Stack effect

An intense fire can develop sufficient heat and pressure that the heated smoke and gases rise several floors within the stairwell and inside vertical shafts. At some point the fire gases cool and the smoke stratifies. It could linger at a certain level or be pushed up or down by stack effect.

In older residential high-rise buildings, windows can be opened or closed. In commercial office buildings, many windows do not open, and those that do require a key. In any event, wind introduced from a high-rise window can intensify the fire, causing unpredictable and extreme fire behavior.

For engine companies, no air movement is better than unpredictable air movement. The strategy is for crews to attack the fire without ventilation. This will most likely be a brutal punishing endeavor. Once the

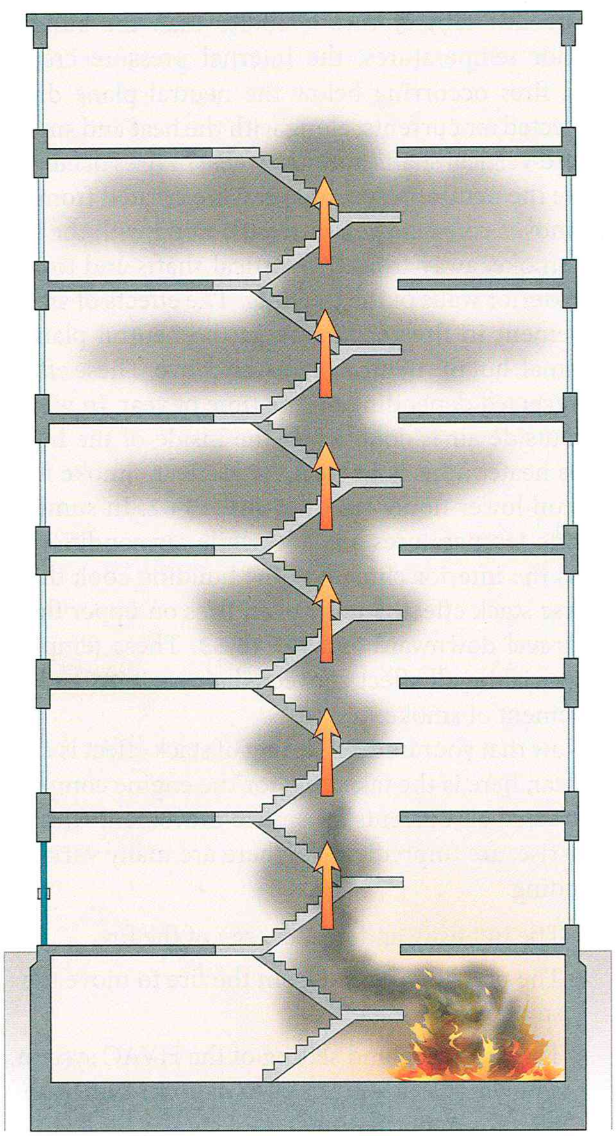


FIGURE 15-62 A winter stack effect occurs when the outside air is much cooler than the interior temperature. Smoke rises in this case in a normal stack effect.

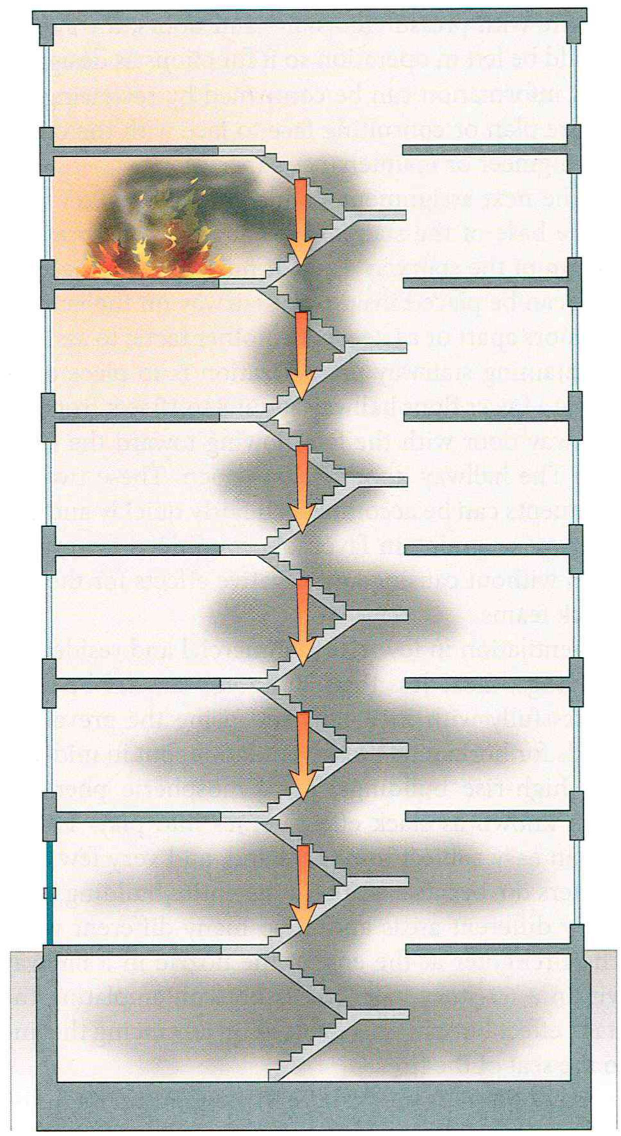


FIGURE 15-63 A summer stack effect occurs when the interior temperature is much cooler than the outside air. Smoke from fires on upper floors can push down in what is called reverse stack effect.

fire is sufficiently knocked down and extinguished, the production of heat and smoke ceases, and ventilation can begin. A combination of ventilation methods can be implemented to vent the existing smoke as quickly as possible. The concern for unpredictable smoke movement isn't as urgent because smoke production has ceased. Residual smoke can be ventilated without concern about additional smoke being generated. The wind is the enemy along with the fire when the fire is uncontrolled. Once the fire is extinguished, the threat is eliminated, and the wind becomes an ally in venting residual smoke **FIGURE 15-64**.

Horizontal ventilation needs to take place as soon as the fire is out to dissipate the heat, by opening or taking out windows. Taking out windows must first be

FIGURE 15-64 Once the fire is knocked down and extinguished, the production of heat and smoke will cease, and ventilation can begin.

coordinated with the IC. When the IC verbally confirms an "all clear below" over the radio, then crews can take out windows. This is an extremely dangerous job because, although ventilation is accomplished, a severe fall hazard has now been created.

Transitional ventilation is a series of tactics that starts with horizontal ventilation supported by PPV fans on the fire floor once the fire is extinguished. Consider where the wind is coming from and use it so it works in your favor. The pressurization in the evacuation stairway is maintained while the pressurization fans in the firefighting stairway are manually and mechanically shut down. The roof access door or the roof hatch in the firefighting stairway is opened. Firefighters must be positioned at the doors of the floor landings in both stairways to control the doors and to prevent unauthorized entry into the firefighting stairway. One firefighter opens the door onto the fire floor from the evacuation stairway, which increases the pressure on the fire floor. Then the door to the firefighting stairway on the fire floor is opened. The pressure differential along with the stack effect ventilate the smoke horizontally into the firefighting stairway, then it transitions and vertically ventilates the smoke out through the roof access portal at the top of the firefighting stairway. Once the smoke has cleared, the firefighting stairway door is closed, and the process is repeated up through the building.

Transitional ventilation should start with the fire floor and the first two floors above the fire floor. The company officer in charge of ventilation should evaluate the rest of the upper floors of the building for smoke conditions; it may be necessary to skip the rest of the floors and start transitional ventilation on the top floor, then work back down.

Once each floor is thoroughly vented, occupants who sheltered in place can be escorted safely by the SER team to the evacuation stairway and to a safe location outside the building. Although the building may be sound, maintenance or restoration issues may need to be handled before the building can be reoccupied.

Make sure to vent for CO. As smoke stratifies, fire gases that are lighter than air will continue to rise above the level of stratification. Firefighters should remain on air with SCBA until atmospheric readings are taken to ensure that CO levels are well below 35 ppm.

Post-Fire Operations

Once the fire is extinguished, the sprinkler system should be shut off; two firefighters should remain at the control valves to quickly turn the system back on if necessary. To avoid water damage, there is a tendency to prematurely shut down the sprinkler system. The emphasis should be on complete extinguishment before worrying about water damage. A premature shutdown of the sprinklers can allow the fire to regain intensity, causing further property damage and financial loss.

Overhaul should be performed in the usual manner. The monetary losses in high-rise fires are high, so try and protect the area of origin for fire investigation. Salvage and property conservation should be started during extinguishment efforts. In fires of such magnitude, it is unlikely there will be personnel to spare. The best strategy for salvage and property conservation is to put the fire out.

The Barrington Plaza fire on January 29, 2020 in Los Angeles, California demonstrates many of the points discussed in this chapter. The 26-story, non-sprinklered, residential building has no pressurized stairways. The fire had self-vented and was blowing out of a unit on floor 7 fueled by a 35-mph wind (see Figure 15-64). Many occupants did not hear a fire alarm but heard the sound of arriving fire engines or were notified by friends in the neighboring buildings, and one resident was notified by a family member who was watching the national news.

Firefighters climbing the firefighting stairway were met by fleeing occupants. The attack from the windward side was stalled until it was verified the occupants were out of the stairwell above the fire floor. The wind was blowing across the A side of the building from D to B and not directly into the unit; however, the wind drove heat and smoke into the stairways. It took many occupants more than 10 minutes to evacuate the stairway. Some collapsed on the stairs and needed to be rescued.

E37 initiated fire attack on floor 7 using a 2-inch hand line. The smoke and heat were down to the floor with zero-visibility and firefighters had to crawl on their bellies to reach the fire room. The attack was stalled again when they came across an unconscious male. The captain split the crew, designating one firefighter to effect rescue and leaving two firefighters to continue pushing forward, which they would not have been able to do if they were using 2½-inch hose. Exhausted from the heat and the smoke in a now untenable hallway, and almost out of air, E37 had to retreat back to the stairway landing.

The IC opted for a transitional attack, defensive to offensive. Interesting to note, it was made using one 1¾-inch handline operating off the tip of the aerial, spraying a straight stream into the unit using a combination nozzle. According to the fire chief, 335 firefighters had the fire out in 79 minutes. This fire also demonstrates why transitional attacks should be considered sooner rather than later.

After-Action REVIEW

IN SUMMARY

- A high-rise apartment or office building is a complex environment that presents several difficult challenges for firefighters to overcome when it is on fire. The primary goal is still to put the fire out quickly.
- High-rise fires are not quick incidents. They can last from hours to days, and they physically wear out crews.
- Without ground-level access and the ability to ventilate a high-rise fire quickly, intense sustained heat quickly fatigues firefighters during interior operations.
- Frequent rotation of crews helps prevent heat exhaustion.
- Elevation affects the physical stamina of firefighters and creates possible water pressure and supply problems.
- The secrets to success in fighting fires in high-rise buildings are prefire planning, consulting with the building or maintenance engineer, developing a prefire plan, and following the IC high-rise fire checklist.
- The first thing the company officer needs to determine when arriving at a high-rise fire is the location of the fire or the location of the fire alarm activation. Everything hinges on this information.
- Occupants who are self-evacuating can be anywhere, and stairways could be congested with hundreds of people.
- SER is a shift in the traditional term of (SAR) in high-rise firefighting because evacuation may be the next critical task related to the search that isn't a factor in other types of structural firefighting.
- The initial IC must gain control of the HVAC system, the elevators, and other building systems.
- The initial IC needs to decide where to place the first hose line. Due to the lack of ground operations and aerial access, the primary strategy for high-rise firefighting is a direct frontal attack with enough water to overwhelm the fire.
- One of the most dangerous situations created during the fire attack is the sudden change of conditions inside the firefighting stairway above the fire floor.
- The main strategy for SAR is defend in place, or shelter in place. This strategy for life safety in residential and commercial high-rise buildings means that the residents or occupants are safer staying in their units or work areas than they are trying to evacuate the building where the hallways and stairs can be charged with heat, smoke and CO.
- Wind is a major factor in firefighting operations. Wind can create unpredictable air currents and uncontrolled movement of smoke, leading to fire spread. Thus, ventilation usually takes place after the fire has been controlled or extinguished.
- A wind-driven fire can be a major problem when the exterior windows of a high-rise building fail. This can also lead to autoexposure: the lapping of flames to the floor above.
- The lack of ventilation creates the greatest physical stressor that firefighters must confront in high-rise firefighting: heat.
- The risk of injuries and death for firefighters is always greater in buildings that are not sprinklered.
- High-rise buildings without sprinkler systems require a massive amount of staffing and resources, and high-endurance efforts made by firefighters.
- After the fire has been knocked down and extinguished, efforts should be shifted immediately to ventilation, primary searches that weren't possible, and secondary searches.
- Unpredictable air currents are dangerous when there is a thermal threat of spreading the fire, but once the fire is out, crews can deal effectively with unpredictable air movement of residual smoke with relative safety.

KEY TERMS

approach assessment Part of the size-up, it includes a 360-degree assessment to view exterior conditions and as many sides of the building as possible while the apparatus is approaching the scene.

fire tower An enclosed stairway connected at each story by an outside balcony or a fireproof vestibule vented to the outside.

flow the floor The process of wetting down the entire exposure floor above the fire to prevent vertical fire spread.

plenum The space between the structural ceiling and the dropped ceiling of a floor/ceiling assembly; the underside of the floor above. It houses and conceals telecommunications cables for telephone and computer networks, and supports and conceals air ducts of the HVAC system.

rapid ascent team (RAT) A search team designated to quickly climb the entire firefighting stairway to ensure it is clear of any occupants fleeing from the fire floor landings.

shelter in place The strategy for life safety in residential and commercial high-rise buildings. Residents or occupants are safer staying in their units or work areas than trying to evacuate the building where the hallways and stairs can be charged with heat, smoke, and carbon monoxide.

stack effect The vertical air flow within high-rise buildings caused by the temperature-created density differences between the building interior and exterior, or between two interior spaces. (NFPA 92)

transitional ventilation From a pressurized stairway, smoke on a floor is directed horizontally to a nonpressurized stairway where the pressure differential causes the smoke to transition to vertical ventilation out through the rooftop portal.

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