High-Rise Buildings

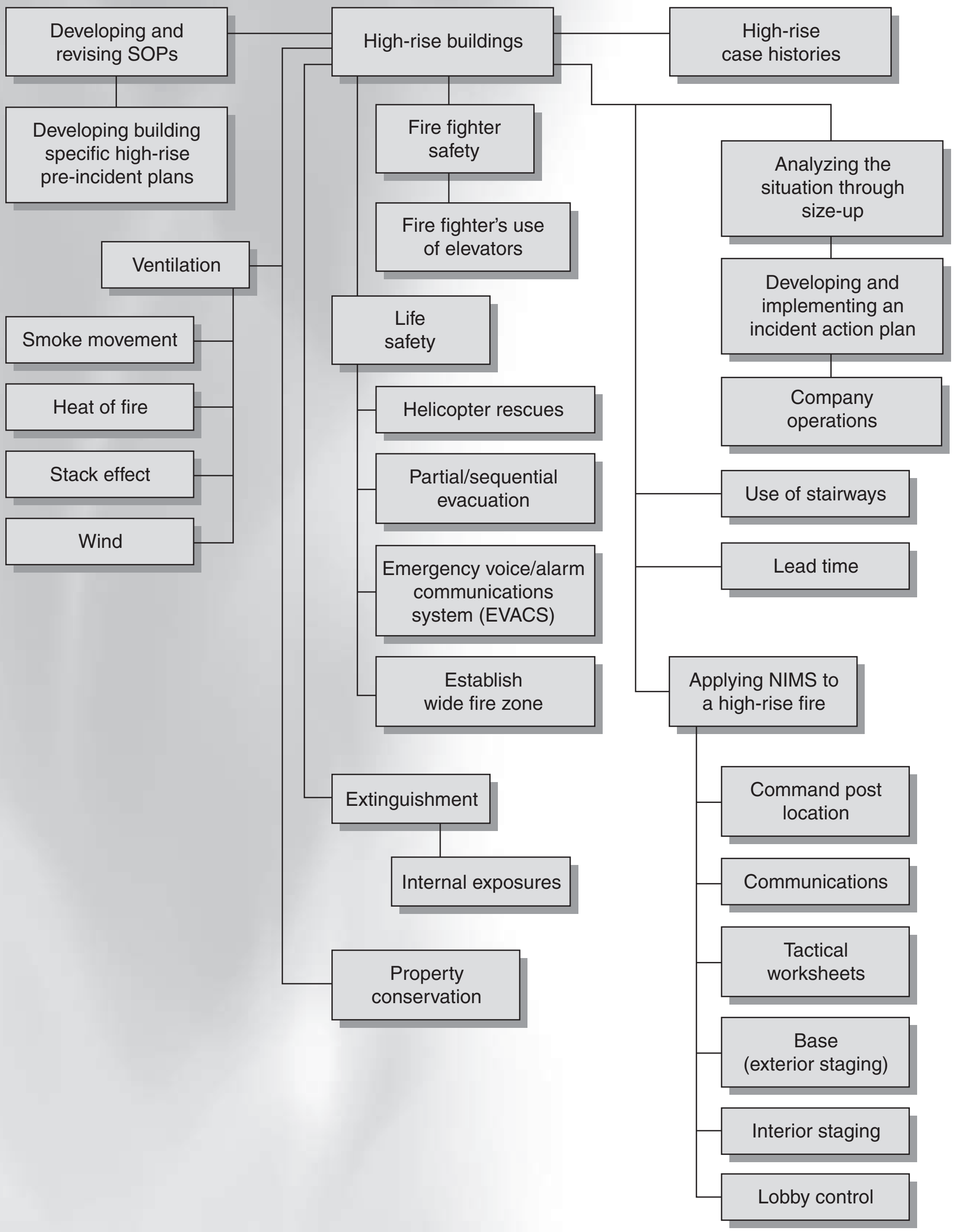

Figure 12-1 Chapter 12 learning chart.

Chapter 12

Learning Objectives

- Describe the magnitude of the high-rise fire problem in terms of number of fires, number of fire fatalities, and property loss.
- Explain the effect the loss of life and property at the World Trade Center on September 11, 2001 has on the statistical analysis of high-rise fires in relation to loss of life and property in high-rise buildings.
- Define a high-rise building from a fire department perspective.
- Explain elevator recall and its advantages during a fire emergency.
- Enumerate the responsibilities of lobby control.
- Explain why using an elevator during a fire emergency is a calculated risk.
- List and discuss the seven rules for safety when using an elevator during a high-rise structure fire.
- Describe the process of using an elevator under fire department control.
- Explain the duties of stairway support and when it should be used.
- Compute the number of fire fighters needed to staff stairway support for a fire on the 30th floor of a high-rise building where the elevators are unsafe to use.
- Identify negative and positive aspects of using helicopters at a high-rise building fire.
- Construct a chart showing the angle of deflection for fire streams operated from the exterior into an upper floor of a high-rise building.
- Compute the approximate pump discharge pressure needed to supply a hose stream operating on the 20th floor.
- Explain when the command post should be located in the lobby, outside the building, or at a remote location.
- List four occupancy types that are commonly found in high-rise buildings.
- List five special considerations when developing a pre-plan for a high-rise building.
- Compare old-style tower construction to modern, planar-style high-rise buildings.
- Define and explain the advantages of a smoke-proof tower.
- Discuss methods that can be used to maximize the limited stairway capacity in a high-rise building and how fire department operations can hinder evacuation.
- Describe an EVAC system and identify the advantages and disadvantages as compared with other notification systems.
- Explain the difficulties in determining the location of the fire from the exterior of a high-rise building.
- Develop a high-rise decision tree with decision points addressing fire location, size, and elevator availability.
- Explain how heat affects smoke movement in a high-rise building.
- Define stack effect and explain the conditions necessary for positive and negative stack effect.
- Explain how wind affects the neutral pressure plane.
- Discuss the importance of extinguishment to life safety in a high-rise fire.
- Explain what is meant by a “wrap-around” fire.
- Describe the hazards involved in ventilating upper floors by removing window glass and how to protect fire fighters and civilians on the street below.
- List pathways for floor-to-floor fire extension in a high-rise building.
- Define “lead time” and extrapolate the estimated lead time for a fire on the 40th floor of a high-rise building when elevators are unavailable.
- List practical forms of non-radio communication that can be used at a high-rise building fire.

Learning Objectives, continued

- Discuss when interior and exterior staging would be used at a high-rise fire.
- List the duties of the interior staging officer.
- List the duties of lobby control.
- Compare and contrast factors that affected fire operations at the One Meridian Plaza fire in Philadelphia and at the First Interstate Bank Building fire in Los Angeles.
- Evaluate the number of possible fire deaths in a high-rise building at the Peachtree Plaza fire in Atlanta based on the number of actual civilian fire deaths and probable deaths had the fire been on a higher floor.
- Explain the negative effects of operating an exterior stream into a high-rise building.
- Compare the designed "accidental aircraft" impact at the World Trade Center to the actual impact of the aircraft on September 11, 2001.
- Describe the conditions leading to structural collapse at the World Trade Center.
- Describe how a "convergence cluster" could affect search-and-rescue operations at a high-rise building.
- Evaluate operations at a simulated high-rise fire in your response area.
- Size-up, develop an incident action plan, assign units to carry out the plan, and develop a NIMS organization for a simulated high-rise fire scenario.

Introduction

The basic tactics and strategic objectives used in high-rise firefighting are the same as those that apply to any other structure fire, but with special considerations because of the height of the building. The differences are great enough to deserve this separate chapter.

Table 12-1 shows the average number of high-rise fires, as well as the average annual loss of life and property in high-rise buildings for the period 1985 to 2002,[1] which provides a good indication of the magnitude of the problem. As can be seen in Table 12-1, the September 11, 2001, attack on the World Trade Center skews the statistical analysis. The World Trade Center bombings in 1993 and attack in 2001 are not typical high-rise fire situations. But this is the nature of the high-rise problem. There are often intervals of several years between major loss-of-life or large property-loss fires in high-rise buildings in the United States, but the potential always exists. The overall number of fires, civilian fire deaths, and property loss seems to be trending downward. This is probably due to more high-rise buildings being sprinkler protected. In the mid-1970s, most jurisdictions required new high-rise buildings to be sprinkler protected, but very few required existing buildings to be retrofitted. The World Trade Center was fully sprinkler protected, but the system was severely damaged on impact, and the jet fuel provided a fire load beyond the design capacity of the system.[2] There is absolutely no doubt that a sprinkler-protected building is a safer building for fire fighters and occupants; however, fire departments should not place total reliance on the sprinkler system.

High-rise fires represent an extraordinary challenge to fire departments and are some of the most challenging incidents a fire department encounters. High-rise buildings can hold thousands of people well above the reach of fire department aerial devices, and the chance of rescuing victims from the exterior is near zero once the fire is above the operational reach of aerial ladders or elevating platforms.

Case histories provide an excellent way of learning. By studying past fires, it is possible to gain experience that may not be gained in any other way. Outside of New York, Los Angeles, Chicago, and a few other very large cities, not many chiefs experience enough working high-rise fires to gain confidence in managing such incidents. Communities with one or two high-rise buildings may never experience a serious fire, yet the fire department is expected to be prepared if a high-rise fire occurs. For this reason, several high-rise fires are discussed at the end of this chapter. Studying these and other high-rise fire case studies is strongly recommended.

Figure 12-1 is a learning chart showing the topics in this chapter. It also represents a logical method of first planning for high-rise fires in your jurisdiction, and then handling an incident in a safe and effective manner. This chapter ends with a discussion of a few notable high-rise fires and the lessons that have been learned from each.

Developing and Revising High-Rise Standard Operating Procedures

Pre-incident planning and code enforcement can reduce the scope of the high-rise problem. However, special tactics will be needed to control fire forces working in different areas within these large structures while providing the necessary logistical support. Using the national incident management system (NIMS) and developing high-rise SOPs can do much to ensure successful operations.

A difference of opinion exists as to the definition of a high-rise building. Most codes define the high-rise building in terms of height and/or stories. Fire departments tend to think of a high-rise building as being beyond the reach of the aerial fire equipment available to them. Since the focus of this text is on fire-ground tactics, the fire department definition is most appropriate. However, do not forget the obvious; an eight-story building will not present the same challenges as an 80-story high-rise building. Logistics and access problems increase with height. The more floors that are located above the fire, the more people are likely to

TABLE 12-1 High-Rise Fires 1985–2002

Annual Average*	Including World Trade Center*	Without World Trade Center*
Number of high-rise fires	22,171	22,171
Number of civilian fire deaths	244	91
Property loss	$2,230,000,000	$372,000,000

*Note: These numbers are annual averages over 18 years, not exact numbers per year.

need fire department assistance, and the more fuel there is to burn.

High-rise buildings were once found exclusively in larger cities, but today they are commonly found in small and mid-sized communities as well. In most cases high-rise buildings in these smaller communities are newer, lower in height, and protected by automatic sprinkler systems. Even if your department does not respond to a high-rise building at present, if urban sprawl continues as expected, it probably will in the future. If you have a mutual aid contract with a jurisdiction that contains high-rise buildings, they are likely to need your help in combating a working high-rise fire. Several larger cities that once contained just a few notable high-rise structures have experienced an incredible growth in high-rise construction. Given the special problems that these buildings present, each department that could reasonably be expected to respond to a high-rise fire should have a high-rise SOP and train accordingly.

Fire Fighter Safety

The risk to fire fighters and occupants increases in proportion to the height of the building and the height of the fire above grade level. Once fire fighters are operating above the reach of aerial devices, the only viable means of egress is the interior stairs; extra protection afforded by laddering the building is not possible.

Good tactics and fire fighter safety cannot be separated. The tactics that are explained throughout this chapter improve fire fighter safety. The safety considerations that were discussed in Chapter 5 apply to high-rise firefighting, but additional safety measures need to be taken during a high-rise operation.

It is common knowledge that occupants should not use elevators to escape a high-rise fire except under special circumstances, and then only under fire department supervision. For this reason, many modern building elevators have fire department controls. When the alarm system is activated, the elevators return to the ground floor and remain there for use by the fire department. Older buildings may have fire department controls but may not have the feature that automatically returns elevators back to the ground level.

Elevator recall is a safety feature that is designed to send elevators to ground level when the fire alarm is activated. Elevators then remain locked out at ground level until fire fighters arrive and use a key to place the elevator on fire department service.

Case Summary

A fire on May 4, 1988, in the First Interstate Bank Building in Los Angeles destroyed four floors in a 62-story building. The fire required a total of 64 fire companies and 383 fire fighters; it took 3½ hours to control. Despite the magnitude of this fire, only one person was killed: a maintenance worker who took an elevator to the fire floor to investigate the alarm.

Source: Thomas J. Klem, *First Interstate Bank Building Fire, Los Angeles, California, Fire Investigation Report.* Quincy, MA: NFPA.

Figure CS12-1 The fire at the First Interstate Bank Building.

A responsibility of **lobby control** is to control, operate, and account for all elevators. Some fire service professionals say that elevators should never be used under fire conditions or suspected fire conditions until their safety can be verified from the fire floor. This may not be practical in situations where fire companies respond to alarms in high-rise buildings several times each day. Requiring fire fighters to ascend 20 flights of steps to check an odor of smoke is not a productive use of resources. A more reasonable approach is to develop procedures and conduct training to reinforce the safe use of elevators.

Fire Fighters' Use of Elevators

A critical variable in high-rise fire operations is the availability of reliable elevators. If fire fighters can safely use the elevators, fire-ground logistics are dramatically improved. When the fire is located many floors above ground level, there is a strong inclination to use the elevators. However, elevators often stall or act erratically under fire conditions. Fire fighters who are trapped in a stalled elevator become part of the problem, as other fire fighters are then needed to rescue the rescuers. Therefore, the department SOPs should address the safe use of elevators, including circumstances in which it is unsafe for fire fighters to use them. These procedures should include alternative measures for getting needed equipment to the fire floor when elevators cannot be safely used. Fire department service controls and other elevator safety features will vary by age and elevator manufacturer. Building pre-plans should include information and instructions for using the elevator system.

One of the dangers in using elevators is that the doors may open on the fire floor, exposing fire fighters on the elevator to smoke and heat before they are in position with hose lines to attack the fire. Once elevator doors open on the fire floor, sensing devices (electric eyes, etc.) may prevent the doors from closing, thus trapping the fire fighters. This is a potentially deadly mistake that should be avoided at all costs. If fire fighters are caught in this situation, they may be able to use an override switch to force the doors to close. If not, they may be forced to exit the elevator in an attempt to escape the fire floor via the stairway. Similarly, elevators can stall in the shaft at or above the fire floor, also trapping fire fighters in the elevator car. Fire fighters should never, under any circumstances, use an elevator if there is a chance that the elevator will travel to or above the fire floor. This is another, possibly fatal, mistake.

Elevators are equipped with redundant safety systems to prevent them from falling. In many cases, an elevator car has to be nearly destroyed before it will fall. The elevator shaft is a fire-protected enclosure, but a fire of sufficient intensity can invade the shaft, and smoke and toxic gases will certainly enter elevators that are stalled above the fire floor. This could prove deadly for fire fighters, who should be fully equipped with personal protective clothing, including self-contained breathing apparatus

Using elevators during a fire emergency is a calculated risk.

Case Summary

On April 11, 1996, a fire occurred on the ground floor in the airport terminal in Düsseldorf, Germany. It spread rapidly throughout the area and into the upper levels. Several people standing on the roof of the adjacent parking garage observed the smoke and decided to use the elevator to exit the garage. Unfortunately, the elevator opened into the fire area on the ground floor of the terminal. The smoke obscured the electric eye on the elevator door, so it could not be closed. Seven people died in this elevator. Ten others were killed throughout the terminal.

Source: Edward R. Comeau, *Düsseldorf Airport Terminal Fire*, NFPA Fire Investigation Report. Quincy, MA: NFPA.

Figure CS12-2 The elevator that brought seven people to the ground floor opened directly into the fire area, trapping and killing them.

(SCBA). Civilians without protective gear have even less chance of survival when trapped in an elevator on or above the fire floor. Maintenance and security people should never be taken into the elevator until it has been verified that the elevator is completely safe.

The first rule of elevator safety is to avoid the use of elevators unless they will substantially improve operations. Fires on lower floors do not warrant the use of an elevator unless someone on the fire floor can verify its safe use. The first-arriving companies should use the stairways for fires on lower levels. Department SOPs and pre-incident plans must address this issue specifically. Once the safety of an elevator has been established, then fire fighters can use it under the close supervision of lobby control. Two other factors to be considered are fire separations between the elevator bank and fire location and whether the elevator goes to or above the fire floor.

High-zone/low-zone (split bank) elevators are not uncommon, and some split bank elevators are divided into several zones. For example, a three-zone bank of elevators would have one bank serving lower floors only, another bank serving only the middle floors, and a third bank providing access to upper floors only. This is important information that should be included in the pre-incident plan. For example, for a confirmed fire on the 10th floor, it is fairly safe to use elevators that terminate at the eighth floor **Figure 12-2**.

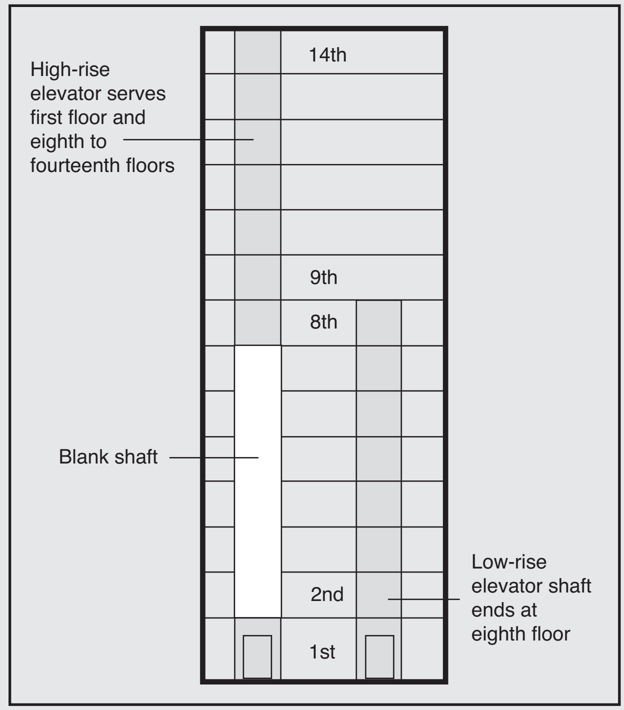

Figure 12-2 Split bank elevators with upper and lower zones.

When there is a fire separation between the elevators and the fire area, it may be possible to safely use the elevators in another building zone and then travel horizontally to the fire. This approach is much easier than ascending the stairs. Large high-rise buildings, especially hospitals, often have building zones. Fire walls and fire doors create a horizontal barrier to smoke and heat from the fire. Hospital patients are usually moved horizontally to another zone, rather than taken down to the ground floor or evacuated from the building. If another building zone is safe for the patients, it should certainly be safe for fire fighters.

When separate low-zone/high-zone elevators are unavailable or the building is not adequately zoned horizontally and the fire is on the upper stories of the building, extreme caution should be used if the IC decides to use elevators to transport fire fighters.

Listed below are several rules that should be observed in taking the calculated risk of using an elevator during a fire situation. These rules for elevator safety should be considered when writing department high-rise SOPs.

1. *Do not use an elevator of questionable safety or for a fire on a lower level*. Elevators should not be used for fires on lower floors in the building or if there is any doubt about the safety of the elevator.
2. *Never take an elevator directly to the fire floor or above*. This is the cardinal rule of elevator safety and must be rigidly enforced. Department SOPs should state that the elevator should be taken to two floors or more below the fire, and then fire fighters should walk up the stairways to the fire floor. This rule also applies to split bank elevators that do not travel to the fire floor. If split bank elevators are available, use an elevator that does not travel to or above the fire floor. Again, exit the elevator at least two floors below the fire and use the stairway to reach the fire floor.
3. *Place the elevators under independent (fire department) control*. Keys should be made available to the fire department so that elevators can be placed under independent control. Newer elevators cannot be operated without a key once the fire alarm has sounded. This independent control greatly increases fire fighter and civilian safety, as the elevator will not be responding to calls from occupants.
4. *Control all elevator cars in multiple hoistways*. This not only provides the fire department access to upper

floors, but also prevents erratic response to other calls within the building. Controlling elevators is a responsibility of lobby control.

5. *Never overcrowd elevators*. This is doubly important for fire fighters, not only because it is unsafe to exceed the weight limit on an elevator, but also because fire fighters may need space to don SCBA or to use tools to force their way out of the elevator.
6. *Wear personal protective clothing, including SCBA, and bring forcible entry tools*. Air supply should be conserved by not donning the SCBA facepiece or connecting the breathing hose until approaching the fire area or when conditions indicate the need to be on air. Never forget that using an elevator is taking a calculated risk. Even when every reasonable precaution is taken, what lies at the top of the ascent is unknown. Forcible entry tools must be available to escape the elevator if necessary. Understanding elevator door operations can be extremely valuable if personnel become trapped in an elevator that stalls. In trying to escape a stalled elevator, always activate the emergency stop switch. Opening an emergency escape door or ceiling panel should also stop the elevator, as the interlocks are designed to prevent accidental movement when people are trying to escape.
7. *Send equipment rather than fire fighters on elevators*. Many times elevators that are considered unsafe for fire fighters can be used to transport tools and equipment to the interior staging area (usually two or more floors below the fire floor). Fire fighters can then safely ascend the stairs without the burden of heavy tools and equipment. It is not always possible to send an unstaffed elevator to a desired floor. When the fire alarm is activated it may be necessary to mount the elevator and hold a floor button or elevator key before the elevator will move. If this is the case, equipment cannot be sent above without a fire fighter. Freight elevators are usually less safe than passenger elevators, but they may be suitable for sending equipment above without placing fire fighters in the elevator car.

When ascending in an elevator, it is good practice to stop periodically, possibly every five floors, to check for smoke. This is accomplished by opening the top elevator escape panel and using a flashlight to see whether smoke is present in the shaft. This is also a test of the elevator's ability to stop on demand. It is further recommended that fire fighters stop the elevator three or more floors below the fire floor, step out into the hallway, and check the general floor arrangement to get a feel for the building layout. By examining an uninvolved floor, fire fighters can become familiar with landmarks and can quickly identify the location of secondary exits, floor configurations, and potential ventilation locations. The first and second floors are generally not typical floor layouts; therefore, it is better to check an upper floor that will likely be similar to the fire floor. Many high-rise office buildings have floor layouts that resemble a maze, making it very easy for a fire fighter to become disoriented and lost. Therefore, fire fighters should constantly ask themselves, "Where am I in relation to the stairways and elevators?"

The IC must always conduct a careful risk-versus-benefit analysis before placing fire fighters in an elevator. Furthermore, there is seldom justification for placing civilians in elevators before the fire is completely extinguished and the smoke is ventilated from the building. SOPs regarding the use of elevators should be kept current, and all fire fighters should be thoroughly familiar with them. These procedures should consider the height of buildings in your jurisdiction, automatic fire suppression equipment, type of occupancy, and the safety considerations outlined in this text.

Stairway Support

How do fire fighters, air cylinders, hoses, nozzles, first aid supplies, and forcible entry tools get to the fire floor? The easiest way is to use the elevator. What if it is not safe to use the elevator? As was previously discussed, many times elevators are out of service or unsafe to use. Moving supplies and staff up 10, 20, 30, or more stories is an arduous task. If it is not properly managed, no one will reach the fire floor with the physical stamina necessary to fight the fire. Imagine returning to the apparatus for a fresh air tank from the top floor of the 1454′ (443-m), 110-story Sears Tower in Chicago. When elevators cannot be used, gaining access to the upper floors of a building will take significant time. Getting fire fighters and equipment to an interior staging area will considerably reduce lead time for supporting a high-rise fire operation.

Stairway support is a procedure that is used to move supplies to the interior staging area when using elevators is not a safe option. Fire fighters

Stairway support places one or more fire fighters on every other floor to shuttle equipment up through the building to an interior staging area or resource floor.

Fallacy	Fact
Stairway support conducts a primary search of the stairways.	Stairway support moves equipment from the ground floor to the interior staging area.

Interior staging is set up in a safe area two or more floors below the fire floor when it is impractical for fire fighters to go outside at ground level to change SCBA cylinders and for rest and recuperation (REHAB).

assigned to stairway support ascend two stories with air cylinders and other equipment, where the next fire fighter picks up the equipment and relays it two additional floors. After moving the equipment up two stories, fire fighters descend two stories empty-handed, providing a rest period. During extended operations involving many companies in rescue and suppression activities, it may be necessary to place two fire fighters on every other floor or possibly recycle air cylinders to grade level for refill.

Moving equipment up through the building with the elevators out of service is a mammoth undertaking, but stairway support provides a reasonable alternative. Depending on conditions in the stairway, it may be possible to allow members who are assigned to stairway support to work without their SCBA and turnout gear. This will preserve their energy and allow them to transport more equipment faster. For example, experience indicates that wearing rubber boots while ascending the stairs is particularly fatiguing. However, always err on the side of caution. If there is any chance that members assigned to stairway support will encounter smoke or other hazardous conditions, they should be required to wear appropriate protective equipment. Stairway support should be one of the first assignments given when the fire is on the upper floors in a building without elevator service. Stairway support should be explained in the department's high-rise SOP.

Life Safety

As search-and-rescue teams proceed with a systematic search, they must provide status reports to their supervisor and mark areas that have been searched. A simple marking system is placing a chalk "X" on doors to rooms that have been searched and/or indicating that the whole floor has been searched by marking hallway doors or walls opposite the elevator. Door hangers or other marking devices are commercially available for this purpose as well. A method of indicating areas searched should be part of the department's high-rise SOP.

Many high-rise buildings lock the doors from the stairs to the hallway, further complicating search-and-rescue efforts. This was a major factor in the loss of life at the Cook County Administration Building fire in Chicago, Illinois,[3] where occupants encountered fire on the 12th floor while attempting to escape. Fleeing occupants then attempted to re-enter floors above the fire, where doors leading to the hallway were locked on the stairway side. Forcible entry tools should be carried by rescue and extinguishment teams to force entry when necessary. When selecting the tools to carry, remember that power saws might not operate because of heavy smoke conditions. Further, using gasoline-powered equipment inside of a building can create other hazards if the area is not adequately ventilated.

Once doors have been opened, it is important to prevent them from relocking behind fire fighters entering the floor. Some departments use a piece of rubber with two holes that cover the doorknob and lock to prevent the door from relocking. For most door types this method works very well. During pre-incident planning, examine the doors to determine which method would work best for the style(s) of doors in that building. However, whatever method you decide to use, be careful not to leave doors propped open, as this will most certainly allow smoke to move from the stairs into the hallway or from the fire floor into the stairs.

The primary search should also include a search of all elevators. Elevators should be brought down to the ground level and checked by lobby control. If elevators are stalled or otherwise located above the ground floor, they must be checked for victims. It is essential that all elevators be accounted for and checked for occupants.

Rescuing and Evacuating Occupants

Helicopter Rescues

There have been occasions when helicopters were successfully used to rescue occupants during high-rise fires. **Figure 12-3** shows a helicopter rescue operation in progress at the MGM Grand fire in Las Vegas. However, helicopter rescues are extremely dangerous and, in most cases, unnecessary. Few instances warrant the use of a helicopter in removing occupants from a roof, and many roofs make poor helicopter landing zones. A few fire departments have developed

Figure 12-3 MGM Grand helicopter rescues.

programs that use helicopters to place fire fighters on roofs, sometimes by having them rappel from the helicopter to the roof. Fire fighters placed on the roof can calm the occupants and protect the area from fire, and they can also descend to areas that are inaccessible from below.

These programs have merit, but require constant training on the part of the rappel team and the helicopter crews. At last count, New York City had 32 buildings over 600′ (183 m) in height. New York and other very large cities can no doubt justify the training and associated expenses related to such a program. However, the need or justification for such a program is doubtful for a department with only a few well-protected high-rise buildings within their response area. It is unlikely that members of such a department would have the expertise or equipment needed to safely operate from helicopters.

Helicopters can sometimes be used for reconnaissance. An aerial view can provide information that is not available from the interior or the exterior at ground level. At the World Trade Center on September 11, 2001,[2] police in helicopters could see signs of an impending structural collapse. Unfortunately, they were unable to communicate this message to the fire department.

Helicopter operations above a burning building can actually create additional risks owing to the thermal updraft. Helicopters flying near a burning building can create high winds that negatively affect operations. Remember, as when considering any tactic, before deciding to use helicopters to assist fire fighters or occupants or for reconnaissance, always conduct a risk-versus-benefit analysis. Is the risk to occupants, fire fighters, and the helicopter crew warranted? Or, could other less risky methods be used?

Partial or Sequential Evacuation

A decision for partial or sequential evacuation can be made in advance of a fire and incorporated into the alarm system. Alternately, the IC may make this decision at the time of the fire. When the fire is small or smoke has entered the stairway, the IC may decide that it would be best to leave occupants in their rooms rather than attempting a complete evacuation. A defend-in-place tactic places a great burden on the IC, as a successful outcome depends on the fire being promptly extinguished. However, many times occupants are placed in greater danger by attempting to evacuate them through smoke, using resources that could have been assigned to extinguishment duties.

If the fire is not quickly controlled, the people who are left in the building will be in great danger because of the non-evacuation decision. Much of this decision-making process has to do with fixed fire protection features that are designed into the building. For example, there is less risk associated with the non-evacuation decision if the building is sprinkler-protected.

Many departments permit the use of alarm systems that advise only the occupants in affected areas to evacuate the building. Rather than sounding a general alarm throughout the building, the evacuation alarm may sound only on the fire floor, one floor above, and one floor below. Occupants on the other floors may receive a pre-alarm notification advising them to remain on the floor until further notification.

Any time a decision is made to leave occupants inside a burning building, the IC is taking a calculated risk. However, pre-incident plan information along with accurate, timely, and continuous status reports will provide the IC with the information necessary to make the correct decision.

This evacuation tactic reduces stairway traffic but also leaves occupants inside the building. Use of a partial or sequential evacuation system requires a sophisticated fire alarm system and/or manual control. The IC should have pre-incident plan information about the operation of the system readily available at the command post.

Relying on building management or security to notify occupants of the need to evacuate is generally a mistake. Maintenance or security people have a propensity to investigate alarms first, thus delaying notification of the fire department. This has been the case in many deadly high-rise fires, such as the First Interstate Bank Building in Los Angeles and One Meridian Plaza in Philadelphia. When a fire is discovered, many times in-house employees are not properly trained in how to initiate a safe, orderly evacuation. The answer lies in requiring direct and immediate fire department notification, regardless of the type of internal alarm system or method of evacuation.

Whenever occupants are left in the structure, the IC is depending on the construction features, fixed fire suppression systems, or manual suppression efforts to confine the fire and ventilate the smoke and toxic gases.

Emergency Voice/Alarm Communications System (EVACS)

Many high-rise buildings are equipped with an emergency voice/alarm communications system (EVACS). The EVACS uses recorded messages to notify occupants of a fire and provides specific directions for reaching places of safe refuge within the building. The EVACS sometimes directs people above the fire to higher floors within the structure, avoiding the need to pass the fire floor. People on the fire floor and the floor below are directed to an area two or three floors below the fire or to evacuate to the outside. When occupants are sent to other floors within the building, the occupants on the receiving floors are also notified of the evacuation. The EVACS notifies people on elevators that the elevator is responding to the ground floor, where they are to exit. By directing occupants away from the immediate fire area soon after the fire is detected, the EVACS helps to solve many high-rise evacuation problems.

Because a fire scenario presents many uncontrolled variables, caution is in order when using any automated system such as the EVACS. Stairways that would be perfectly safe if the fire were to occur in one floor area might not be safe in another circumstance. All evacuation variables should be thought out in advance, and a manual backup system must be in place. The EVACS will generally have manual overrides that allow fire fighters or building management to direct the evacuation. Manual directions could include which occupants are to evacuate and the stairway(s) to use. Most of these systems can limit notification to occupants on specific floors or notify all of the building's occupants. Sequential evacuation may be best to reduce stairway congestion. If fire companies are using a stairway to attack the fire, it is best to direct evacuating occupants to other stairways.

At the Cook County Administration Building fire in Chicago, Illinois,[3] security unintentionally notified all building occupants to evacuate; the evacuation message was intended for the fire floor only. In this case, the fire department was criticized for not using the internal communications system to notify occupants to avoid the stairway where fire operations were taking place in favor of the stairway on the opposite side of the building. However, occupants will often disregard verbal instructions, which was the case at the Cook County Administration Building fire, where many occupants ignored instructions to use the stairs and instead used the elevators. Another example is the World Trade Center, where occupants were trained to sequentially evacuate the building. When aircraft struck the buildings, many occupants self-evacuated and ignored the EVACS as well as what they had been taught during training.[2] In this instance, the decision to ignore the system proved to be the best decision, as a sequential evacuation would have resulted in more people being in the buildings when they collapsed.

Reliance on the EVACS should be limited to compartmentalized buildings with full sprinkler system coverage. If the sprinkler system fails to control the fire and fire forces are unable to quickly extinguish or confine the fire, all occupants above the fire floor should be evacuated. Further, the IC and lobby control officer should have a thorough knowledge of the EVACS.

Extinguishment

What makes high-rise firefighting different? In the lower portions of the building, the main difference is the exposure of many stories above the fire to vertical fire spread. Above the eighth floor most exterior defensive fire control tools

Case Summary

A New York City high-rise fire occurred in a 10-story apartment building. The fire started in an apartment on the 10th floor, and three fire fighters were killed during firefighting operations. Another fire occurred in an apartment in a 51-story high-rise building in Manhattan. Four civilians were killed in this fire. All of the fatalities were remote from the fire and occurred when the victims were overcome while trying to exit the upper stories.

Source: Robert Duval and Robert Solomon. Unpublished NFPA Fire Investigation Report. Quincy, MA: NFPA.

are no longer effective. Elevated streams can sometimes reach the fire floor, but the angle of deflection inside the window diminishes with each floor above the maximum height of the appliance. To improve fire stream penetration, it is necessary to move the nozzle further away from the building, thus reducing the angle of deflection. In most cases the width of the street is the limiting factor in determining how far away the appliance can be placed from the building. If the width of the street is not a limiting factor, the effective reach of the nozzle will determine the maximum distance the nozzle can be placed from the building. At the Cook County Administration Building fire in Chicago, Illinois, an elevated master stream was used to control a fire on the 12th floor; however, a delay occurred while the apparatus was repositioned.[3] In operating above the eighth floor, it is unlikely that ground-based appliances will deliver effective stream penetration to the fire area **Figure 12-4**. Furthermore, operating an exterior master stream into a building can push the fire into unburned areas, endangering fire fighters and civilians who are in the building. This is true in any building, but the danger is much greater in a high rise due to the size of the building and the possibility of pushing the fire into hallways or stairways and involving more than one floor. Above the eighth floor, the occupants are also beyond the reach of elevating platforms, aerial ladders, and ground ladders; therefore, attempting an exterior rescue would be extremely dangerous for both fire fighters and occupants. In fact, the building's stairways are the best means of egress, even when floors are within the reach of aerials. For these reasons, it is extremely important that fire forces prevent fire extension into the stairways, because stairways are the safest and most effective egress routes.

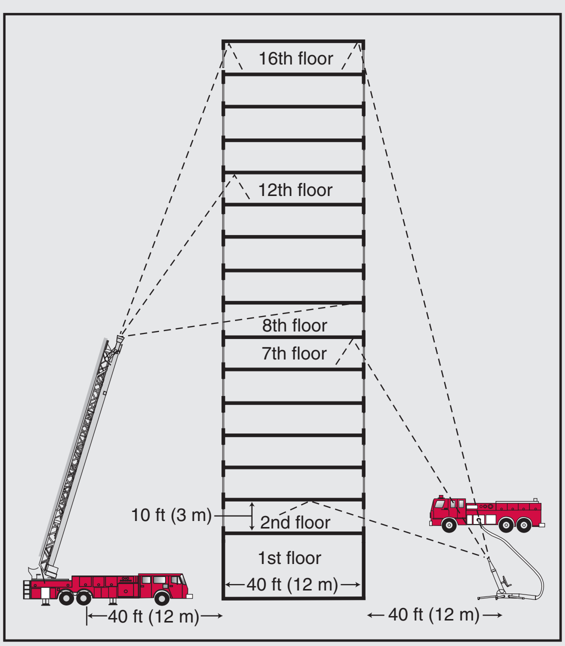

Figure 12-4 Stream deflection.

In Chapter 7, we discussed standpipe operations including pressure- or flow-reducing valves. Generally speaking, the pressure at the standpipe discharge will be lower than the pump discharge pressure used to supply hose streams connected to the pumper. Departments compensate for the lower pressure by using smooth-bore or low-pressure nozzles. Some departments have purchased hose that has less friction loss, or they use 2½″ (64-mm) hose for standpipe operations. Any method of reducing the friction loss in the hose will increase the nozzle pressure. However, 2½″ (64-mm) hose is more difficult to handle in small areas. As discussed in Chapter 8, flow requirements are lower in smaller rooms; therefore, 2½″ (64-mm) hose may not be the best choice in buildings subdivided into small compartments.

Taller buildings will tend to have pressure-reducing valves; however, not all high-rise buildings are equipped with these pressure-reducing or flow-reducing devices. If a building is not equipped with pressure-reducing valves, the pressure on the lower floors of the building will be higher than the pressure on the top floors. It is also possible to increase the pressure in the standpipe system by pumping into the fire department connection. Pumping into the fire department connection may be an effective means of boosting the pressure and increasing the water supply. Very high buildings have complex water supply systems, and pumping into the fire department connection may not increase pressure at the standpipe outlet. In these buildings, fire department pumpers alone cannot supply sufficient pressure for firefighting on upper floors, and the building's internal fire pumps must provide primary pressure.

Although the ceiling height of individual floors will vary in high-rise buildings, a fair estimate for the floor-to-ceiling height is allowing 20′ (6 m) for the first floor and 10′ (3 m) or more for each additional floor.

The loss of pressure due to gravity (elevation) is 0.434 psi per foot (3 kPa/305 mm). The pressure loss for a hose line operating at the top floor of a 40-story building with 10′ (3-m) floors would be calculated as follows:

First floor = 20′ (6 m)
39 floors × 10′ (3 m)/floor = 390′ (117 m)
Total elevation: 410′ (123 m)
410′ × 0.434 psi/ft = 178 psi elevation loss
(123,000 mm/305 mm × 3 kPa = 1210 kPa)

If the floor height is changed to 12′ (3.7 m), then the pressure loss would be

First floor = 20′ (6 m)
39 floors × 12′ (3.7 m)/floor = 468′ (144 m)
Total elevation: 488′ (150 m)
488′ × 0.434 psi/ft = 212 psi elevation loss
(150,000 mm/305 mm × 3 kPa = 1475 kPa)

In addition to the elevation loss noted above, friction loss in the standpipe system and the hose line, as well as nozzle pressure, must also be added. Friction loss will vary greatly depending on hose size and type, and nozzle pressure will vary from 50 to 100 psi (345 to 690 kPa) according to the type of nozzle used. However, to compensate for friction loss and nozzle pressure, it would be necessary to add an additional 75 to 150 psi (1034 to 1379 kPa). A quick look at these calculations makes it obvious that standard fire department pumpers alone could not support hose streams on the upper floors of these ultra-high-rise buildings.

Pumping into the fire department standpipe connections can assist internal fire pumps and is a good practice. If provisions are not made to provide an external backup supply and the internal pumps fail, the only protection will be the fire-resistive nature of the structure (fire enclosures). In high-rise building fires, when the fire is above the reach of aerial ladders and the building is not protected by an automatic sprinkler system, the fire can be expected to burn out all floors above the fire unless the fire can be brought under control by an offensive attack. Contingency plans for supplying the standpipe and/or reservoirs in case of breakdown, developed in cooperation with building management, could prevent a disaster. These contingency plans should be included in the pre-incident plan.

Command Post Location

Fire department SOPs often list the lobby as the preferred command post location. Many times this is true, but on occasion the lobby is a poor choice for a command post. When fire or the products of combustion threaten the lobby, the command post should be located elsewhere. In Chapter 1 it was mentioned that the larger the incident, the farther away the command post should be. The idea is to isolate the IC from disruption so that the command process can be carried out efficiently. When large numbers of people are attempting to exit through the lobby and fire fighters are gathering there in an effort to ascend toward the fire, the lobby is a poor location for the IC. The September 11, 2001, World Trade Center fire provides an example of the lobby being a poor choice for the command post. At this incident, the buildings ultimately collapsed, but even if the structures had not collapsed, the heavy traffic on the first floor of each building would have made the lobby a poor choice for the command post.

Newer high-rise buildings are sometimes equipped with a command center, which is usually near the lobby. This is often the ideal command post location, as these centers often provide good communications and the needed work space for command activities.

Once the command post has been established, its location should be communicated to all responding companies. Some department SOPs use a street name to notify companies of an exterior command post location, such as Main Street Command. A command post located inside a building may be identified using the building's name, such as Whitmore Command.

All high-rise buildings should be pre-incident planned.

Developing Building-Specific High-Rise Pre-Incident Plans

Knowing the location of interior command rooms is just one more of the many issues that should be addressed in the high-rise pre-incident plan. A good high-rise pre-incident plan will address all of the issues covered in a standard building pre-incident plan, including occupancy type. Chapter 11 describes the importance of occupancy types, and Chapter 2 lists occupancy type as one of the major subjects to be addressed in a pre-plan. Knowing the building's use is essential to pre-planning. Most high-rise buildings are businesses, hotels, apartment buildings, or health care occupancies. Some high-rise buildings are mixed occupancies with assembly or mercantile occupancies on the first floor. In addition to the standard pre-incident planning factors, there are many special considerations in a high rise, including:

- Elevator operations and elevator key location
- Access/egress issues, such as stairway doors that automatically lock
- Standpipe operations, especially if field-adjustable, pressure-reducing valves are present
- Floor layouts for each floor that is different or special (e.g., when tenants occupy several contiguous floors, there may be internal stairs between floors)
- Ventilation, such as the use of the heating, ventilation, and air conditioning (HVAC) system; presence of

operable, tempered glass, or special windows (e.g., hurricane resistant)
- Procedures or operations that are unique to the building

High-rise buildings are generally of fire-resistive construction, with the older high-rise buildings often being superior to newer ones in many construction features **Figure 12-5**. Older tower buildings have better compartmentation, more fire-resistive components, and generally better exit facilities. Newer buildings may have one significant advantage: They are often fully sprinkler protected. However, there was a period when high-rise buildings were constructed using the modern, lightweight construction methods but were not protected with automatic sprinklers. These new-style, non-sprinkler-protected high-rise buildings are likely to be most problematic.

Since the mid-1970s, codes used in the United States, with one notable exception, required high-rise buildings to be sprinkler protected. In New York City, until a change was made in March 1999, it was possible to construct a residential high-rise building without a sprinkler system. Two tragic fires led to a change in the building codes, and now all new high-rise buildings built in New York are required to have a sprinkler system installed. Also, within the past few years, many major cities such as New York and Chicago have implemented high-rise sprinkler retrofit programs for some existing high-rise buildings. For instance, the city of Chicago recently adopted an ordinance that requires high-rise buildings (above 80′ [24 m]) to be retrofitted with sprinklers. However, if residential properties and certain other high-rise buildings that are classified as historical pass a locally-developed life safety evaluation (LSE), they may opt out of the retrofit requirement.

In many new-style high-rise buildings where core construction methods are used, fire attack and evacuation tactics are further complicated. In these buildings,

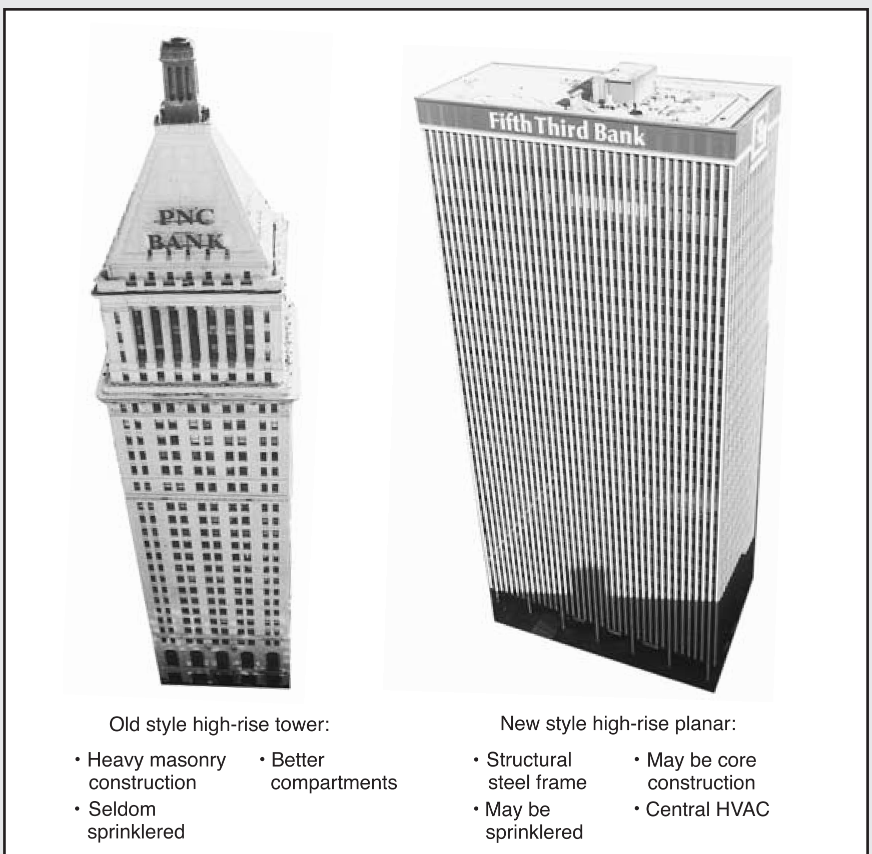

Figure 12-5 Old-style tower construction versus new-style planar construction.

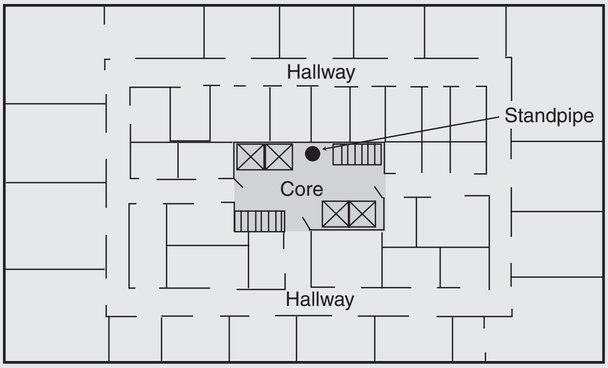

Figure 12-6 Central core layout.

stairways are usually located in the center of the building Figure 12-6. Therefore, if occupants are trapped or if the fire occurs near the core or between the occupants and the core, evacuation and fire attack positions are limited. Fire streams operated from the core may push the fire toward the victims at the periphery, creating a no-win situation. Pre-incident plan drawings will prove to be extremely valuable to the IC in developing evacuation and fire attack plans in these buildings. Some core construction methods move the core away from the center of the building, which is sometimes referred to as side core construction Figure 12-7.

Interior building configurations can be radically different in buildings that appear to be the same from the exterior. Notice that Figure 12-7 shows an open floor layout and standpipes in the stairs, whereas Figure 12-6 shows individual offices and the standpipe in the core area. These seemingly subtle differences can have a major impact on firefighting and rescue operations.

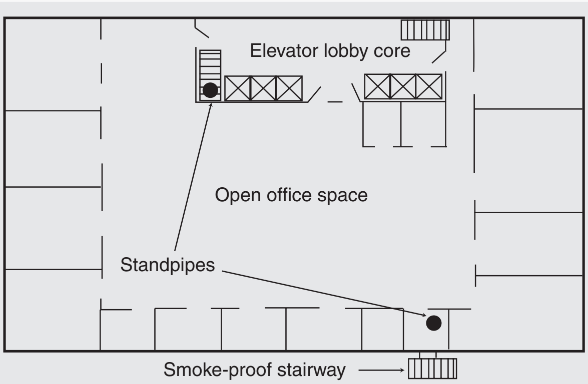

Figure 12-7 Side core layout.

The stairway at the periphery of the side core layout (Figure 12-7) is a **smoke-proof tower**. In smoke-proof construction the stairway is built as a separate structure, thus reducing the possibility of smoke entering the stairs. Also, the stairs could be pressurized to reduce smoke infiltration. Unless there is a compelling reason to use another stairway, the smoke-proof tower or the pressurized stairway should be the stairway of choice for occupant evacuation. This should be noted in the pre-incident plan.

Analyzing the Situation Through Size-Up

All of the factors discussed in Chapter 2 regarding size-up apply to high-rise fires. However, size-up at the scene of a high-rise fire will often be particularly difficult, as visual information may be nonexistent or misleading. Merely finding the fire can be a perplexing chore. A large structure can contain a substantial fire without displaying any external signs. If flame and smoke are visible, it is both a good sign and a bad sign. The good news is that the fire has self-vented, and the IC has some indication of the location and intensity of the fire. The bad news is that the fire has probably gained considerable headway before the arrival of fire fighters.

Observing a high-rise fire from the exterior could result in confusion in directing interior assignments. High-rise buildings often do not have a floor numbered 13, or the mezzanine may be counted as a floor. There may also be half-floor equipment rooms within the building. A heavy volume of fire that originated at a central core may appear at a single window, while a fire that originates near the periphery may cause several windows to break. Visible evidence gained from the exterior, many floors below the fire, may be unreliable. Occupants may report smoke or odors, but these reports typically come from occupants who are many floors above the fire. Information may be available from building occupants regarding evacuation status, but this information is seldom completely accurate in a large building. Even internal alarms are sometimes misleading, as smoke detectors sense smoke above the fire floor or in other areas where the HVAC is depositing smoke. For these reasons, even with fire and smoke showing outside the building, finding the seat of the fire may require assigning several fire companies to different areas of the building.

Matching the occupancy classification to time factors generally gives the IC a good idea of the life hazard potential. There is a tremendous life safety difference in a high-rise office building during working hours compared to the same building during non-business hours. There may be people in the building during non-business hours, but the occupant load during normal working hours will be much greater. How many people would you expect to find in an office building during normal working hours? As a rule of thumb, the average office building has one person for every 100 ft^2 (9 m^2).[4] The pre-incident plan would most certainly aid in determining the life safety problem.

The validity of dispatch information varies depending on the alarm type. A report of a smoke detector alarm on the 30th floor could be for a fire several floors below or for a localized problem on the 30th floor. A report of an odor of smoke from a building occupant may be no more reliable than the smoke alarm in determining the location and nature of the problem. However, a report of visible smoke or flames on the 30th floor in Suite 3012 gives the IC a wealth of information.

It is not unusual for the dispatch center to receive follow-up calls from the public during a high-rise fire. Many of these calls repeat and verify information already received. In many of the fires we studied, building occupants called dispatch after the initial alarm to report people trapped, request evacuation instructions or to report fire conditions in specific areas of the building. This information is critically important and should be immediately relayed to the IC. The IC should notify the operations chief and/or divisions, groups, or companies working in these areas or deploy companies to evaluate the situation. Communications is often a problem; in some of the cases we reviewed, the IC had vital information but was unable to relay it to units working within the building.

In newer high-rise buildings of fire-resistive construction, structural stability will typically be very good. The First Interstate Bank Building and Meridian Plaza fires were both in new-style high-rise buildings, and both sustained large volumes of fire over several floors for an extended period of time. While there was structural damage, especially at the Meridian Plaza fire, neither building collapsed. Further, the old-style high-rise building can be expected to endure even more fire exposure than the more modern, lightweight construction. The Empire State Building serves as a good example of the structural stability of the older, tower-type high-rise buildings. On July 28, 1945, a bomber crashed into the Empire State Building. The aircraft's burning fuel cascaded down and through the building. The building, which sustained both the crash impact and the resulting fire, still stands as one of America's famous landmarks. Fire resistance in older high-rise buildings was achieved through massive structural members

Case Summary

In several fires the smoke has migrated to locations that are remote from the fire. At high-rise fires studied by the NFPA, victims have been killed in locations that were a considerable distance from where the fire originally started. In a hotel fire in Pattaya, Thailand, the fire started on the second floor, yet much of the smoke damage and a number of the fatalities were found on the top floors. Similar situations occurred at the MGM Grand fire, the Las Vegas Hilton fire, and a high-rise fire in 1998 at 124 West 60th Street in New York City that killed four people.

Figure CS12-3 Smoke from the fire that swept through the 36-story President Hotel in downtown Bangkok on February 23, 1997.

covered by concrete. The airplane that struck the World Trade Center was much larger, carried more fuel, and was traveling at a higher rate of speed upon impact compared to the bomber that crashed into the Empire State Building. Therefore, it is difficult to compare the two incidents. However, one of the major factors leading to collapse at the World Trade Center was aircraft debris removing sprayed-on fire-resistive coatings from steel structural members.[2] This sprayed-on insulation was not used in the construction of the older, tower-type high-rise buildings, although it is sometimes used when older buildings are renovated.

Evaluating resource needs is extremely difficult in a high-rise building. However, the staffing and resources necessary to combat a large fire are significant, as you will see in the analysis of high-rise case studies later in this chapter.

The high-rise decision tree shown in Figure 12-8 considers a few major factors that could lead to a call for additional alarms at the scene of a high-rise fire. This decision tree by no means provides a complete size-up of the potential challenges that a high-rise fire presents. However, it does offer a thought process to assist in determining resource requirements. An examination of the decision tree demonstrates that a large fire, located beyond the reach of ground equipment and with elevators unavailable, will require extensive resources.

Some department SOPs require that the first-arriving company request an additional alarm for any working fire in a high-rise building. There is justification for this precaution, given the life hazard, extinguishment, and property conservation potential. In most instances additional personnel will be needed to augment the initial attack and to provide logistical support. The actual staffing requirements will vary depending on the circumstances, as demonstrated by the scenarios and case studies in this chapter.

Smoke Movement

Weather conditions, together with fire intensity, can have a significant effect on smoke movement within a high-rise structure. While the IC should consider these factors, a degree of unpredictability should be expected regarding the effects of weather and fire intensity on smoke movement.

Heat of the Fire

The intensity and size of the fire will determine the extent to which combustion gases are heated and how high they will rise inside the building. In lower structures there is

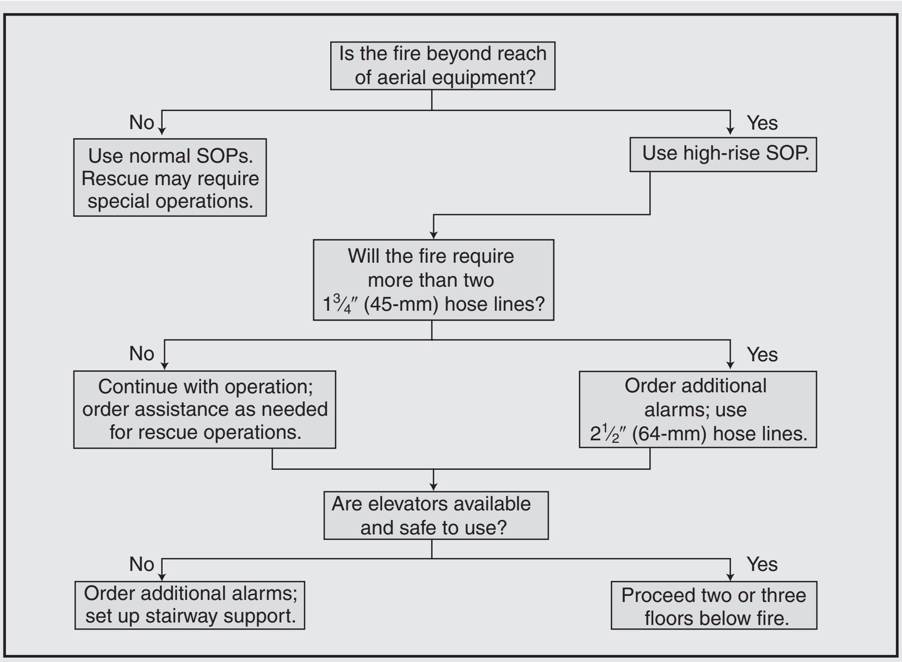

Figure 12-8 High-rise decision tree.

generally enough heat energy to cause the heated fire gases to rise to the highest level in the structure. In high-rise buildings the smoke and toxic gases will tend to rise until they reach temperature equilibrium, at which point they will stratify. It is not unusual to have heavy smoke on a mid-level floor and smoke-free floors above. This stratification can endanger occupants who enter a smoke-free stairway and then discover smoke several stories below. Many times doors leading back into a floor area are locked, forcing the fleeing occupants to seek refuge in the stairway or proceed through the smoke.

Stack Effect

The air tightness of the structure has much to do with **stack effect**—the vertical airflow caused by temperature differences within and outside the building. The unpredictable behavior of smoke within a high-rise is due, in large part, to stack effect. Many fire departments have been surprised when they tried to ventilate a high-rise building using a technique that was previously effective in that or a similar building, only to get an entirely different outcome. In some buildings the stack effect is so great that it interferes with the proper operation of the HVAC system. The colder it is outside, and the warmer it is inside, the greater the positive stack effect (upward movement). Conversely, the stack effect can be negative (downward) on a warm day within an air-conditioned building. The heat of the fire and stack effect are interdependent. The chances of smoke stratification are less on a cold day than on a warm day. There are formulas for calculating stack effect, but they have little application for field use.

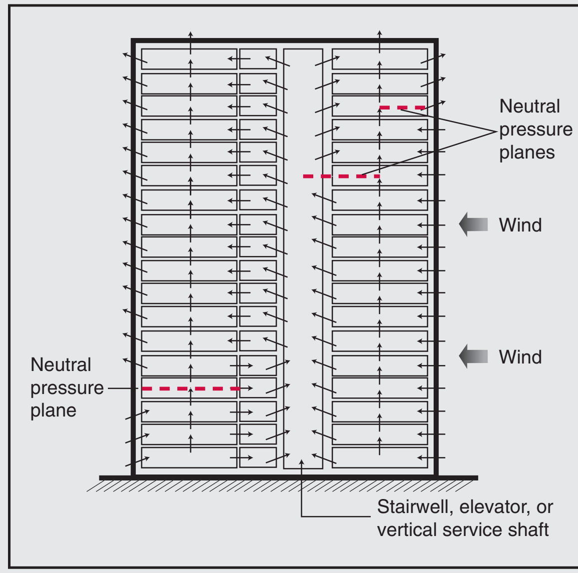

Figure 12-10 Effect of wind on the neutral pressure plane.

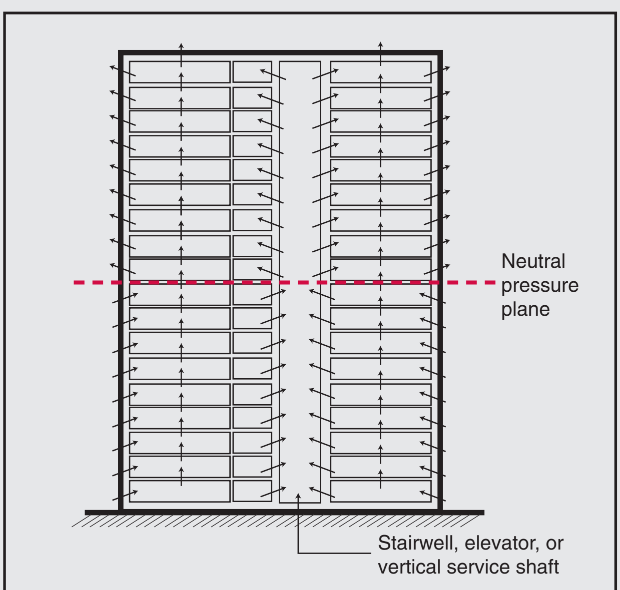

Figure 12-9 Neutral pressure plane.

Wind

There is a point within a high-rise structure of sufficient height called the *neutral pressure plane (NPP)*. Below the NPP air is moving into the building; at the NPP forces are neutral (air is not moving in or out); above the NPP air is moving out of the building **Figure 12-9**. The NPP is affected by heat from the fire and the stack effect. Wind also plays a major role **Figure 12-10**.[5]

Ground-level winds are not always a good indication of wind direction and speed at higher elevations. Downtown areas of large cities containing large numbers of high-rise buildings are like giant canyons. Wind entering the high-rise canyon is redirected and becomes very turbulent. These wind gusts also prevail high above the ground but possibly in another direction and/or at a higher velocity.

Wind passing over a roof opening has a pulling or venturi effect. In addition, the wind will push smoke back

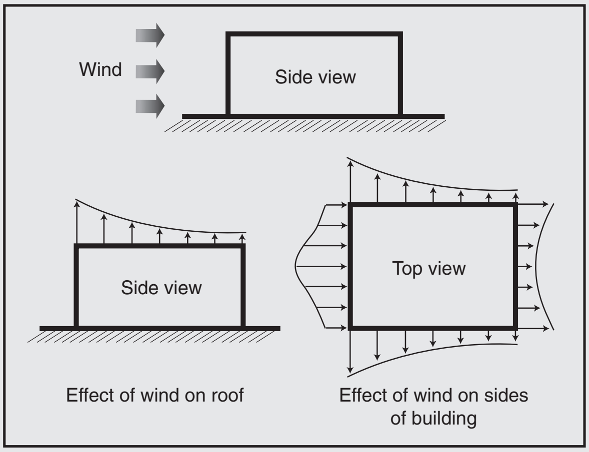

Figure 12-11 Air pressure distribution along the four sides and roof of a building.

into the building on the windward (upwind) side and help to vent smoke out of the building on the leeward (downwind) side **Figure 12-11**.

In reality, predicting the wind factor on the fire ground is more an art than a science. Wind direction and velocity can change dramatically and without warning, even when atmospheric conditions are not changing significantly.

Developing and Implementing an Incident Action Plan

Incident priorities (life safety, extinguishment, and property conservation) remain the same, regardless of the type of structure. Each type of building or occupancy presents a special set of hazards to the occupants and the property. When people and property occupy buildings that are 110 stories high, the risk to life safety and property is obvious.

> **The primary rescue tactic in a high-rise building is a well-placed offensive attack.**

In a high-rise, more than any other building, quickly confining and extinguishing the fire are critical, as ventilation and evacuation options are limited. Once the fire is extinguished, the toxic products of combustion are no longer being produced, and the operation becomes more manageable.

How much water flow will be needed to extinguish a well-involved fire in a large high-rise building? Compartmentation plays a major role in fire flow calculations. Some office occupancies are divided by substantial walls; others have glass panels or portable dividers separating work areas. Further, there are often large, undivided spaces within high-rise buildings. These undivided areas create a high hazard requiring large flows. In the case of the MGM Grand fire, which is described later in this chapter, the required rate of flow was beyond a reasonable flow capacity, and the size of the area made it impossible for fire streams to reach the opposite interior walls from the access points.

There have been cases in which master stream appliances were brought into upper stories of a high-rise building and operated on the interior, but few standpipes could flow a sufficient volume of water to support master streams. To compensate, 5″ (127-mm) hose was used in the building at One Meridian Plaza. However, even this tactic was unsuccessful in controlling or suppressing the fire.

Using master streams within a building would be an unusual tactic, but this could be the only realistic way to control a large-area fire on the upper levels of a high-rise building. Methods have been developed for advancing large diameter hose up interior stairways for use as a portable standpipe, but the time and staffing required to advance the hose to an upper story presents a significant challenge and becomes unrealistic at higher elevations. Master stream appliances could be supplied by fire department pumpers on the exterior, provided that the elevation pressure, friction loss, and required nozzle pressure do not exceed safe operating pressures. If master streams are operated on or into the interior, the structural integrity of the building must be closely monitored. Water from master streams could add several hundred thousand pounds of weight within the structure in a relatively short period of time. It is also easy to imagine the damage that internal master streams would do to property within the structure.

Until ventilation is accomplished, the floor area of a fire-resistive building can be very dangerous for fire fighters operating hose lines. Hose lines operated on the fire floor may push the fire. Like all other energy and matter, the fire will follow the path of least resistance. If the floor is not properly ventilated, fire, smoke, and heat will follow pathways through hallways or concealed spaces. This can be extremely dangerous in a closed high-rise building, as the fire can “wrap around,” moving through these spaces and getting between fire fighters and their exit route. Fog streams exacerbate this problem and should be avoided. The floor should be ventilated as soon as possible; at the same time, fire fighters should be aware of the special hazards associated with breaking glass on the upper floors of a high-rise building. Backup lines should always be in place to protect exit routes.

Company Operations

In attacking a fire in a high-rise building, as in any structure fire, engine company and truck company operations must be coordinated. Truck company members will be needed to force entry to floors and rooms. Upon reaching the fire floor, truck company members should remove ceiling tiles to ensure that the fire is not getting behind the engine company crew and should ventilate the fire floor when possible. Suspended ceilings are common concealed spaces and a likely place for a "wrap-around" fire. This area sometimes contains cables and other equipment that can drop down, trapping fire fighters. Ventilation is crucial in a high-rise fire, though often very difficult to perform.

The attack line is used as the lifeline to safety. Members should stay within range of this protective line, not only for fire suppression purposes but also as a means of finding the stairway in heavy smoke conditions. It is also good practice to place a fire fighter at the stairway opening to the floor. This fire fighter will be needed to help extend the hose and can direct fire fighters to the exit if necessary. Some department SOPs require the use of lifelines (ropes) in these situations, which is a good safety precaution.

Use of Stairways

The occupants of an office building are generally mobile and able to escape on their own, provided that stairways are available for their use. When fire fighters are trying to advance up stairways while occupants are attempting to evacuate, the result is gridlock. What can the fire department or occupants do to alleviate the problem? Many high-rise building managers and fire officials recognize that it is not always the best policy to have all of the building's occupants in the stairways at the same time. The people on the fire floor and the floor immediately above are in the greatest danger and should be among the first groups evacuated. When the stairway is filled with people from other floors, those in greatest danger cannot safely evacuate the building.

Mass evacuations also complicate fire operations, as fire fighters are forced to "swim upstream" in a stairway full of evacuees moving downward. Furthermore, when there is a mass evacuation, occupants above the fire must pass by the fire floor to reach safety. Fire fighters tend to exacerbate this problem by blocking doors open with fire lines, thereby venting the products of combustion into the stairway. These were contributing factors to the loss of life at the Cook County Administration Building fire in Chicago, Illinois. There is no easy or, for that matter, best way to deal with this dilemma. Several ideas are presented here that may or may not work in buildings protected by your department.

First, search efforts must be systematic and include a complete primary search of the fire floor and floors above the fire. In searching above the fire it is important to check all stairways. One way to accomplish this is to enter the floor using one stairway and exit the floor using another stairway. If there are more than two stairways it may be necessary to assign a crew(s) to check the additional stairways. Some important questions that need to be answered include:

- Are people in the stairway?
- Are any stairways filled with smoke? Smoke may stratify; therefore, do not assume that the entire stairway is clear simply because it is clear on one floor.
- Are doors from the stairway to each floor level locked?

Forcible entry is often needed, so the search-and-rescue team must carry proper tools. Forcing doors not only will result in damage, but also will physically exhaust the team. Master keys supplied by building management can be invaluable in gaining access to rooms. It is necessary to check individual rooms to ensure that the occupants on any floor that is endangered by the fire or smoke have escaped.

As previously mentioned, another method of facilitating both evacuation and extinguishment is for the IC to designate separate stairways for occupant and fire department use. Fire companies must have control of the evacuation and/or good communications with occupants to successfully use this tactic. An internal public address system or EVACS can be used to direct occupants to evacuation stairways and away from the fire operations stairway. Even though occupants are directed to use stairways other than the fire operations stairs, the fire operation stairway must also be checked, as people do not always follow instructions. As was noted earlier, smoke-proof towers or pressurized stairs may be the best option for occupants. Controlling the stairs and dedicating one stairway for firefighting also reduces the possibility of opposing lines on the fire floor, as it is easier to control the entire attack if it is being made from one entry point. In most cases a stairway with standpipe outlets is the preferred fire operations stairway.

Ventilation

Ventilation and control of the HVAC system should be done by using reversible methods. Breaking windows high above grade level creates a serious hazard below. Plateglass windows tend to break into large, irregular pieces of glass, known as shards. These shards of glass create a very dangerous situation as they drop to the ground below. Tempered glass breaks into very small pellets and is less hazardous to people below. Even if windows are pulled into the building or are made of tempered glass, opening a window is much preferred to breaking a window. If a window is opened and the effect is negative, it can be closed. Unfortunately, most high-rise buildings have sealed windows, which cannot be opened. Sometimes fire codes require that a percentage of the windows be operable or made of tempered glass so that manual ventilation is possible. Codes that require these vent windows also generally require that windows designated for ventilation be marked as such. The location of tempered glass or operable windows should be noted on the pre-incident plan.

The operation of the HVAC system is usually reversible. If operating the HVAC system does not have the desired effect or spreads the smoke, immediately shut it down.

Interior Exposures

All floors above the fire are exposures. Companies need to check above the fire floor for extension and be equipped to fight the fire. In modern buildings with curtain walls fire can extend upward, inside the building near the exterior wall. Stairways and elevator shafts are vertical openings through which fire can spread. Additionally, pipe chases and utilities penetrate floors, creating openings through which fire can spread.

Fires can extend up the exterior of the building by "lapping" from floor to floor. While upward extension is the main concern, the fire can spread downward through melting expansion joints or burning materials dropping below via the HVAC system or by other means. Therefore, areas below the fire must also be checked. If sufficient numbers of fire fighters are available, the search-and-rescue team can check floors above the fire while fire fighters who are assigned to property conservation can check floors below the fire.

Property Conservation

As was previously stated, the first priorities are life safety and extinguishment. However, property conservation should also be considered early in the incident. High-rise office buildings typically contain valuable contents, such as computers and other office equipment and important files and documents. Also, high-rise residential buildings will contain personal items that cannot be replaced. Often, protecting these valuables is overlooked, owing to the labor-intensive nature of rescue and extinguishment challenges in a high-rise building fire.

When considering property conservation, the height of the building comes into play in an opposite way. In life safety and extinguishment, people and property on and above the fire floor are normally considered to be most at risk, because fire, smoke, and heat will first affect these floors. However, the greatest property conservation exposure is often downward as water flows through curtain walls, electrical fixtures, and other openings, damaging valuable property beneath the fire. In addition to moving and covering valuables, fire fighters should channel the flow of water down stairs or through drains. Like life safety and extinguishment, property conservation operations must be pre-planned and well executed to reduce the loss.

Lead Time

Experienced ICs understand that when an assignment is given, it takes time to see results. As an example, if a portable master stream appliance is to be used on the 10th floor it could take a considerable amount of time before fire fighters and equipment are in position to operate the master stream. The level where the fire occurs has the greatest impact on lead time, especially when elevators are not available. Table 12-2 displays the results of a training program conducted at a 48-story building. The results clearly demonstrate an increased lead time related to the height of the building. For purposes of this study, fire recruits and instructors were in full turnout gear, but not on air. Each five-person company (four recruits and an instructor) was assigned 150′ (46-m) of 1¾″ (44-mm) hose, nozzles, extra SCBA cylinders, and hand tools. The average time to walk up one floor for the first 10 floors was 20.8 seconds or a total of 3:07 to walk up to the 10th

TABLE 12-2 Climbing Stairs to the Top of a 48-Story Building

Floors	Average Time per Floor in Seconds
1–10	20.8
11–20	27.8
21–30	33.6
31–40	45.9
41–48	59.0

floor level. The last eight floors took 59.0 seconds per floor. On average, it took 28 minutes and 52 seconds to reach the top floor of this building. This does not include time needed to connect to the standpipe, place the SCBA in service, and advance on the fire. This building is less than half the height of some high-rise buildings, and the participants were in better-than-average physical condition. Our research indicates that fire fighters at some incidents were unable to reach the fire floor or needed to stop and rest during the ascent.

If the IC waits to give assignments until the need is obvious, he or she has waited too long. The IC must be able to anticipate needs and assign resources in advance.

Establishing a Wide Fire Zone

The area immediately adjacent to the exterior of a high-rise building fire is an unsafe place, particularly if glass is falling. A perimeter should be established to keep civilians out of danger and to provide a safe working area for fire fighters outside the building. Fire fighters who must work within the perimeter should be kept within vehicles or under protective structures. The importance of establishing zones changes with each incident. If there is danger from falling glass, a 200′ (61-m) perimeter should be enforced around the building. As was mentioned previously, plate glass falls to the street in large shards and at times will float a considerable distance from the base of the fire building. Opening windows by pulling the glass inward greatly increases safety at high-rise building fires. This technique has been tried with limited success, using tape, suction cups, and other methods. When there is a working fire in a high-rise building, fire fighters may be forced to break windows on the upper floors or the fire may self-vent without warning. Therefore, the IC should expect glass to fall at any time and direct that a safe perimeter be established early in the incident.

Applying NIMS to a High-Rise Fire

NIMS should be used at every structure fire, and a high-rise building fire is certainly no exception. Proper use of NIMS is a test of the department's training, pre-incident planning, and discipline.

A look at the logistical requirements and multiple staging areas makes it apparent that the span of control can be quickly exceeded at a major high-rise fire. In the case of a high-rise fire, the IC is well advised to hand off the operations and/or planning sections early on in the incident so that other priorities can be addressed. Record keeping is essential. If the IC has an assigned aide, this person usually acts as the initial planning officer and records situation reports and resource status and assignments. Units operating on the fire floor and staging area can be managed by a forward rescue/suppression branch director or operations section chief who documents which companies are in staging, in REHAB, and working on the fire floor.

Communications

Communication and accountability are simplified by using NIMS. Companies working on the fire floor may change; however, the geographic designation remains the same. For example, if Truck 1 and Engine 2 are assigned to the 15th floor for search and rescue, they would be identified as Division 15. If Truck 1 and Engine 2 are later reassigned to REHAB and replaced by Truck 3 and Engine 4, these companies now become Division 15. Remember that "division" is the NIMS term used to identify a geographic location or assignment.

Suppose a fire is on the 10th floor of a 20-story building. A rescue and evacuation group is doing the primary search on floors 12 to 20. Fire attack units are on the 10th and 11th floors. Figure 12-12 is a NIMS chart and communications network for this operation. Communications for this fire would be as follows:

- The rescue and evacuation group would be communicating with the operations section as well as with companies in the rescue and evacuation group as to the status of various floors.
- The Division 10 supervisor (fire floor) would be communicating both with the operations section and with companies assigned to Division 10.
- The Division 11 supervisor would be doing much the same as Division 10.
- Companies assigned to stairway support would be communicating with each other and with logistics.
- Operations would be communicating with Divisions 10 and 11, the rescue and evacuation group, and the IC.
- The staging officer would be communicating with the operations section, which would then order the necessary staffing, equipment, and supplies for the staging area.
- Safety as well as the operations and logistics sections would be communicating with the IC.
- If staffed, the command staff positions of liaison and information, as well as the planning and administration/finance sections would most likely be at the command post location, communicating face to face with the IC.

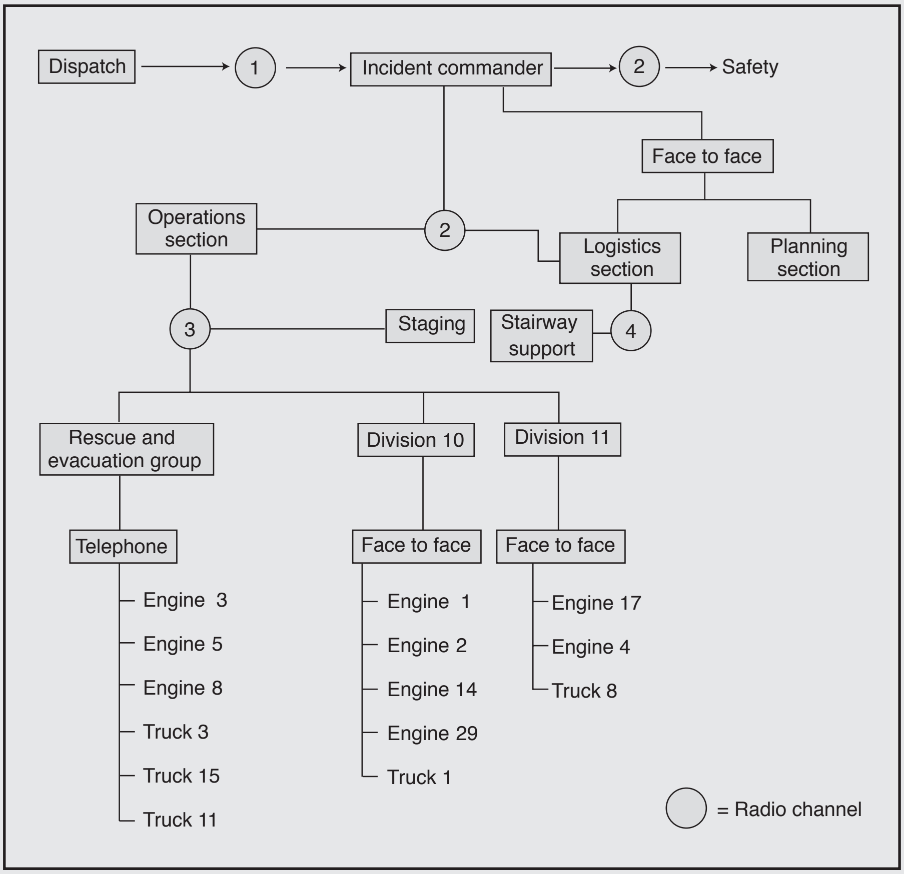

Figure 12-12 High-rise communications network.

Communications is the most frequently cited problem during major emergency operations. Communications can be very complicated within a high-rise building. If separate radio frequencies or hardwire communications are not provided at the incident scene, a breakdown in communications may occur.

Radio discipline *must* be maintained and alternative methods should be arranged (e.g., messenger, hardwire telephones). Note that the rescue and evacuation group in Figure 12-12 is communicating via telephone. Hardwire telephones are abundant in most high-rise buildings; consider using them as a means of emergency communications. In the Figure 12-12 example, the search-and-rescue group supervisor could be located in a room off the lobby, on a lower floor, or in another building where two or more telephones are readily available. All units working in this group would be given the contact numbers for the group supervisor, which would be used to call in status reports and receive new assignments. Alternate communications must also be available because the fire could damage the telephone system. Complicating the communications problem at a high-rise building is the fact that using radios is difficult within many structures. In fact, it is often impossible to receive radio transmissions from inside a structural steel building.

Tactical Worksheets

Fire departments have devised a wide assortment of tactical worksheets to be used in documenting and tracking activities on the fire scene, including some that are specifically designed for high-rise fires. Most worksheets contain checklists to remind the IC of important functions.

A good tactical worksheet will include sections to record the fire location and the location of companies at the incident scene. During high-rise fires companies will be working at different levels; therefore, the tactical worksheet should provide a generic sketch of a high-rise building that can be used to record activities on each floor.

Occupants on the fire floor and above are normally in the greatest danger, but it is necessary to search below the fire as well. A search-and-rescue group normally works above the fire to conduct a primary search and to assist in evacuation. This group is generally very active, moving from floor to floor. Therefore, it is very important for the group leader to keep the IC (or operations chief) current on the group's location in the building and the status of the primary search.

The high-rise worksheet in Figure 12-13 lists various high-rise positions described in this chapter and provides space to enter companies working on each level.

Upper Search and Rescue Group
Floors: From ________ to ________
Supervisor ________

Engine Cos.	Truck Cos.	Others

Floor # ________

Engine Cos.	Truck Cos.	Others

Division # ________
Supervisor ________

Floor above fire
Floor # ________

Engine Cos.	Truck Cos.	Others

Division # ________
Supervisor ________

Fire floor
Floor # ________

Engine Cos.	Truck Cos.	Others

Division # ________
Supervisor ________

Floor # ________

Engine Cos.	Truck Cos.	Others

Division # ________
Supervisor ________

Staging
Floor # ________

Engine Cos.	Truck Cos.	Others

Division # ________
Supervisor ________

Floor # ________

Engine Cos.	Truck Cos.	Others

Division # ________
Supervisor ________

Lower Search and Rescue/Property Conservation Group
Floors: From ________ to ________
Supervisor ________

Engine Cos.	Truck Cos.	Others

Floor # ________

Engine Cos.	Truck Cos.	Others

Division # ________
Supervisor ________

Lobby control
Supervisor ________
Company ________

Stairway support
Supervisor ________
Companies ________

Figure 12-13 High-rise tactical worksheet.

The value of an operations section aide is clear. The operations section chief needs to know the location of all companies operating in the building but does not always have time to keep the worksheet up to date. An aide, acting in a planning capacity, can assist in tracking and recording this information.

Base (Exterior Staging for High-Rise Fires)

The term "base" is used by wildland fire fighters to identify a location housing reserve equipment and personnel (base camp). This term is not normally used for structural firefighting but has utility in managing high-rise fires. The base for high-rise fires is a location where support equipment and personnel are kept on the *exterior* of the building. Depending on interior conditions and the location of the fire, an exterior staging area may be established near the fire perimeter, but is generally limited to fires on lower floors. The reason for this distinction is that the staging area is normally moved inside the structure during a high-rise fire. Unless there is a possibility of moving to an exterior operation or the fire is involving other structures, it would be unusual to amass a large force on the exterior at a high-rise fire when the fire is on an upper floor. While "base" is the commonly used term for the exterior staging area at a high-rise fire, it would also be appropriate to refer to it as "exterior staging."

Staging (Interior)

In a high-rise situation, most of the reserve force is moved through the lobby and then to the interior staging area. This area is normally two or more floors below the fire. A rehabilitation area may be set up at the staging area or on another floor. The concept is the same as in exterior staging: to provide a readily available reserve force. To avoid the confusion of having a different name for the exterior staging area, the interior staging area could be identified as interior staging or as the resource area. Department SOPs should address this issue, using either the suggested terms of "base" and "staging" or other terminology that is consistent throughout the region.

The supervisor in charge of the staging area or an assistant can act as the accountability officer for crews that are working out of the staging area. Tracking crew rotations can be a challenging task. If an extended operation becomes necessary, three fire fighters will be needed for each position on a hose line. For example, a four-person fire company operating a 2½″ (64-mm) hose line on the fire floor will exhaust its air supply in approximately 15 minutes. To continually operate the hose line on the fire floor, this crew will need to be relieved by an available crew in staging. As the crew leaves the fire floor, it will move to REHAB, and another crew will move to the ready position Figure 12-14.

The person in charge of the interior staging area reports to the operations section but also communicates with the logistics section. The duties of the staging area officer are as follows:

- Report to the operations section if it is staffed. Otherwise, interior staging would communicate directly with the IC. The IC could elect to have the interior staging officer communicate directly with the logistics section.
- Maintain records of the companies that are in staging and REHAB.
- Maintain a minimum reserve of engine and truck company personnel as established by the IC.
- Request additional resources to maintain the established reserve force.
- Maintain an adequate supply of air cylinders and other equipment as needed.
- Supply first aid equipment and medical services for units that are involved in rescue and suppression.

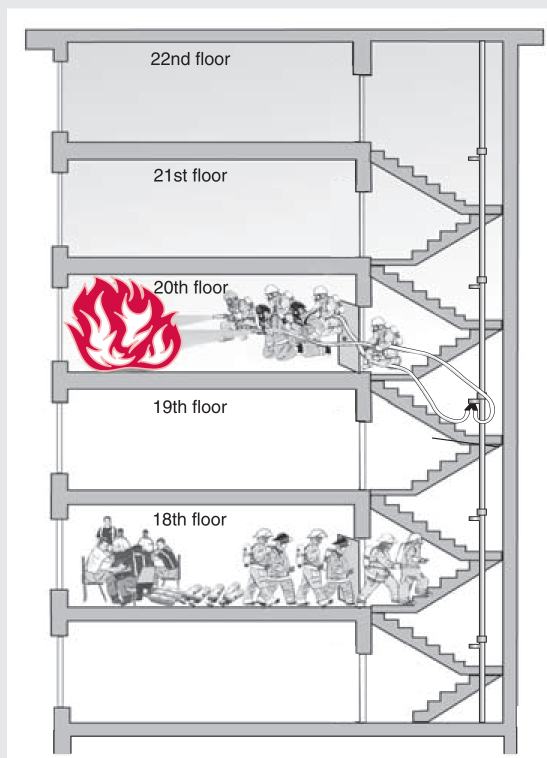

Figure 12-14 Fire companies rotating from REHAB.

The concept of an interior staging area should not be reserved for high-rise fires. Any time an extensive interior attack is in progress where fire fighters expend more than one cylinder of air, staging and rehabilitation may be needed.

Lobby Control

The primary accountability officer may be part of the lobby control crew or co-located in the lobby. Lobby control is established regardless of whether the elevators are going to be used. The duties of lobby control include the following:

- Controlling, operating, and accounting for all elevators
- Assisting in incident command post operations
- Locating and controlling all interior stairs
- Directing incoming companies to the proper elevator or stairway
- Consulting with the building engineer
- Controlling or shutting down the HVAC system after consulting with the IC

Controlling the elevators and stairways is the only way to effectively gain access to the upper floors of a high-rise building. Many department SOPs assign these initial lobby control tasks to a member of the first-arriving truck company. Another important lobby-control duty is to gain control of the HVAC system. If operated properly, the HVAC system can prevent heat, smoke, and toxic gases from reaching occupants. Conversely, if it is operated incorrectly, it may spread the products of combustion well beyond the immediate fire area and into occupied areas.

In some buildings it is virtually impossible to know what is going to happen when the HVAC system is operated because of the many unknown variables, such as heat produced by the fire, stack effect, and wind. Furthermore, few building engineers are completely knowledgeable about the operation of the HVAC system. For these reasons many fire departments require an emergency shutdown switch near the lobby.

High-Rise Case Histories

The One Meridian Plaza Fire

The One Meridian Plaza fire in Philadelphia, Pennsylvania, occurred at 8:40 PM on Saturday evening, February 23, 1991 Figure 12-15.[6,7] Because the fire occurred outside normal working hours, the threat to occupants was minimal. However, this fire claimed the lives of three fire fighters.

Fire fighters provided a considerable occupant load in the fire building as the operation resulted in 316 fire fighters being called to the scene. The building was in total darkness and without elevator service.

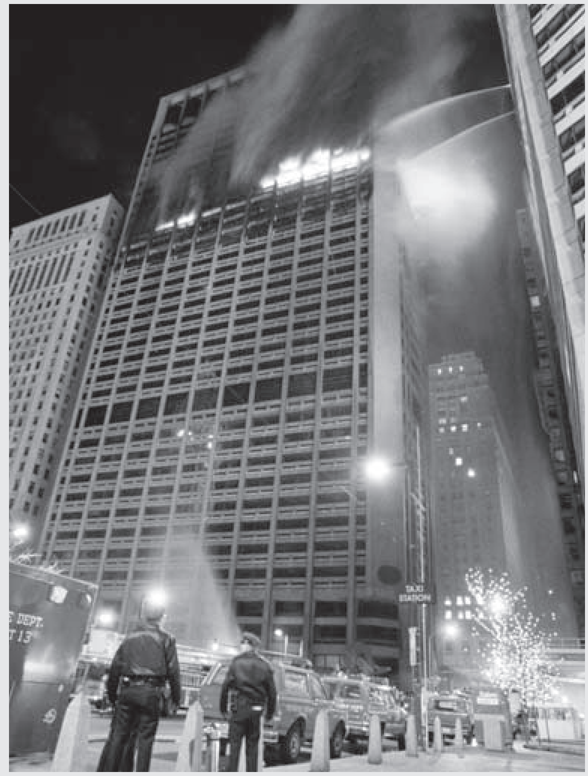

Figure 12-15 One Meridian Plaza, Philadelphia, Pennsylvania.

Perhaps the One Meridian Plaza fire would not have gained the same headway had the building been occupied, because the fire probably would have been detected earlier. The reports do not provide the total number of occupants in the building during normal working hours, but the worst-case scenario was alarming. Each floor had 17,000 ft^2 (1579 m^2) of usable space. According to the 100-ft^2-per-person (9-m^2-per-person) rule from the *NFPA Life Safety Code*, if the building had been fully occupied, there could have been 170 people per floor.

The fire began on the 22nd floor and dropped down to the 21st floor. The top (38th) floor is a mechanical floor, meaning that the occupants on floors 21 to 37 (17 floors) would have been in immediate danger had the building been fully occupied. At 170 people per floor, 17 floors could be occupied by up to 2890 people. The eight floors that were destroyed could have held 1360 people.

The One Meridian Plaza fire most certainly points out the potential for a large-loss-of-life fire in a non-sprinkler-protected high-rise building. The building was being retrofitted with sprinklers at the time of the fire. Floors 22 to 29 were not sprinkler protected and were lost to the

Figure 12-16 First Interstate Bank Building, Los Angeles, California.

fire. It is interesting to note that the fire was suppressed on the 30th floor by ten sprinkler heads operating at the points of penetration. Can the value of sprinkler protection in high-rise buildings be underestimated? This fire serves as a testimonial to the value of automatic sprinkler systems in high-rise buildings.

The First Interstate Bank Building Fire

On May 4, 1988, at 10:25 PM, a fire similar to the One Meridian Plaza fire occurred in Los Angeles, California, at the 62-story First Interstate Bank Building Figure 12-16.[8,9] At this fire four floors were completely destroyed, and a fifth floor was heavily damaged. The building was unoccupied except for security and maintenance personnel. The First Interstate fire burned floors 12 to 15 and was stopped at the 16th floor. Again, to consider the potential loss of life, we can look to the *NFPA Life Safety Code*. According to the *Life Safety Code*, the maximum number of occupants permitted per floor would have been 175. The fire was on the 12th floor of a 62-story building. Therefore, 51 floors were exposed to the fire and smoke conditions. This yields a potential occupant load of 8925 people above the fire. In this case the actual number of building occupants was listed as 4000. If the occupant load is averaged equally among the floors, as many as 3290 people could have been above the fire during normal working hours.

Comparing the One Meridian Plaza and First Interstate Bank Building Fires

Examining similarities between these two fires enhances the learning experience that would be gained by studying a single fire. Table 12-3 compares the two incidents.

When studying case histories you should note the effect of delayed alarms. A 16-minute delay occurred at the First Interstate Bank Building fire. Had the fire department been notified 16 minutes earlier, there is a high probability that the fire could have been extinguished without exposing fire fighters to prolonged, extreme danger, and with much less property loss and damage to the structure. Some would speculate that this delay is unlikely when the building is fully occupied, but Francis L. Brannigan, in one of his monthly *Fire Engineering* articles, took exception to this theory. Someone suggested that during normal working hours the employees at the First Interstate Bank Building would use the occupant-use hose line to extinguish the fire. Brannigan states:

> I think this answer is unrealistic. On a trading floor, operatives are dealing in multi-million-dollar split-

TABLE 12-3 Similarities Between the One Meridian Plaza and First Interstate Bank Fires

	One Meridian Plaza	First Interstate Bank
Deaths	3 fire fighters	1 maintenance person
Occupancy	Office building	Office building
Time of day	8:30 PM, unoccupied	10:25 PM, 40 occupants
Alarm	Delayed, 4 minutes+	Delayed, 16 minutes+
Sprinklers	Partial, being retrofitted	Partial, being retrofitted
Floor of origin	22	12
Area of involvement	8 floors, 17,000 ft^2/floor (1579 m^2/floor)	5 floors, 17,500 ft^2/floor (1626 m^2/floor)
Responding fire fighters	316	383

> second transactions. I think it would be more like the Bradford Stadium fire in England, where the fans kept alternately watching the fire and the game until they died. In addition, to the typical computer nerd, the thought of water on his computer is anathema.[10]

There are many documented large-loss fires in occupied buildings in which delayed alarms played a significant role. In hotel and office occupancies, security or maintenance personnel may first attempt to investigate the fire before calling the fire department. Sometimes, they become involved in firefighting operations with occupant-use hose lines or fire extinguishers and delay calling the fire department until the fire is out of control.

A fire that occurred on January 6, 1995, in North York, Ontario, verifies Brannigan's assertion that delayed alarms should be anticipated in occupied buildings.[11] This fire also demonstrates that multiple-fatality high-rise fires are not limited to office and hotel occupancies. This fire, which occurred in a 29-story apartment building, killed six occupants. The occupant in the apartment of origin first attempted to extinguish a couch cushion fire with water. Other occupants smelled smoke and investigated, then assisted in trying to extinguish the fire. Finally, one of the occupants called 9-1-1. The door to the apartment of origin was left open, allowing the fire to spread into the hallway and extend into one of the two stairways located at the central core.

The high-rise apartment building fire discussed above was not a unique incident. According to Dr. John Hall, NFPA Assistant Vice President, between 1989–1998 high-rise apartment buildings and hotels averaged 10,500 reported structure fires a year, or 86% of the combination of high-rise apartment buildings, hotels, office buildings, and hospitals. Also, during this same reporting period, high-rise apartment buildings and hotels averaged 51 reported civilian fire deaths a year, or 96% of the combination of the four types of high-rise properties. The vast majority of these residential high-rise fires and deaths are specifically in apartment buildings. Also, the percentage of reported high-rise fires in buildings with sprinklers in 1998, the latest year in the range (and the one where the percentages were highest) was 36% for apartment buildings (compared to only 5% for apartment buildings that were not high-rise), 77% for hotels, 80% for hospitals, and 63% for office buildings. It is pretty clear that the high-rise buildings that present the largest problem are apartment buildings, where—no coincidence—the usage of sprinklers lags far behind the usage in other high-rise buildings.

Experienced fire officers have speculated that a working fire in a large, high-rise building during periods of full occupancy could require the services of 500 or more fire fighters. The fires in Philadelphia and Los Angeles make this estimate appear low, given that both occurred when the building was occupied by only a small staff of security and maintenance personnel.

Fire fighters in Los Angeles successfully mounted a manual attack on the 16th floor, whereas the One Meridian Plaza fire was not contained until it reached a sprinkler-protected floor. The difference was the standpipe system. At One Meridian Plaza pressure-reducing valves reduced the water pressure below the operating pressures needed to properly supply the automatic nozzles being used by the fire department. The codes governing standpipe installations required reducing valves to avoid overpressurization. The flow-reduction valves that were used to meet code requirements were incorrectly set at a pressure below the required pressure and could not be changed at the time of the fire. Manufacturers now provide nozzles that will effectively operate at lower pressures. Smooth-bore nozzles are another option when faced with low pressures.

The Peachtree Plaza Fire

On June 30, 1989, a much smaller fire in a 10-story office building in Atlanta, Georgia, occurred at 10:30 AM on the sixth floor while the building was occupied **Figure 12-17**.[12,13] Five of the 40 occupants on the sixth floor were killed, and at least six others where rescued by using aerial ladders. Eleven of forty occupants (28% of the occupants on the sixth floor) probably would have perished if the fire floor had been beyond the reach of aerials. Additional occupants were evacuated from other floors by using the interior stairways. Many of the occupants were able to survive by breaking windows and

Figure 12-17 Peachtree Plaza.

waiting for exterior rescue. If this fire had occurred above the reach of aerials, a fatality rate of at least 25% for the involved floor is a reasonable assumption. Translate that to the 170 and 175 people per floor in One Meridian Plaza and the First Interstate Bank Building, and the result would have been a major catastrophe.

Cook County Administration Building Fire

On October 17, 2003, a fire on the 12th floor of the 37-story Cook County Administration Building in Chicago, Illinois resulted in six civilian fatalities.[3,14] The fire was believed to have originated in a closet within a 2629 ft^2 (244 m^2) suite of offices on the east side of the 12th floor **Figure 12-18**.[15] Actual fire damage was contained to the office suite due to fire-resistive building features, but smoke and fire migrated to the entire 12th floor. The fire self-vented through eight exterior windows on the east side of the suite, thus creating the potential for floor-to-floor fire extension via the exterior **Figure 12-19**.

This fire was first noticed at approximately 5:00 PM; fire reports did not mention the total number of people in the building at the time of the fire. However, it is likely that some workers had left for the day, leaving the building below full occupancy. Building occupants were notified to evacuate the building via the stairways. However, some occupants used the elevators to escape, while others used the east and west stairways to evacuate. The fire department advanced a hose line into the 12th floor via the east stairway. When the door to the 12th floor was opened to advance the hose line into the fire area, smoke levels in the east stairway increased dramatically. As far as can be determined, there were thirteen occupants above the 12th floor in the east stairway when the fire department began attacking the fire. Doors from the hallways on each floor were locked on the stairway side trapping these occupants in the stairway above the fire. Seven of the occupants in the stairway found a door that did not completely latch on the 27th floor and were able to leave the east stairway and escape. Six others perished in the stairway.

Fire fighters were faced with an intense fire that they were unable to extinguish from their hallway position. Elevated master streams were used to knock down the fire from the exterior. Interior hose streams were then redeployed to achieve final extinguishment. Tight compartmentation and closed doors contained the fire to the suite where it originated.

Using exterior streams to attack a fire in a high-rise building is seldom recommended even on lower floors of

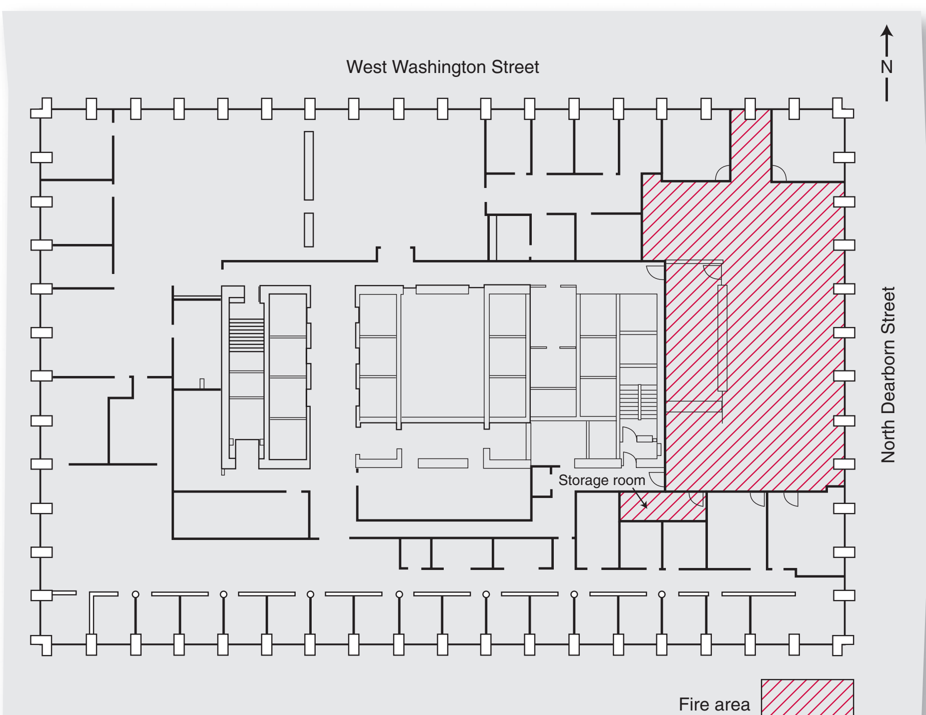

Figure 12-18 Plan view of Cook County Administration Building, 12th floor.

Figure 12-19 East side of 12th floor, Cook County Administration Building.

the building. If fire separations are left open or the compartmentation is compromised, exterior streams can rapidly spread the fire and threaten occupants and fire fighters.

At a 1994 fire on the ninth floor of the Regis Towers apartments in Memphis, Tennessee,[16] heavy smoke and fire were encountered on the ninth floor. Fire companies made several attempts to rescue occupants and extinguish the fire from the interior. When the fire self-vented a heavy volume of fire was visible from the exterior. An elevated master stream was operated into the apartment of origin to knock down the visible fire. In this case, the door between the apartment of origin and hallway was open. The exterior stream pushed the fire into the ninth floor corridor where a company was advancing toward the fire. Heat and smoke conditions immediately became worse on the ninth floor, forcing fire fighters to retreat. Two fire fighters who had been attacking the fire became disoriented and had to be rescued. Two fire fighters and two civilians perished at the Regis Tower fire.

Terrorist Attacks at the World Trade Center

The two largest high-rise incidents to date were the result of terrorist attacks on the World Trade Center in New York City in 1993 and 2001 Figure 12-20.

World Trade Center Bombing: February 26, 1993

The first attack involved a truck bomb.[17,18] Although this incident was the result of a terrorist's bomb, fire and smoke were the major concerns. A quote from Chief Anthony L. Fusco after the first attack identifies the fire danger and reinforces the contention made throughout this book: the most important life safety measure is often extinguishment. In his remarks, Chief Fusco stated, "The decision to attack the basement fires in the initial stages of the incident was the most important decision of the incident [commander] in that hundreds, maybe thousands, of lives were saved owing to timely extinguishment of the fires."

The first World Trade Center attack should have removed any doubts about the potential for death and injury in high-rise building fires. The World Trade Center was a seven-building complex that included two 110-story towers and a 22-floor hotel (the Vista Hotel), among other structures. The area of each floor was 40,000 ft^2 (3716 m^2). It was estimated at the time of the truck bomb incident that 60,000 people were working in the buildings, and there were also thousands of visitors. Six deaths and 1042 injuries were reported at this incident, and 50,000 people were evacuated from the building.

This incident was the equivalent of simultaneous multiple-alarm incidents. Five alarms were sounded for the Vista Hotel

Figure 12-20 New York City skyline view including the World Trade Center.

operation, five alarms were sounded for the Tower 1 operation, and four alarms were sounded for the Tower 2 operation. Another alarm was sounded for additional resources. Forty-five percent of the department's on-duty resources were required at this incident. In addition, a large contingent of police officers responded, and 174 ambulances treated and transported the injured. Few fire departments in the world have comparable resources. In fact, very few fire departments could provide the staffing needed to search the 99 elevators in each tower.

The World Trade Center was sprinkler protected, but the blast destroyed the sprinkler piping in the garage area where the fire occurred. With the sprinkler system out of service in the garage, the fire continued to burn and push smoke to the floors above. Once the fire was extinguished, the smoke production stopped. However, the smoke that had already entered the building lingered. As was previously mentioned, venting a high-rise is always problematic and takes considerable time.

World Trade Center Attack: September 11, 2001

The second attack on the World Trade Center resulted in the largest number of civilian and fire fighter fatalities ever recorded in a building fire. Lessons are still being learned from this disaster. Although aircraft flying into buildings is not a typical high-rise fire scenario, it occurs frequently enough to deserve consideration. Small aircraft have flown into high-rise buildings on several occasions. A B-25 bomber flew into the Empire State Building in 1945. World Trade Center building designers had actually planned for an accidental aircraft accident involving a Boeing 707 aircraft making a landing approach. World Trade Center structures were designed to withstand the impact and fire from this slightly lighter aircraft assumed to be low on fuel and traveling at approximately 180 miles per hour. This "planned for" accident would produce much less impact and fire than the Boeing 767s that were nearly full of fuel and traveling at an estimated 470 to 590 miles per hour when they were purposely flown into the buildings on September 11, 2001.

The Boeing 767 airplanes caused considerable structural damage on impact, but the two towers withstood these initial impact forces and remained standing. However, the aircraft debris moving through the building removed sprayed-on fire resistive coatings that protected steel structural components. The ensuing fire weakened the unprotected steel, resulting in the collapse of Towers 1 and 2, which killed 2749 people, including 340 fire fighters. The National Institute of Standards and Technology (NIST) theorizes that the two buildings would not have collapsed had the thermal insulation remained in place.[2] It is estimated that Buildings 1 and 2 at the World Trade Center were 33% to 50% occupied at the time of the attack. Had they been fully occupied, NIST estimates that it could have taken as long as three hours to evacuate the buildings, and as many as 14,000 people could have lost their lives.

Prior to the collapse of the two World Trade Center buildings, high-rise buildings had not been known to collapse even when subjected to intense fires on multiple floors. The Meridian Plaza and First Interstate Bank fires discussed earlier in this chapter both withstood severe fires on multiple floors without collapsing.

The MGM Grand Fire

During the MGM Grand (now Bally's) fire in Las Vegas, Nevada **Figure 12-21**, occupants displayed what we now call convergence cluster behavior.[19,20] They gathered in certain rooms as groups, gaining a feeling of safety in the presence

A.

B.

Figure 12-21 MGM Grand fire, Las Vegas, Nevada. A. Entire building. B. Close-up of people at windows.

of others. What implications does this have for the fire department? Searching fire fighters might not find anyone in several rooms or in an entire floor area, while one room may contain far more victims than anticipated.

The occupancy type has a direct bearing on the behavior and awareness level of occupants as well as the population density. The MGM Grand had 3400 registered guests at the time of the fire. The death and injury toll was due to smoke infiltrating the 21-story tower from a fire in the first-floor casino. The death toll of 85 people made this the second most deadly hotel fire in U.S. history (119 died in the Winecoff Hotel in Atlanta, Georgia, in 1946).

The fire in the MGM Grand started at the rear of the casino and eventually involved the entire 150′ × 450′ (46- × 137-m) casino floor. The ceiling height was not given in the reports, but the ceilings were probably a minimum of 20′ (6 m) high. Using the V/100 formula for 20′ (6-m) ceilings yields a rate of flow of 13,500 GPM (852 L/sec). The size of the fire area and the required rate of flow led to the conclusion that this fire was not going to be extinguished by manual means, and there were no sprinklers in the fire area. Therefore, the best tactic was to keep the fire out of the stairways and towers, and this was accomplished. However, smoke did spread throughout the structure, killing 85 people.

Summary

Recent fires at the World Trade Center and Cook County Administration Building demonstrate that the threat of a major high-rise fire continues. The chance of a serious fire is much greater in the non-sprinkler-protected, modern high-rise. Older high-rise buildings are constructed using massive structural members to support the structure and to provide fire barriers within the structure. Most high-rise buildings constructed in the 1970s and after are sprinkler protected. Buildings that are of newer lightweight construction that are not sprinkler protected present the greatest hazard. High-rise buildings have become a favorite target for terrorists. Previous to the attack on the World Trade Center on September 11, 2001, high-rise buildings had not been known to collapse.

A working fire in a high-rise building can threaten thousands of occupants and the most effective way to extinguish a high-rise fire is by mounting an offensive attack. In the vast majority of cases the best life safety tactic is extinguishing the fire. However, attacking the fire from the exterior places fire fighters and occupants who are still inside the building in great peril. In most cases, using fire-resistive structural features to contain the fire is preferable to an exterior attack.

Fires on the upper floors of a high-rise building will often be beyond the reach of aerial devices; therefore, occupant evacuation is usually limited to the interior stairs that can quickly become overcrowded. Sequential or partial evacuation can relieve the congestion in the stairway, but occupants who are not evacuated remain in a potentially hazardous location.

Fire fighters ascending the stairways can block occupants attempting to evacuate, and fire fighters opening a door from the stairway to the fire floor allow smoke to enter the stairway. These problems can be lessened by assigning a stairway exclusively for fire department use. However, a stairway dedicated to fire department operations decreases the building's total egress capacity.

As the level of the fire floor increases, reliance on the standpipe system also increases. Open-layout floor plans can challenge the standpipe's flow capacity and fire department resources. Getting resources to the places they are needed is complicated and, if the elevator is not safe to use, the lead time dramatically increases for a fire on an upper floor.

Wrap-Up

Key Terms

lobby control A high-rise assignment in which a crew is responsible for duties related to managing the stairways, elevators, and the HVAC systems.

smoke-proof tower A stairway designed to be separated from the building by a landing. This creates a separation that will limit the spread of smoke into the stairway and keep it clear for evacuation.

stack effect The vertical airflow within buildings caused by temperature differences between the building interior and the exterior; depending on conditions, stack effect could be positive or negative, causing smoke to move upward or downward.

Suggested Activities

1. Obtain an analysis of a recent high-rise fire. Critically review the operation in terms of manual fire suppression with emphasis on the following topics:
   - **A.** Establishment of a command system (NIMS)
     - **i.** Geographic and functional delegation
     - **ii.** Command post location
   - **B.** Identification and use of special high-rise components of the IMS
     - **i.** Base
     - **ii.** Lobby control
     - **iii.** Staging
     - **iv.** Stairway support
   - **C.** Tactical priorities
     - **i.** Determine what specific precautions were taken to enhance fire fighter safety.
     - **ii.** Review the primary search-and-rescue efforts.
     - **iii.** Review extinguishment tactics, especially those directed toward rescue operations.
     - **iv.** Explain the ventilation tactics used.
     - **v.** Calculate the required rate of flow.
     - **vi.** Compare the flow applied to the calculated flow.
   - **D.** Elevators
     - **i.** Were elevators used?
     - **ii.** Should they have been used?
     - **iii.** Were the rules of elevator safety applied?
   - **E.** Extension of fire and products of combustion
     - **i.** Where did the fire go?
     - **ii.** How did it get there?
     - **iii.** Where did the smoke go?
     - **iv.** How did it get there?
   - **F.** How did building construction features affect the fire?
   - **G.** What effect did the HVAC system have in smoke control efforts?
   - **H.** Were fire streams effective? If not, why not?
   - **I.** If the fire was in a tower-type high-rise, what effect did construction have on limiting the spread of the products of combustion? If it was in a newer (planar) style building, what effect do you think the heavier tower-type construction would have had on limiting the spread of the products of combustion?
   - **J.** How would the fire have been different in a building protected by a properly operating automatic sprinkler system?
2. Use the following Las Vegas Hilton scenario to answer the questions listed in Question 1. The description of the Las Vegas Hilton fire presented here is a condensed version of an investigative report prepared by the National Fire Protection Association in cooperation with the Federal Emergency Management Agency, the United States Fire Administration, and the National Bureau of Standards.[21] The description provided here disregards non-tactical factors. In reading through the report, pay close attention to the topics discussed in Chapter 12.

Las Vegas Hilton Fire

At approximately 8:00 PM on February 10, 1981, a fire began at the Las Vegas Hilton Hotel in which eight people died and 350 more were injured. This was the largest hotel in the United States at the time. The fire was intentionally started in

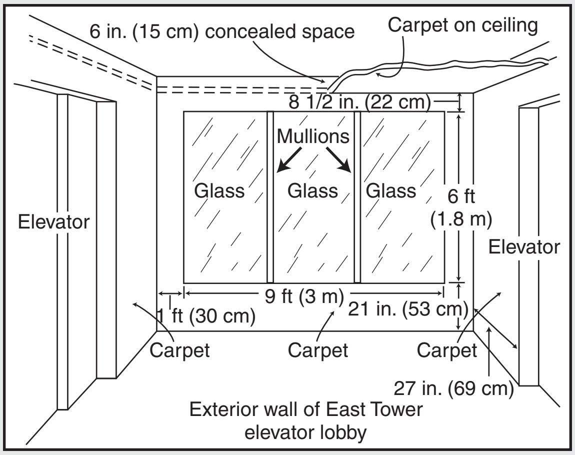

Figure 12-22 Las Vegas Hilton East Tower elevator lobby.

the eighth floor elevator lobby of the East Tower. This elevator lobby, shown in **Figure 12-22**, was completely covered with carpet, which was glued to the walls and ceilings. The elevator lobby also contained draperies, a small wooden bench with a foam cushion, and a table. Most elevator lobbies were similarly furnished; those on a few floors, including the 28th floor, contained larger pieces of furniture and a couch.

The fire spread via the building's exterior, eventually involving the 22 stories above the eighth floor fire.

The Las Vegas Hilton had 2783 guest rooms, which were constructed in three phases **Figure 12-23**:

- Central Tower: 1969
- East Tower: 1975
- North Tower: 1979

The ground floor and second floor contained the casino, restaurants, and showrooms and was larger in area than the hotel towers above. The top (30th) floor contained additional assembly areas. The entire building was of fire-resistive construction, but alarm systems, fire separations, and other protective features varied, owing to the differences in the codes enforced when the three towers were constructed. The guest rooms were decorated and furnished much like those in other luxury hotels. Parts of the first and second floors were sprinkler protected, but other areas were unprotected. There was a hotel fire brigade, and standpipes were located in the stairways. The HVAC system, located on the roof, supplied air to the corridors but did not return air from these corridors. Room air was supplied from the corridors. Smoke detectors, which were designed to close dampers under fire conditions, were installed in corridor ductwork. Toilet exhaust fans were also provided.

At 8:05 PM the hotel's security office received a telephone call from an employee reporting a fire on the eighth floor near the East Tower elevator lobby. Two security officers were sent to investigate via the Central Tower elevator. While the two security officers were responding, an annunciator transmitted an alarm for the eighth-floor elevator lobby. The hotel's fire brigade was notified. The two security guards reached the eighth floor, verified the fire, and radioed the security desk to call the fire department. The fire department received the alarm at 8:07 PM.

Clark County Fire Department Station 18 was adjacent to the hotel. While responding, Station 18 fire fighters saw flames coming from two floors on the building's exterior. During their short response time, the fire extended to involve two additional floors.

The first-arriving engine companies supplied the standpipe and proceeded inside with their high-rise packs. Additional alarms were sounded to muster additional forces for rescue, fire control, and emergency medical services support. A ladder pipe, used to knock down a portion of the fire, was also directed into the East Tower elevator lobbies from the fire floor up to the 16th and 17th floors. Hundreds of people were at their room windows, and fire fighters observed one person jump or fall from the 12th floor.

The fire chief established a command post in the parking lot near the East Tower. An interior command post and medical areas were set up on the seventh floor. Additional divisions were established on the 14th and 20th floors, as well as on the roof.

Fire fighters used the smoke-proof tower and stairway, located in the East Tower, for firefighting operations. Occupants were also using these stairways. Because of the number of fire fighters and equipment necessary for a multi-level attack, these stairways were inadequate. The interior stairway in the East Tower became filled with smoke, due to hose lines entering the hallway from the stairs, blocking the doors in the open position.

Alarm systems were activated, although many occupants reported that they did not hear the alarm. The alarm system in the East Tower may have failed because of electrical problems.

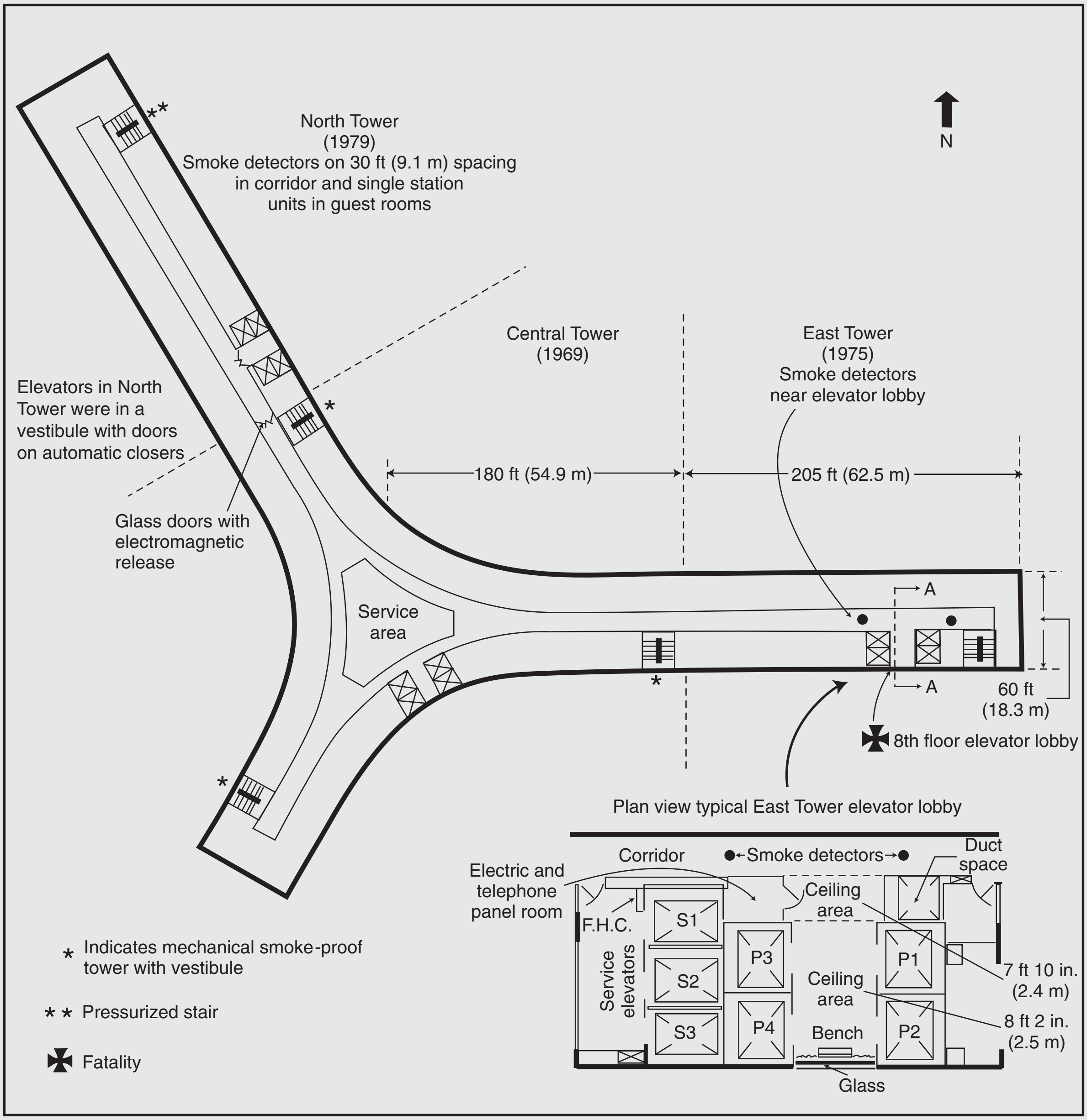

Figure 12-23 Las Vegas Hilton Towers.

The fire department used the voice annunciation component of the fire alarm system to notify guests that fire fighters were on the scene and advised the guests of what actions to take. People trying to evacuate via the stairways encountered smoke, especially those in the East Tower stairs. Some people in the stairways were able to reach the roof, where they were rescued by helicopters. Hotel operators advised guests who called to place wet towels around door openings and wait for the fire department. One person who was trapped in his room reported smoke coming in through the HVAC opening. He heard a sound like a door closing, and the smoke stopped. This undoubtedly was a smoke damper operating.

All East Tower and Main Tower elevators were brought to the first floor and placed on manual control. Three groups of fire fighters used elevators operated by security in the East Tower to reach the seventh floor. A guest using an elevator to evacuate, before it was controlled by the fire department, opened the elevator door on the eighth floor, which was filled with smoke. He crawled down the hallway and knocked on room doors. One door was opened, and he entered and waited out the fire there. Three other people who used the same elevator were found dead in the elevator lobby.

Fifteen hundred people were evacuated from a first-floor showroom without incident.

A total of 23 engine companies, 6 ladder companies, 2 snorkels, 9 rescue units, and 12 aircraft were used during the operation. Forty-eight fire fighters were injured, one suffering a severe heart attack.

Smoke spread throughout the East and Central Towers. The North Tower received little damage, as it was equipped with glass doors at the end of the Central Tower that automatically closed when the fire alarm system was activated.

Figure 12-24 shows the vertical spread of fire up the exterior of the building and the locations of the victims.

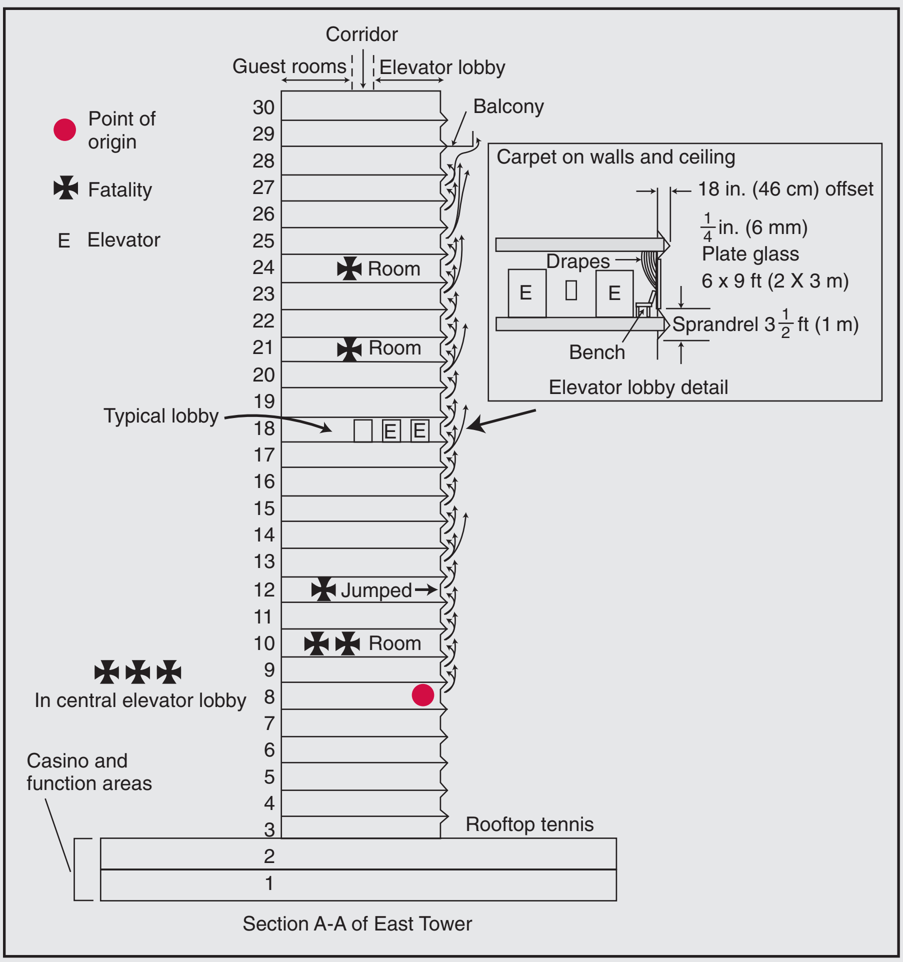

Figure 12-24 Las Vegas Hilton exterior fire spread and location of victims.

TABLE 12-4 Las Vegas Hilton Flame Extension in East Tower Corridor

Floor	Extension of Flame Down Corridor, in ft (m)
8	299 (91)
9	247 (75)
10	181 (55)
11	162 (49)
12	161 (49)
13	174 (53)
14	88 (27)
15	147 (45)
16	143 (44)
17	104 (32)
18	126 (38)
19	90 (27)
20	131 (40)
21	83 (25)
22	75 (23)
23	68 (21)
24	63 (19)
25	65 (20)
26	169 (52)
27	38 (12)
28	302 (92)
29	limited
30	limited

Source: David P. Demers, *Investigative Report on the Las Vegas Hilton Fire*, Quincy, MA: NFPA, 1982, p. 16.

Note that Section A-A of this figure corresponds to Section A-A in the East Tower portion shown in Figure 12-23.

The fire spread varying distances down the hallways of the East Tower, as shown in Table 12-4. The differences were probably the result of the effectiveness of interior fire suppression, lead time, the effect of the exterior ladder pipe, and the nine-foot overhanging balcony on the 29th floor. It is estimated that the exterior vertical spread took 20 to 25 minutes to reach the top of the building.

3. Use the RGB high-rise fire scenario on the following pages to do the following:

A. Size up the fire using the information from this chapter and the size-up factors in Chapter 2.

B. Establish a strategic mode: offensive, defensive, or non-attack.

C. Outline an incident action plan.

D. Assign/reassign companies to tactics and tasks necessary to carry out the incident action plan.

E. Organize the operation using NIMS. Use high-rise positions described in this chapter as necessary, such as stairway support, lobby control, staging, and base.

A sample answer is included. We suggest that you write out your answers and then compare them to the answers included in the text.

Figure 12-25 is the pre-incident plan narrative for the RGB high rise. Figures 12-26, 12-27, 12-28 and 12-29 are drawings showing the floor layout. Use the pre-plan information and scenario to complete suggested activity number 3.

RGB High-Rise Scenario

Assume the role of the IC and retain that role, even though command may change.

Using the alarm card, call whatever assistance you need. Start by using on-duty resources. Then request mutual aid assistance as needed and call back off-duty personnel. Background information:

- Fire report from dispatch:
  "Smoke detector alarms were received from floors 19, 20, 21, 22, and 23, and the 27th-floor equipment room. In addition, telephone calls were received from the 20th floor reporting a fire in the office area. A call from the 21st floor was also received reporting heavy smoke conditions."
- Day/date: Tuesday, August 1
- Time: 1600 hours
- Weather conditions:
  - 90°F (32.2°C)
  - Dew point 75 degrees
  - Partly cloudy
  - Wind from the southwest at 1 mph (1.6 kph)
- The report from Engine 1 is as follows:
  "Engine 1 and Truck 1 are on the scene of a 26-story office building with a working fire. Fire is visible from several windows on an upper floor on the Central Parkway side. We are proceeding to the 18th floor via the main elevator. Engine 1 is RGB command."

  Engine 1 is carrying a high-rise pack including 1¾″ (44-mm) hose to the fire area.

You arrive on the scene at the same time as Engine 2, Truck 2, and the heavy-rescue unit. You notice that Engine 1 has a water supply and that the pump operator is at the apparatus hooking up to the hydrant. The security people approach you and verify that people leaving the 20th floor saw visible flames on the Central Parkway side.

Truck 1's officer is now on the radio:

"Truck 1 reporting that Engine 1 and Truck 1 are hooking up to the standpipe on the 19th floor for a confirmed working fire on the 20th floor. The 20th floor appears to have an open layout and heavy fire. The main elevator is free of smoke and operational."

You ask security, "Who occupies the 20th floor?" Security replies, "*I will get back with you.*" You request that security also find out as much about the floor layout as possible.

You set up command in the first-floor lobby alarm/command room. You notice on the annunciator panel that Floors 19 to the penthouse are in the alarm mode because of smoke detectors activating.

(continues on page 337)

Life Safety/Fire Fighter Safety

Occupancy Type
- **Business occupancy**

Occupant Status
- **Estimated number of occupants**
  - 98% occupancy rate for building on last inspection
  - As many as 9000 occupants during normal business hours (0700 to 1800 hours weekdays)
  - At least two security personnel and sometimes cleaning and maintenance people outside normal business hours
- **Mobility of occupants**
  - Most are highly mobile
  - Places of safe refuge in center core elevator lobbies floors 2 to 25
  - Floor wardens on each floor assigned to assist handicapped employees and visitors
- **Primary and alternative egress routes**
  - 3 stairways (see floor plans)
  - DOORS FROM STAIRWAYS TO HALLWAYS AUTOMATICALLY LOCK WHEN CLOSED–THERE IS NO RE-ENTRY FROM THE STAIRWAY SIDE.

Operational Status
- **Rescue options**
  - Stairways
  - Ladders will not reach beyond eighth floor
- **Access to building exterior**
  - Streets on three sides
  - Attached parking garage on "D" side
- **Access to building interior (forcible entry)**
  - Open during business hours
  - Front entry locked after 2000 hours, and on weekends and holidays
  - Security has keys to public areas and a few businesses
  - Security maintains log of people entering and exiting building from 2000 to 0600 hours and on weekends
  - Most doors leading to office areas are alarmed to an off-site security provider
  - Elevator keys located with standpipe pressure-regulating valve tool in special case in the first-floor lobby command room

Structure
- **Collapse zone**
  - Highly improbable collapse
  - Beware of debris and glass falling from upper floors
- **Construction type**
  - Fire-resistive core construction
- **Roof construction**
  - Builtup roof on concrete slabs supported by heavy metal trusses
  - Trusses protected with fire-resistive coating

Figure 12-25 RGB high rise pre-incident plan narrative.

- **Condition**
  - Last inspection revealed minor fire code violations including fire extinguisher inspections out of date
  - Building generally well maintained
- **Live and dead loads**
  - Offices tend to have a slightly higher than average live load
  - Storage area on Floor 26 has large live load
  - Mechanical room on Floor 27—large air handling equipment—a substantial dead load
- **Enclosures and fire separations**
  - Basement and sub-basement are open layout
  - First-floor lobby open layout with fire separated restaurant and bank
  - Monumental–open stairs between first- and second-floor lobbies
  - Floors 3 to 25 vary in layout. Most are open layout with six-foot cubicles separating work stations. Some floors have offices separated by walls that go from floor to suspended ceiling. Area between suspended ceiling and ceiling a common plenum on every floor.
- **Extension probability**
  - No fire separations except elevators and stairways to prevent fire from extending to involve entire floor on most floors
  - Heavy fire-resistive construction between floors with utility openings
- **Concealed spaces**
  - Area between suspended ceiling and actual ceiling
  - Telephone cables contained in cabinets on each floor—not sealed between floors
- **Age**
  - Built in 1970
- **Height and area**
  - 26 stories (no 13th floor)—Roof 316′ (96 m) above grade
  - Basement, sub-basement, and floors one to three 145′ × 185′ (44 m × 56 m)
  - Ceiling height 10′ (3 m) on all floors except basement and sub-basement (9′ [2.7 m]) and first floor (30′ [9 m])
  - Tower floors 4 to 27—60′ × 160′ (18 m × 49 m)
- **Complexity and layout**
  - See drawings
  - Core construction

Extinguishment

- **Probability of extinguishment**
  - Once fire involves a major part of open layout floors a large rate of flow will be required using multiple 2½″ (64-mm) hose lines (see rate of flow).
- **External exposures**
  - Exterior exposures are low-rise buildings with street separating buildings from RGB.
  - Primary extension is via burning debris.
- **Internal exposures**
  - The attached garage
  - Three-story buildings on Side "D"
  - Floor-to-floor extension possible via utility openings in floors
  - Floor-to-floor extension possible via fire venting out windows
- **Manual extinguishment**
  - **Fuel load**
    - Slightly above average fuel load in offices
    - Heavy fuel load in storage areas on 26th floor
    - Low to moderate fuel load in lobby, basement, sub-basement, and 27th floor
- **Calculated rate-of-flow requirement**
  - Flows are the maximum flow requirements with deductions for enclosures such as elevators and stairs.
  - Basement and sub-basement V/100 = 2000 GPM (126 L/sec)
  - First-floor lobby V/100 = 4500 GPM (284 L/sec)
  - First-floor bank V/100 = 480 GPM (30 L/sec)
  - First-floor restaurant V/100 = 320 GPM (20 L/sec)
  - Second-floor lobby V/100 = 920 GPM (58 L/sec)
  - Floors 4 to 27 with open layout V/100 = 960 GPM (61 L/sec)
  - Third floor has compartmented offices and some tower floors are sub-divided into smaller compartments. Areas not listed are within the capacity of two 125-GPM (8 L/sec) standpipe hose lines (250 GPM [16 L/sec]).
  - Garage (all levels) V/100 = 760 GPM (48 L/sec)

Figure 12-25 RGB high rise pre-incident plan narrative, *continued.*

- **Water supply**
  - 20,000 GPM (1262 L/sec) available from primary water supply
  - Can be cross-tied to the Eastern Hills supply for an additional 20,000 GPM (1262 L/sec)
  - Hydrants are located on each side of the building
  - Hydrants in the business district are located on each corner with an additional hydrant in the middle of the block
- **Apparatus pump capacity**
  - Pumpers have a minimum 1000 GPM (63 L/sec) pump, some have 1250 GPM (79 L/sec) pumps
  - Aerial apparatus are not equipped with fire pumps
- **Manual fire-suppression system**
  - Standpipe system with discharge on every floor in central core (see drawing)
  - 1000 GPM (63 L/sec) standpipe diesel pump located in basement
  - Fire department connection on Vine Street side (see drawing)
  - Field-adjustable pressure-regulating valves set to 100 psi (690 kPa)
  - Pressure-regulating valve tool located with elevator keys in special case in the first-floor lobby command room
- **Automatic fire suppression equipment**
  - No automatic sprinkler system
  - Dry chemical kitchen hood system in restaurant

Property Conservation

- **Salvageable property**
  - Computer equipment, business records, and furnishings located throughout building
- **Water damage**
  - **Probability of water damage**
  - **Susceptibility of contents to water damage**
    - High probability
    - Computers and business records very susceptible to water damage
- **Water pathways to salvageable property**
  - Utility holes in floors, stairs, elevators
- **Water removal methods available**
- **Water protective methods available**
  - Per standard SOPs
- **Smoke damage**
  - **Probability of smoke damage**
    - Smoke will migrate upward, but automatic dampers and strong compartmentation will retard spread
  - **Susceptibility of contents to smoke damage**
    - Office furniture and computer equipment very susceptible
- **Damage from forcible entry and ventilation**
  - Secured areas will require considerable force to enter
  - HVAC not reliable under fire conditions (shut down)
  - Venting will involve breaking windows which will endanger fire fighters and civilians at grade level

General Factors

- **Total staffing and apparatus available**
  - See alarm card—each company staffed by an officer, driver, and two fire fighters

Alarm	Engine Companies	Truck Companies	Others
First	1, 2, 3, and 4	1 and 2	Heavy Rescue, District Chief 1
Second	5, 6, 7, and 8	3 and 4	District Chief 2, ALS 1
Third	9, 10, 11, and 12	5	Chief of Department, 4 Assistant Chiefs
Fourth	13, 14, 15, and 16	6	Five additional District Chiefs from Administrative staff, ALS 2, BLS 1
Fifth	17, 18, 19, and 20	7	Air Supply Truck, Command Vehicle

Fire department has a total of 25 engine companies, 13 ladder companies, 2 heavy rescue companies, 7 BLS and 4 ALS units.
Mutual aid is available from 50 fire departments in the county with an additional 123 engines, 22 aerials/platforms, and 41 heavy-rescue companies.
Approximately 500 off-duty fire fighters can be recalled via a telephone-relay system.

- **Utilities (water, gas, electric)**
  - Main electric in sub-basement DO NOT ATTEMPT TO DE-ENERGIZE
  - Gas and water street valves on Court Street
  - Gas and water meter equipment in basement

Figure 12-25 RGB high rise pre-incident plan narrative, *continued.*

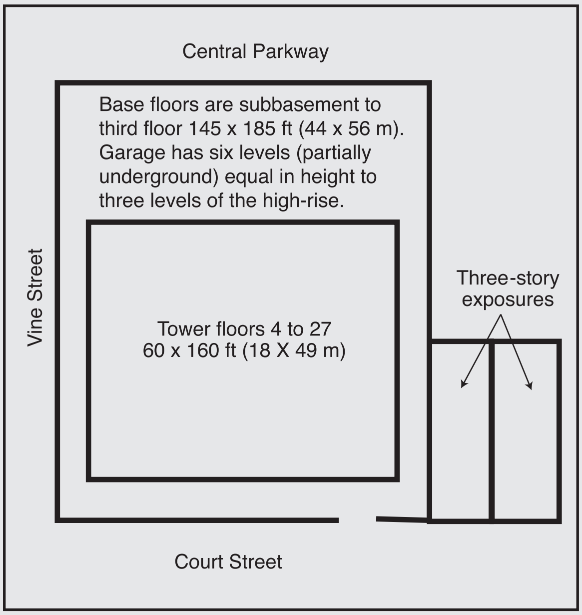

Figure 12-26 RGB high rise plan view, lower levels.

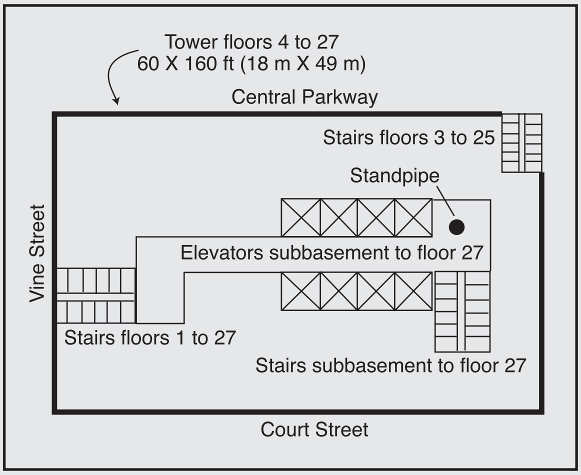

Figure 12-27 RGB high rise plan view, upper levels.

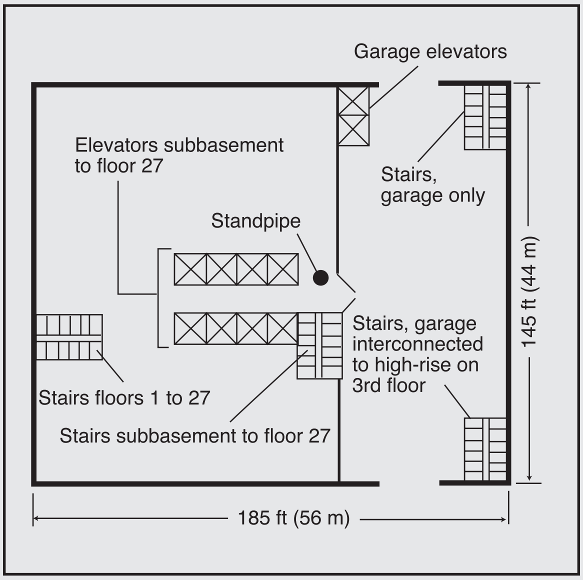

Figure 12-28 RGB high rise typical floor plan. Floors 1 to 3 of high rise, floors 1 to 6 of garage.

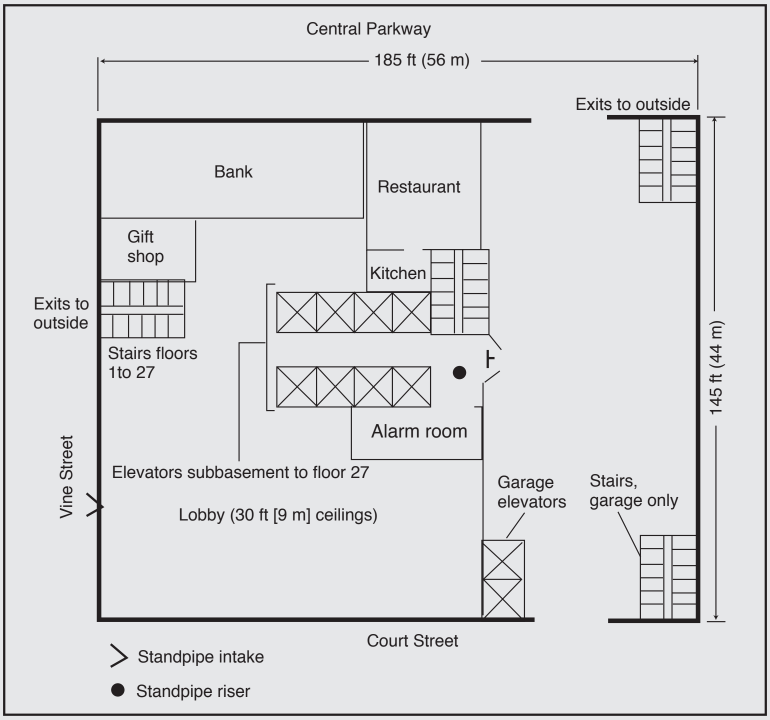

Figure 12-29 RGB high rise, first floor.

It is now 1608 hours. You strike the second alarm, and Engines 3 and 4 are approaching the command post. The heavy-rescue unit is in the elevator lobby, and all of the elevators have been recalled to the first floor. The heavy-rescue unit is assuming its normal role as the rapid intervention team.

Engine 1 is now reporting back to the command post via radio:

"Engine 1 and Truck 1 are now on the 20th floor. We estimate the fire to cover the entire Central Parkway side of an open-layout floor plan. We have heavy smoke throughout the floor. Our 1¾" (44-mm) line is not making progress on the fire. We need 2½" (64-mm) fire lines on the 20th floor."

Truck 1 is now reporting back to the command post via radio:

"On the way up to the 20th floor we ran into at least 10 people evacuating via the stairway. The occupants looked okay, but a few were coughing. The stairway has moderate smoke from the 19th floor to at least the 21st floor."

Now that you have reviewed the RGB high-rise building pre-incident plan and fire problem information, answer suggested activities 3A through 3E (page 332). After you complete suggested activity 3, compare your written responses to the sample answers on the following pages.

4. Use the RGB high-rise scenario, but change the situation and occupancy to see what effect these changes would have:
- Place the fire in a residential occupancy for the elderly.
- Place the fire in a hotel.
- Change the situation:
  - Elevators are out of service.
  - The fire area is subdivided into small office areas.
  - The fire occurs on Sunday afternoon in an office building.

- The building is protected by a working sprinkler system.
- There are heavy smoke conditions on the fire floor and above.

Sample Answer to the RGB High-Rise Problem

Size-Up

Life safety/fire fighter safety

- **Smoke and fire conditions**
  - **Fire location**
    - 20th floor
  - **Direction of travel**
    - Will involve remainder of 20th floor if not extinguished
    - Possibility of extension upward via utility openings or via building's exterior
- **Ventilation status**
  - Self-vented on 20th floor
  - Smoke may migrate upward through building
- **Occupancy type**
  - High-rise office building
- **Occupant status**
  - Estimated number of occupants
    - The office building is probably fully occupied, given the time of day and the day of the week.
- **Evacuation status**
  - Self-evacuation has begun, but the status and number of occupants remaining in the building are unknown.
  - Office occupancy density can be one person per 100 ft^2 (9 m^2), or 96 people per floor on the 20th (fire floor) through 25th floors, or nearly 600 people.
  - Floors 26 and 27 are equipment and storage areas.
  - The elevators have been recalled to the ground floor and are under fire department control.
- **Occupant proximity to fire**
  - Occupied floor
- **Awareness of occupants**
- **Mobility of occupants**
  - Occupants should be alert, and most are mobile
- **Occupant familiarity with building**
  - Occupants should be somewhat familiar with the building but probably do not routinely use the stairs
- **Primary and alternative egress routes**
  - Three stairways are the only viable means of egress
- **Medical status of occupants**
  - It appears that the few occupants encountered have minor smoke inhalation.
  - Additional EMS will be needed to treat and possibly transport many potential occupants exposed to smoke and toxic gases.

Operational status

- **Adherence to SOPs**
  - On-scene companies appear to be following SOPs related to standpipe operations
  - Using an elevator that reaches/penetrates the fire floor, without first confirming that the 18th floor is clear of fire and smoke, could prove to be deadly. Dismounting the elevator two floors below the fire is proper, but given the circumstances, the fire could be on a lower floor or the heavy fire conditions could be affecting the elevators.
  - Engine Company 1's officer is acting as the IC.
- **Fire zone/perimeter**
  - PPE needed on fire floor and above
  - Beware of falling glass and debris.
  - Place exterior fire fighters in sheltered areas.
  - Maintain a fire perimeter of at least one additional block in all directions.
- **Accountability**
  - Accountability has not yet been established but is needed.
- **Rapid intervention**
  - A rapid intervention crew (RIC) has been formed.
- **Organization and coordination**
  - Engine 1's officer established command.
  - Command transferred to District Chief 1.
  - Need to establish tactical level management units per NIMS.

- **Rescue options**
  - The only realistic rescue option available is evacuation via the three interior stairways.
- **Staffing needed to conduct primary search**
- **Staffing needed to conduct secondary search**
- **Staffing needed to assist in interior rescue/evacuation**
  - Primary and secondary searches are needed for the fire floor and all floors above.
  - A complete evacuation may be ordered.
  - Companies should be assigned as follows:
    - One company to the floor below the fire
    - One to the fire floor
    - One to each floor above
  - The actual staffing needed to accomplish the life safety priority is highly dependent on how many people have escaped and smoke conditions on the upper floors. Moderate smoke conditions have been reported in the stairway. Initially allow five to nine companies to search the fire floor and floors above.
- **Staffing needed for exterior rescue/evacuation**
  - None at this time, low priority
- **Apparatus and equipment needed for evacuation**
  - Interior evacuation, no apparatus or rescue equipment needed
- **Access to building exterior**
  - Access on three sides
  - Keep non-operating apparatus outside fire perimeter
- **Access to building interior (forcible entry)**
  - Building open for business, little need for forcible entry except possibly from stairways to floor areas

Structure

- **Signs of collapse**
- **Collapse zone**
  - Structural stability is not an immediate problem
- **Construction type**
  - New high-rise (fire-resistive) central core construction
  - Will withstand a considerable fire
- **Roof construction**
  - Sound roof structure
  - Not a factor; fire is many floors below the roof
- **Condition**
  - Well maintained
- **Live and dead loads**
  - Above average live load in 26th-floor storage area
  - Large dead load in 27th-floor mechanical room
  - 26th and 27th floors are not an immediate concern
- **Water load**
  - Possibly a factor
- **Enclosures and fire separations**
- **Extension probability**
  - Fire-resistive construction should contain main body of fire to the fire floor.
  - Need at least one precautionary hose line on the floor above the fire.
- **Concealed spaces**
  - Between suspended ceiling and actual floor/ceiling assembly
- **Age**
  - New-style planar construction
- **Height and area**
  - 26 stories
  - Large, undivided area on fire floor
- **Complexity and layout**
  - Elevators, stairs, and standpipe locations uniform throughout building
  - Work areas separated by cubicles—large floor area could be confusing and requires team search

Extinguishment

- **Probability of extinguishment**
  - The heavy volume of fire means that it will take time to amass the force necessary for extinguishment.
  - Further extension and the continued production of smoke and toxic gases are likely.
- **Offensive/Defensive/Non-attack**
  - A sizable offensive attack is warranted.
- **Ventilation status**
  - Self-vented in fire area
  - May need to ventilate other floors

Wrap-Up, continued

- **External exposures**
  - The fire is self-venting; external exposures are well below the fire floor.
  - Falling debris could ignite buildings in area.
- **Internal exposures**
  - There is a possibility of internal extension.
- **Manual extinguishment**
- **Fuel load**
  - Above average fuel load in fire area
- **Calculated rate-of-flow requirement**
  - The pre-incident plan indicates that 960 GPM (61 L/sec) is needed to extinguish the fire as reported by Engine 1. Pressure-regulating valve tool located with elevator keys in special case in the first-floor lobby command room.
- **Number and size hose lines needed for extinguishment**
  - The only line being used at present is a 1¾″ (44-mm) line at approximately 125 GPM (8 L/sec), leaving a deficit of 835 GPM (53 L/sec).
  - This is a definite "big water" fire; therefore, 2½″ (64-mm) lines are needed. Three 2½″ (64-mm) lines plus the 1¾″ (44-mm) line already deployed should be enough to provide the 960-GPM (61 L/sec) fire flow.
  - The use of straight- or solid-stream nozzles are needed for reach and to avoid wrap-around fires. However, the fire appears to be self-vented, reducing the possibility of a wrap-around situation occurring.
- **Additional hose lines needed**
  - Additional hose lines are needed to back up the attack on both the 20th and 21st floors.
- **Staffing needed for hose lines**
  - Staffing should be at least three fire fighters per attack line (assign a full company to each attack line).
  - For each attack position there should be two crews in reserve to maintain a continuous attack.
- **Water supply**
  - More than adequate
- **Apparatus pump capacity**
  - Only need one pumper to supply fire department connection
- **Manual fire suppression system**
  - Connecting to the standpipe system below the fire floor will provide a marginal water supply with little reserve.
  - The building's 1000-GPM (63 L/sec) fire pump should be augmented by pumping into the fire department connections.
- **Automatic fire suppression equipment**
  - No sprinkler protection.

Property conservation

- **Salvageable property**
- **Location of salvageable property**
  - Computers and records storage are high-value items that are located throughout the structure.
- **Water damage**
  - **Probability of water damage**
    - Heavy water damage is likely on the 19th floor. Tarps should be used to cover equipment and channel water from the building.
  - **Susceptibility of contents to water damage**
    - Computers and records are highly susceptible to water damage.
  - **Water pathways to salvageable property**
    - Utility openings in floors
    - Stairs
    - Elevators (do not use for water removal)
  - **Water-removal methods available**
    - Chutes to stairway
    - Using toilet as temporary drain
    - Water vacs
  - **Water-protective methods available**
    - At least two companies will be needed to cover equipment and to channel water from the building.
- **Smoke damage**
  - **Ventilation status**
    - Self-vented on fire floor
    - Will need to vent other areas
  - **Probability of smoke damage**
    - Smoke damage is likely on the floors above the fire.

- **Susceptibility of contents to smoke damage**
  - Office furniture and electronic equipment sensitive to smoke
- **Damage from forcible entry and ventilation**
  - Little forcible entry needed
  - If necessary to vent via windows, expect window damage.
  - Considering the life safety problem, damage from venting or forcible entry is justified.

General factors

- **Total staffing available versus staffing needed**
  - Four engine companies, two truck companies, one heavy rescue, and 1 district chief responded on the first alarm.
  - Engine 1 and Truck 1 are already committed to the fire floor for fire extinguishment.
  - One company per floor is needed to conduct a primary search of the 19th and 20th floors.
  - One additional company is needed to back up the fire attack team on the 20th floor.
  - At least one company is needed on the 21st floor to protect internal exposures. This company may also be able to conduct a primary search of the 21st floor.
  - Additional search-and-rescue teams should be assigned to the lower floors (17 and below).
  - A property conservation team should be assembled.
  - A minimum of 13 companies are needed to provide initial primary search and extinguishment activities.
  - Personnel are needed to fill staff positions: safety, planning, division 20, search-and-rescue group, and staging (interior staging).
  - Search and rescue on floors below the fire floor, staging, and property conservation may require additional staffing, depending on initial success.
  - Additional EMS response of at least five units is needed. (Only one unit is responding.)
- **Total apparatus available versus apparatus needed**
  - Only need one pumper to supply standpipe
- **Staging/tactical reserve**
  - Staging needs to be established. (This could require as many as ten companies to provide the fire fighters needed to provide a continuous fire flow on the 20th floor.)
- **Utilities (water, gas, electric)**
  - Located in basement and sub-basement
  - Do not attempt to interrupt power supply.
- **Special resource needs**
  - Police to maintain fire perimeter.
  - Additional EMS units
  - Large supply of air cylinders
- **Time**
  - The time of day is 1600 hours.
  - The day of the week is Tuesday. Anticipate the building being occupied at full capacity.
  - Traffic will be moderate to heavy at this time of day.
  - Daylight will provide light for operation should the power fail.
- **Weather**
  - It is hot and humid with a light breeze.
  - Negative stack effect is possible.
  - If the HVAC system is shut down, conditions will become very uncomfortable inside.

Incident Action Plan

Primary Objectives

1. Initiate an aggressive interior fire attack on the fire floor.
2. Conduct a primary search on the fire floor and the floors above.
3. Check for fire extension on the floors above the fire.

Secondary Objectives

4. Conduct a primary search on floors below the fire.
5. Conduct a secondary search of fire floor and floors above the fire.
6. Conduct a secondary search of floors below the fire.
7. Initiate property-conservation operations.

Wrap-Up, continued

Assignments

- Engine Company 1 initially assumed a fast-attack incident command until relieved by District 1. On arrival of the fire chief, District 1 transferred command to the fire chief. The fire chief assigned District 1 as the planning section chief.
- Engine Company 1's officer was initially the Division20 leader. This assignment was transferred to District 2.
- Engines 1, 2, 3, and 4 and Truck 1 are attacking the fire on the 20th floor. Engine 9 is staffing the backup line on the 20th floor. These companies, under the direction of District 2, make up Division 20.
- The heavy-rescue company is assigned as the RIC and located on the 18th floor.
- A search-and-rescue group is being supervised by Assistant Chief 1.

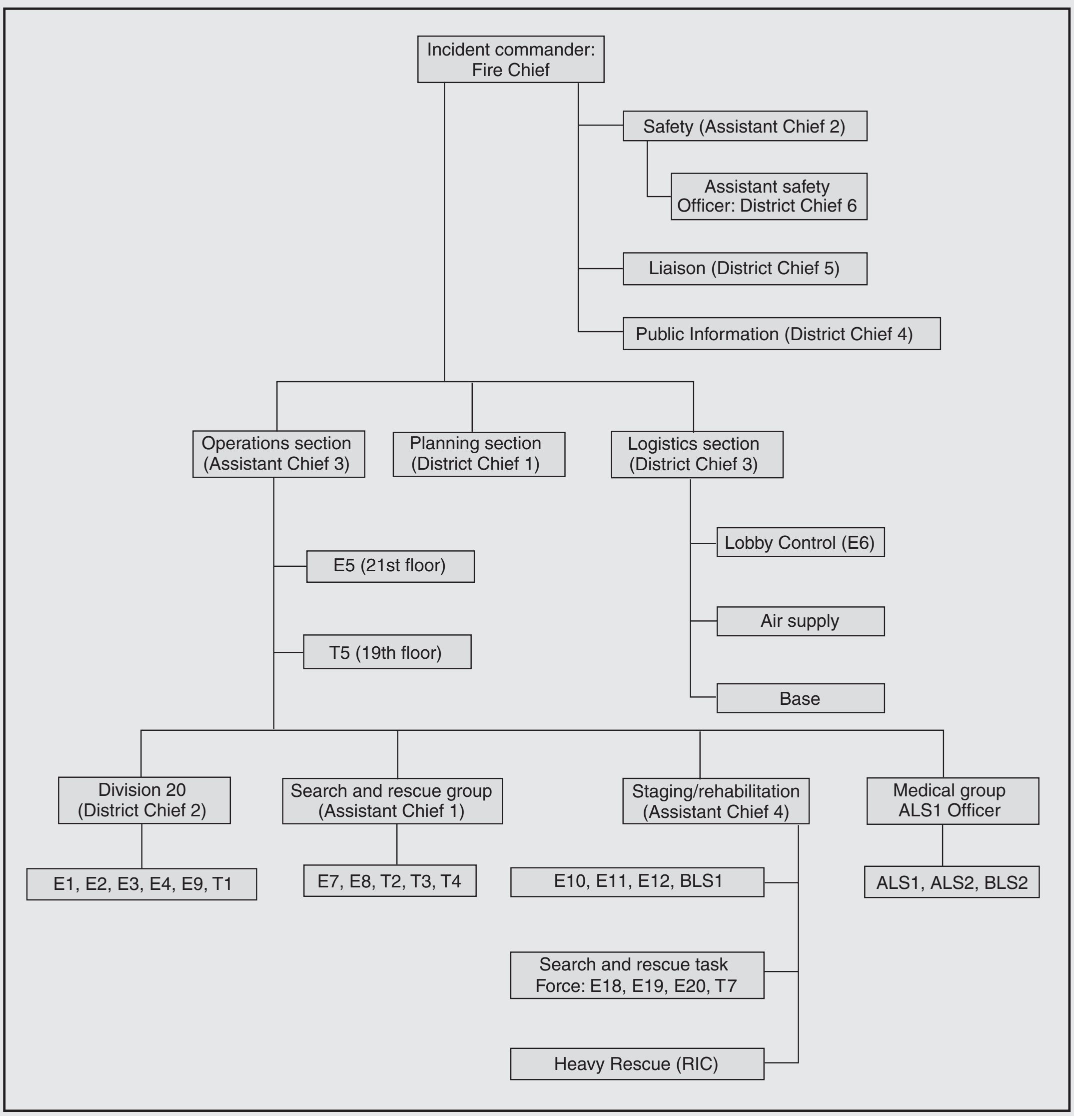

Figure 12-30 RGB high-rise fire: NIMS organizational chart.

- Truck 2 begins search-and-rescue activities at the 21st floor and works upward.
- Engines 7 and 8 and Trucks 3 and 4 are also assigned to the search-and-rescue group.
- Engine 5 is assigned to the 21st floor for extinguishment. Engine 5 is Division 21.
- Engine 6 is assigned the dual duties of lobby control and accountability. Engine 6 is located in the lobby.
- ALS 1 and additional EMS units are providing medical treatment in the lobby. ALS 1 is the Medical Group leader.
- Truck 5 is assigned to search-and-rescue duties on the 19th floor. Truck 5 is Division 19.
- Assistant Chief 2 is assigned as the safety officer.
- Assistant Chief 3 is assigned as the operations section chief.
- Interior staging is set up on the 18th floor with Assistant Chief 4 in charge of staging. Engines 10, 11, and 12 and BLS 1 are located in the 18th-floor staging area.
- District Chief 3 is assigned as the logistics chief with the following subordinate units reporting:
  - Lobby control
  - Air supply
  - Base (exterior staging)

  If the fire is under control when three alarm companies are in place, reassignment of companies to REHAB and property conservation is possible. The IC may also elect to re-assign personnel to check conditions on lower floors.

If necessary, augment the primary search effort by rotating the original search-and-rescue companies through REHAB with at least four additional companies handling the secondary search assignment: Engines 18, 19, and 20 and Truck 7.

Air truck personnel are assigned to work with lobby-control personnel to move air cylinders to the 18th floor via elevators, provided the elevators are found to be safe for fire department use.

The four remaining district chiefs are assigned to command staff, groups, and divisions as needed. District Chief 4 is assigned as the public information officer, District Chief 5 as the liaison officer, District Chief 6 as the assistant safety officer, and District Chief 7 as the property conservation group supervisor. Property conservation is not yet assigned; therefore, the property conservation group is not shown in the NIMS chart in Figure 12-30.

There are many correct ways to organize this operation using NIMS. It is important to use the correct terminology, maintain a reasonable span of control, and account for all companies.

Wrap-Up, continued

Chapter Highlights

- Tactics and strategic objectives used in high-rise firefighting are the same as those that apply to any other structure fire, but with special considerations because of the height of the building.
- High-rise fires are some of the most challenging incidents a fire department encounters because of the high occupant load and building height/configuration.
- Pre-incident planning, code enforcement, use of NIMS, and developing high-rise SOPs improve the chance for successful operations in high-rise buildings.
- Logistics and access problems increase with building height.
- Elevators should not be used for evacuation except under special circumstances and only with fire fighter supervision.
- Avoid using elevators unless they will substantially improve operations, and even then, use with extreme caution.
- During a structure fire, never use an elevator to travel to or above the fire floor; exit the elevator at least two floors below the fire.
- All elevators should be under the control of fire fighters.
- When in doubt about the safety of elevators a possible option is to use the elevator to send equipment (rather than personnel) to the floors above.
- Getting fire fighters and equipment to an interior staging area via stairs is essential when elevators are unsafe or unavailable and returning to ground level is impractical.
- Stairway transport of equipment is done via relay (stairway support) to conserve personnel.
- When the fire is on an upper floor of a high-rise building interior staging should be set up two or more floors below the fire.
- Simple marking techniques indicating areas where the primary search is complete are essential to an efficient search-and-rescue operation.
- Tools for forcible entry should be carried to assist in eliminating barriers to evacuation (e.g., locked doors) and to facilitate access to locked areas.
- Helicopter rescues are extremely dangerous and usually unnecessary; alternate, superior tactics are usually available.
- Partial or sequential evacuation can reduce stairway congestion, but could also delay evacuation.
- Emergency Voice/Alarm Communications Systems (EVACS) are available in some buildings, but occupants do not always follow the instructions given.
- Most exterior defensive fire control tools are ineffective above the eighth floor.
- Fire forces must prevent fire extension into the stairways, which are the safest, most effective, and sometimes the only available, egress routes.
- Pressure-reducing valves and fire pumps both affect standpipe hose pressures.
- Pumping into the fire department standpipe connections can assist internal fire pumps and is a good practice.
- Due to large numbers of people and other distractions in the lobby, a high-rise lobby may be a poor choice for a command post.
- A command post's location should be transmitted to all responders regardless of whether it is inside or away from the building.
- Special considerations during a high-rise fire include elevator operations and elevator key location; access/egress issues; logistics, staging, and standpipe operation; floor layouts; ventilation; and procedures and operations unique to the building.
- Subtle differences in interior building configurations can have a major impact on firefighting and rescue operations.
- Weather conditions, fire intensity, stack effect, wind, and atmospheric pressure can have a significant effect on smoke movement within a high-rise structure.
- Ventilation is crucial in a high-rise fire, though often very difficult to perform.
- Dedicating a stairway with standpipe outlets for firefighting reduces the possibility of opposing lines on the fire floor.
- To avoid exposing people and equipment at ground level to falling hazards, a wide fire perimeter is essential.
- Communications is the most frequently cited problem during major emergency operations.
- High-rise tactical worksheets can be used to assist with planning functions and accountability.
- Controlling the lobby, elevators, stairways, and HVAC, facilitates both fire fighter access to, and successful evacuation of, the upper floors of a high-rise building.

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