FIRE AND RESCUE DEPARTMENTS
OF NORTHERN VIRGINIA

FIREFIGHTING AND EMERGENCY
OPERATIONS MANUAL

HIGH-RISE BUILDING FIRES

Third Edition

Issued: June 2002
Revised: September 2022

ACKNOWLEDGMENTS

The third edition of the *High-Rise Building Fires* manual was developed through a cooperative effort from the following Northern Virginia fire departments:

- City of Alexandria
- Arlington County
- City of Fairfax
- Fairfax County
- Fauquier County
- Fort Belvoir
- Fort Myer
- Loudon County
- City of Manassas
- City of Manassas Park
- Marine Corps Base Quantico
- Metropolitan Washington Airports Authority
- Mount Weather Fire and Rescue Department
- Prince William County
- Stafford County

The NOVA Fire Operations Board and a group of subject-matter experts developed the first edition of the *High-Rise Building Fires* manual (released in June 2002). The Technical Writing Group revised the manual in March 2012, and the NOVA Fire Operations Board approved and published a second edition.

The Technical Writing Group developed the *Midrise Building Fires* manual in December 2012, and the NOVA Fire Operations Board approved and published the first edition.

The NOVA Fire Operations Board oversaw the consolidation of content from these two manuals into this third edition of the *High-Rise Building Fires* manual with content developed by the Technical Writing Group.

PREFACE

Northern Virginia has several hundred high-rise and midrise buildings, with many more under construction or in the planning stages. Preplanning enables personnel to familiarize themselves with the wide variety of building layouts, sprinkler systems, standpipes, fire detection systems, and fixed fire suppression systems. Remarkably, a significant number of residential and commercial high-rise buildings in the region have nothing more than a standpipe for fire protection. Many midrise buildings are not equipped with standpipes.

Leaders at each fire station should ensure that preplans exist for high-rise and midrise buildings in their area. Where possible, a copy should be available in the fire control room at each building.

Fires in high-rise and midrise buildings present some of the most challenging incidents to which fire department personnel respond. These incidents pose a high risk for loss of life and can require substantial resources to evacuate building occupants.

The purpose of this manual is to

- describe the differences between residential and commercial high-rise and midrise buildings,
- identify the construction features and firefighting problems associated with fires in these buildings,
- identify risks and hazards unique to high-rise and midrise building fires,
- provide guidance to company officers directing and coordinating fire attack and support activities, and
- identify and establish assignments for apparatus responding to initial and subsequent alarms.

Significant changes from the original manual include

- a glossary,
- an expanded discussion of pressure-regulating devices,
- an expanded discussion of water supply and fire department connection operations,
- the addition of standpipe hoseline deployment content related to the advantages of flow meter use and considerations associated with gated wyes,
- an expanded discussion of water supply for hoseline deployment to the floor above a fire,
- the requirement for all engine companies to bring hose packs to the incident scene, and
- the consolidation and inclusion of content from the *Midrise Building Fires* manual.

GLOSSARY

The following key terms and definitions were used in this manual:

Access stairs – Access stairs are open, unprotected stairs in a multistory building that connect two or more floors for the same occupant space. The stairs allow tenants to move among their floors without using public stairs or elevators. These are also called "accommodation stairs" and "convenience stairs."

Annunciator panel – An annunciator panel is a unit containing one or more indicator lamps, alphanumeric displays, or other equivalent means of providing status information about a circuit, condition, or location (e.g., pull station, duct detectors). Additionally, the panel may indicate the status of one or more building systems (e.g., sprinkler water flow, fire pump, emergency generator)

Atrium – This term refers to a multistory open vertical space within a building. Atriums are typically located at the building's main entrance and serve as a focal point.

Cast-in-place concrete – This concrete remains in the location where it is poured and includes plain, reinforced, and post-tensioned concrete.

Center-core construction – In buildings with center-core construction, elevators, stairwells, mechanical rooms, and most utilities are located in the building's core. Office or residential space comprises the floor's perimeter.

Cold smoke – This term refers to the light-colored lazy-moving smoke typically generated by a sprinkler response to a small fire. After water from the sprinkler knocks down the fire, smoldering materials emit cold smoke that has little heat but still carries carcinogens, carbon monoxide, and unburnt fuel molecules.

Curtain wall – A curtain wall is a non-load-bearing enclosing wall located on the outside of a structure that is connected to and supported by the structural members of the building.

Express elevator – This is an elevator that travels at least part of the time in a blind shaft that bypasses numerous floors to stop only at upper floors. Express elevators may also stop at an upper elevator lobby where occupants can access elevators to the floors above. In a tall building, express elevator arrangements provide occupants quicker access to upper floors.

Fire control room – This term refers to a dedicated room for housing fire protection system information and controls. This room usually provides information about and sometimes control of other building systems, including communications, air handling, and elevators. The Virginia Uniform Statewide Building Code refers to the fire control room as the fire command center.

Fire phone – Fire phone refers to telephone communication systems distributed throughout a building for fire department communications. Phones are located in elevator cars, floor lobbies, and stairwell landings on each floor. A fire phone's off-hook status triggers a notification via its indicator in the fire control room.

Freight elevator – A freight elevator is usually larger than passenger-only elevators and is designated for carrying goods. Most are designed to carry both goods and people.

High-rise building – A high-rise building is a building with either six or more stories or a building where the highest occupied story is located more than 75 ft above the lowest level of fire department vehicle access.

Isolated stairs – Isolated stairs are stairs that do not serve all building floors.

Low-mass concrete – This term refers to concrete consisting of up to 20% air to reduce its density. In low-mass concrete, alternative aggregates (e.g., foam polystyrene balls, shale, clay, vermiculite, pumice, and scoria) combine with traditional aggregates (i.e., stone and sand) to create a finished product that is 10–88% lighter than traditional concrete, depending on the mixture's proportions.

Mushrooming – Mushrooming occurs when smoke reaches the ceiling or other overhead obstruction that forces it to move laterally toward the walls. When mushrooming smoke reaches the walls, it banks down toward the floor.

Public address system – A public address system allows fire control room personnel to collectively communicate with occupants of a single floor, combination of floors, or the entire building. Speakers are located in hallways, elevators, stairwells, rooms or tenant spaces exceeding 1,000 sqft, and all dwelling units. The PA system speakers can also be used to sound an alarm to assist in an evacuation operation.

Plenum – This term refers to a void between the ceiling (usually a drop ceiling) and the underside of the floor above. A plenum typically houses components of the heating, ventilation, and air-conditioning system, along with other electrical and communication systems.

Precast concrete – Precast concrete is poured at a location other than where it will be used. It includes plain, reinforced, and pretensioned concrete.

Protect-in-place – This firefighting strategy involves leaving building occupants in the area they occupied prior to the fire outbreak. The area should present no immediate threat to their survival, and efforts to relocate them should pose a greater threat to safety than leaving them in place. Protect-in-place may also be used while waiting for a fire department to secure the resources needed to safely remove the occupants.

Reinforced post-tensioned concrete – A type of prestressed concrete where the concrete is strengthened via a reinforced arrangement held in tension. Steel cables, called post-tensioning tendons, are placed in plastic sleeves and positioned inside the concrete formwork before the concrete is poured. After the concrete is poured and has sufficiently strengthened, the cables are pulled at either end (i.e., tensioned) and anchored on the concrete's outer edges.

Reinforced pretensioned concrete – To make reinforced pretensioned concrete, high tensile steel strands are stretched tightly between the ends of a form. Concrete is then poured. As it sets, it bonds to the steel. When the concrete reaches a specified strength, the strands are released from the ends of the form, allowing them to draw back and compress the concrete. This creates a thinner end-product that can withstand tensile stresses.

Reverse stack effect – This occurs when air moves downward inside a tightly sealed building due to the temperature difference between the air inside and outside the building. The taller the building, the greater the effect. When the air outside the structure is hotter than inside, the structure draws warmer air in from higher openings and pushes cooler air out of the lower openings. Fire does not cause reverse stack effect, but the products of combustion ride its currents.

Stack effect – This occurs when air moves upward inside a tightly sealed building due to the difference in temperature between the air inside and outside the building. The taller the building, the greater the effect. When the air outside the structure is colder than inside, it draws air in from lower openings and pushes hotter air out of the higher openings. The fire does not cause stack effect, but the products of combustion ride its currents.

Stratification – Stratification occurs when fire gases separate into layers according to temperature. The gases with the highest temperatures move to the top layers, and the cooler gases move to the bottom layers. This is also called "thermal layering" or "thermal balance."

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DESCRIPTION – HIGH-RISE BUILDINGS

In February 1976, the Virginia Uniform Statewide Building Code was modified to require a fire control room in buildings with occupied floors located more than 75 feet above the lowest level of fire department vehicle access. Fires that occur in structures with fewer floors, or a lower building height, can still present the same challenges experienced in much taller buildings. A building with four or more stories with at least one standpipe and one elevator may require the same tactical considerations as a high-rise, but it may not have the same built-in fire protection systems.

General Characteristics

High-rise buildings exist throughout Northern Virginia. These buildings vary greatly in height, ranging from six or seven stories to structures exceeding 30 stories. Most were built using fire-resistive construction, but the fire protection systems within these high-rise buildings vary greatly.

High-rises contain a wide variety of occupancies, including assisted living facilities, hospitals, business offices, apartment and condominium units, and hotels. Common features in such buildings include community rooms, restaurants, gymnasiums, swimming pools, parking garages, trash rooms and chutes, trash compactors, dumpsters, and mercantile occupancies. Typically, these common features are located on the lower floors; however, restaurants, bars, or clubs may also be located on the top floor of a high-rise. Due to the variety of potential occupancies, fire personnel may encounter floor plans with extensive compartmentation, or in the case of an office setting, several thousand square feet of open area with cubicle workstations.

Many government and private technology-type occupancies include specialized security features such as vaults with lead-shielded walls and doors and raised floors that limit access to computer and communications wiring. Additionally, fire personnel may find reinforced or special locks that pose forcible entry challenges.

Due to their height, a large portion of any high-rise building may reside beyond the reach of aerial apparatus. Further, a building's significant height increases the potential for moving smoke and heat gases resulting from stack effect, reverse stack effect, and stratification.

The time first-arriving fire department units need to assess a high-rise fire, identify the fire's location, and travel to the affected area for fire attack can be significant. This reflex time may vary depending on building size and situation complexity. Extended reflex time allows a fire to intensify and can significantly change the conditions observed during the initial size-up.

Construction

Modern high-rise buildings involve two basic designs: residential and commercial.

Residential high-rise buildings can include hotels, apartment buildings, condominiums, hospitals, or assisted living facilities. These building types are characterized by center hallways, numerous interior compartments (e.g., rooms, closets), and 24-hr occupancy (see Figure 1).

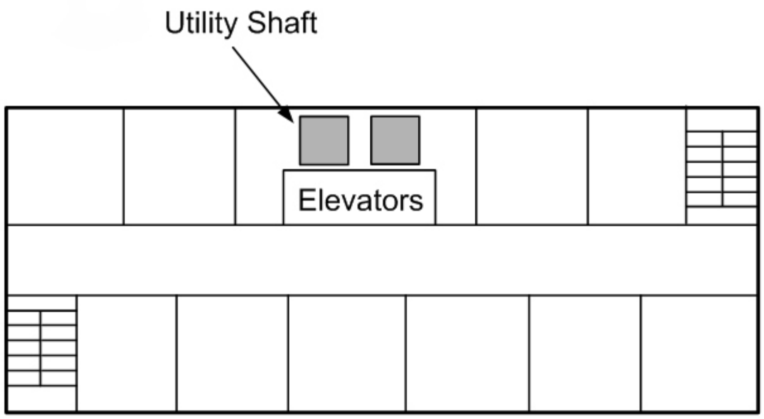

Figure 1. Typical floor plan in a residential high-rise.

Commercial high-rise buildings are characterized by center-core construction (see Figure 2), with circuit corridors around the building's core and likely large, open expanses on each floor. Elevators, stairwells, and mechanical rooms reside in the building's core, with office or residential spaces comprising each floor's perimeter. Occupancy loads are usually greater during normal business hours.

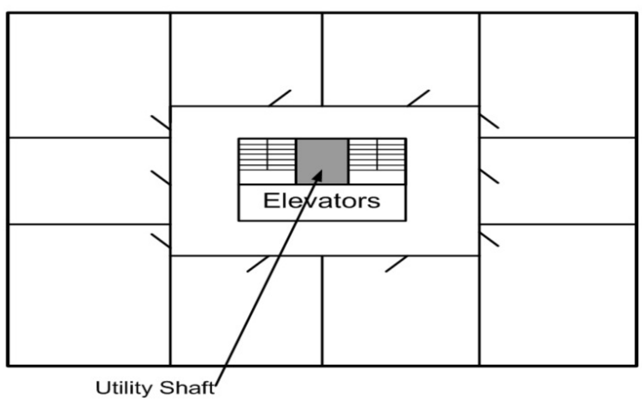

Figure 2. Center-core construction (may or may not be compartmentalized).

Newly constructed hotel and office high-rise buildings often include an atrium, as shown in Figures 3 and 4. Atriums are typically located at the building's main entrance and serve as the structure's focal point.

Atriums make it difficult to control smoke conditions because they simultaneously expose many floors to smoke and fire conditions. Typical requirements for buildings with atriums include full sprinkler protection, smoke exhaust systems, and smoke curtains.

Figure 3. Open atrium.

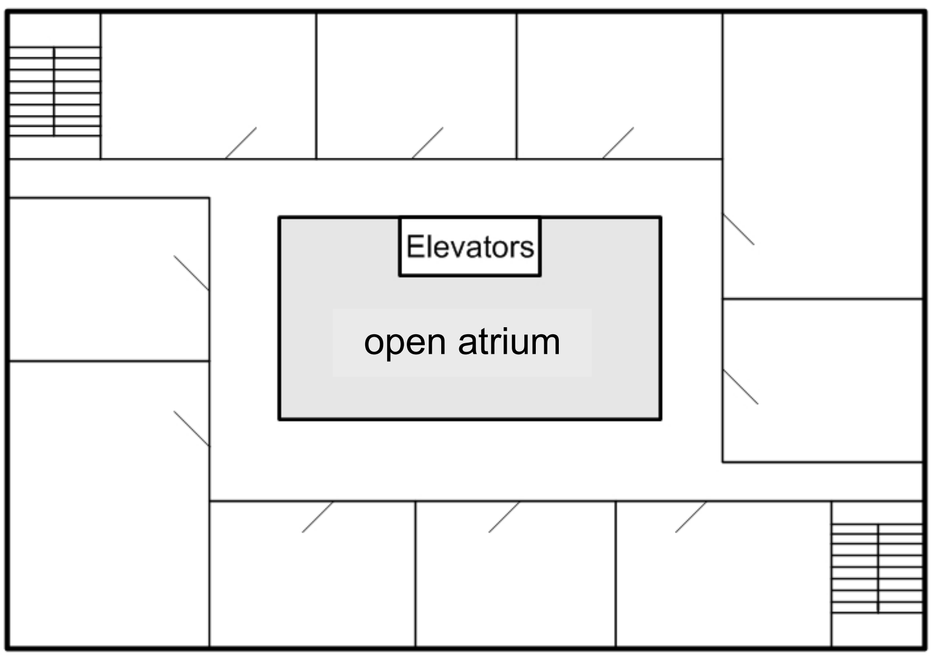

Figure 4. Overhead view of commercial high-rise with open atrium.

In a long hallway, fire personnel may encounter fire-rated doors at various locations along the hallway's length (see Figure 5). To best determine the doors' location in relation to the fire area and the standpipe, firefighters should observe a lower floor when possible. If fire doors section off the hallways, each section should include a stairwell and standpipe.

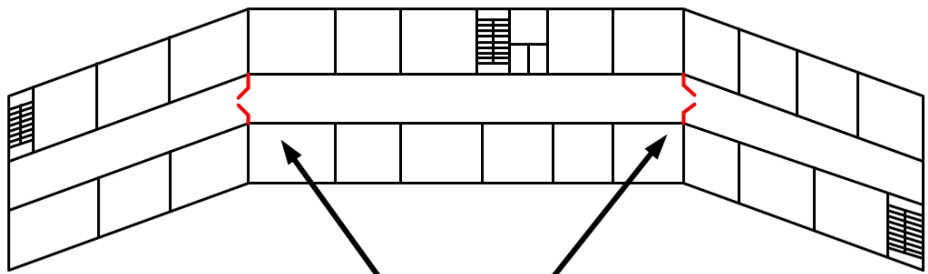

Figure 5. Fire doors.

Two basic types of high-rise buildings exist in the NOVA region: those constructed before February 1976, when lawmakers enacted modern high-rise requirements, and those constructed after the code changes.

Steel and concrete typically comprise buildings constructed prior to the 1976 code requirements. These buildings may have a wide variety of design features and systems. Most lack sprinkler systems, fire control rooms, modern fire alarms, or elevator control systems. Some have been or are in the process of being retrofitted to meet modern standards. Some features common to older structures include the following:

- compartmentalized office and residential spaces with mazelike corridors;
- non-compartmentalized open floor plans for commercial office occupancies;
- window air-conditioning units or a lack of building-wide heating, ventilation, and air conditioning (HVAC) systems;
- conventional windows that may be opened;
- lack of suspended ceilings, which amounts to less hidden void space;
- steel structural members encased in concrete;
- exterior masonry walls that are tied directly into each floor;
- pre- or post-tensioned concrete floors; and
- reinforced concrete columns.

A high-rise building constructed after the 1976 code change will be of fire-resistive construction, which resists structural member and floor collapse and fire passage through floors and other horizontal barriers. Fire resistance does not address life safety concerns or the movement of toxic combustion products.

Required fire protection features include the following:

- A Class 3 standpipe system. The outlets on this system have a 2 ½" diameter and 1 ½" reducers.
- A compartmentation option if built prior to April 1991. However, most NOVA high-rise buildings were constructed after 1976 and are either partially or fully sprinklered.
- Firefighter service to the elevators.

- HVAC systems capable of exhausting smoke.
- At least two approved means of egress from each floor.
- A local fire warning system.
- A building communications system.
- A fire control room.
- Standby and emergency power systems.

With a few rare exceptions, all occupied NOVA high-rise buildings have the following:

- At least two approved exits from each floor.
- Enclosed stairwells.
- Some type of smoke control system or compartmentation. This includes windows that can be opened, tempered glass panels on at least two sides of the building that can be broken out, or a modified HVAC system that can exhaust smoke to the outside without contaminating other floors.

Building codes allow certain exceptions for both active and passive fire protection systems. Fire personnel can only know a building's protections through preplanning. Ideally, preplanning begins when a building is being constructed and continues through the building's existence.

Fire Walls

Multiple layers or thick gypsum and masonry walls typically enclose high-rise stairway, elevator, and other shafts. These will typically have a minimum 2-hr fire-resistance rating. Masonry fire walls may separate occupied areas from storage, utility, and commercial areas.

Roofs

The roof of a high-rise may be of much lighter construction than the floors. It may consist of an insulated metal deck roof or match the construction of the floors below, but with a weather barrier installed.

A common type of flat roof construction uses composite metal floor decking with a rubberized or tar-and-gravel top layer (i.e., a built-up roof) supported by steel bar joist (see Figure 6). Composite metal floor decking is commonly referred to as Q decking due to the popularity of a widely used product brand name.

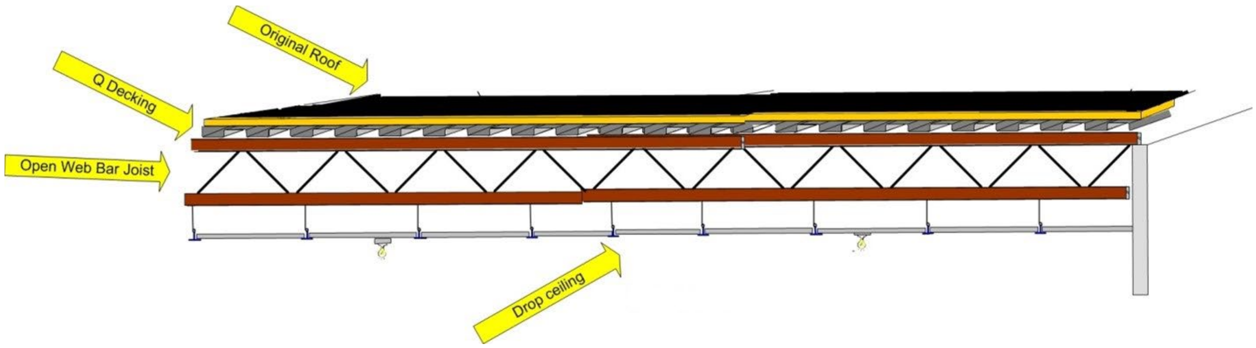

Figure 6. Composite metal floor decking.

The materials comprising the roof may differ from those of the noncombustible lower floors. For example, the roofs of many high-rise buildings include a roof-top community room constructed of lightweight combustible materials.

Flat roofs may be surrounded by facades that create the appearance of a decorative pitched roof or an additional floor. Facades such as a mansard-style facade may protrude high above the actual roofline. Some high-rises have scuppers, which allow personnel to determine the height of the roofline and the start of the facade (see Figure 7).

Figure 7. Scupper.

Individuals typically access the roof area through a hatch or a bulkhead at the top of the stairwells or through the penthouse machine room areas (see Figure 8). Many buildings provide signage indicating which stairwells lead to the roof.

These access points should be indicated in the fire department preplan.

Figure 8. Bulkhead.

HVAC units may be found on the roof area or on various floors. Personnel can find shut-off switches adjacent to these units and possibly in the fire control room. Taller buildings may also position HVAC units at a midway point within the structure.

In most cases, elevator control rooms reside on the roof. The control panel (i.e., shut off) for each elevator is located in this room and should be labeled with its respective elevator car number.

Vertical ventilation shafts for the building's occupancies terminate at the roof level.

Roof areas may also contain helicopter pads, communications equipment, antennae, microwave dishes, and guylines.

Attics and Ceiling Areas

High-rise buildings typically do not have an attic. However, as previously discussed, the top floor or penthouse often contains mechanical and elevator rooms. These areas can fill with smoke from a fire many floors below.

Steel truss ceiling assemblies provide an inherent and useful void space for piping, communications wiring, and other building system materials or equipment. Buildings with slab concrete floors lack an inherent void space, so suspended and drop ceilings are often used to create void spaces. The plenum area created by these void spaces is extensive, may lack fire stopping, and is often used for the return air side of the HVAC system.

In both inherent and noninherent void spaces, wiring and cabling feed through poke-throughs and vertical utility shafts, providing avenues for vertical and downward fire extension.

Walls

The interior walls of a residential high-rise are typically constructed from gypsum board mounted to metal studs. This is also true of commercial high-rises when interior walls are present. Rarely, interior walls may be of masonry construction.

Due to increased security concerns, the interior walls of some newer occupancies (e.g., government facilities or mercantile establishments) are constructed with reinforced drywall, as shown in Figure 9. This material looks identical to regular drywall, but the drywall encases either a layer of wire mesh or a solid sheet of Lexan polycarbonate.

Figure 9. Lexan polycarbonate substrate wallboard.

Interiors can be divided by walls constructed using 2" by 4" wood or metal studs or cubicle partitions depending on occupancy, code, and age. As shown in Figure 10, commercial occupancies may contain large open spaces with few interior walls or partitioned areas such as workstations or cubicles.

Figure 10. Cubicles.

Many buildings with newer construction have exterior curtain walls constructed of glass or panels made of precast metal or masonry (see Figure 11). Depending on the type of bracket (i.e., bolted or welded) used to mount the curtain walls to the floor sections or building frame, gaps of 6–12" may exist between the floor and exterior wall. If gaps exist, then fire-stops are required; however, this barrier's efficiency is uncertain.

Personnel should expect vertical extension between curtain walls and floor sections. Downward extension should also be anticipated into the plenum on the floor below. Curtain wall construction should be denoted in preplanning.

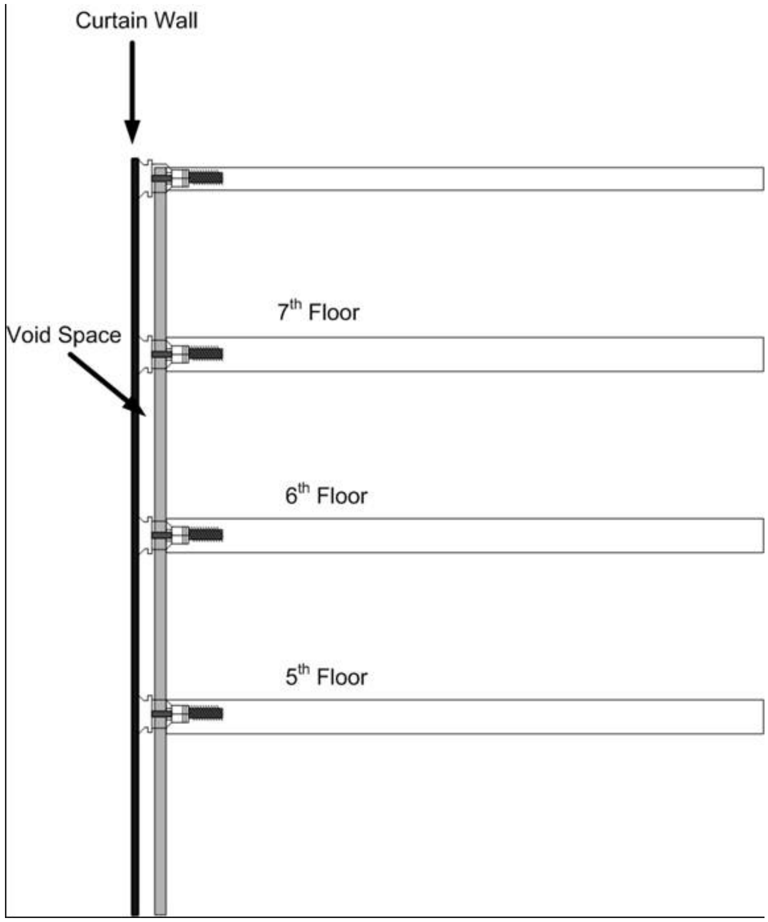

Figure 11. Illustration of a curtain wall.

Floors

High-rise floors may be constructed from reinforced, post-tensioned, cast-in-place concrete or of reinforced, pretensioned, precast concrete. A composite metal floor assembly presents another type of floor found in high-rise construction. These assemblies form both the flooring of one level and the ceiling for the level below. As described by Brannigan and Corbett: "The whole assembly including the ceiling, hangers, electrical fixtures, floor joists, left-in-place form-work for the concrete floor (corrugated steel), air ducts, diffusers, and the concrete floor, make up the entire floor/ceiling assembly."[1]

[1] Glenn P. Corbett and Francis L. Brannigan, *Brannigan's Building Construction for the Fire Service,* 4th edition. (Burlington, MA: Jones & Bartlett, 2007), 327.

Fire resistive measures for floor and ceiling support systems include the direct application of spray-on fireproofing (i.e., intumescent coating, see Figure 12) and suspended ceiling assemblies (i.e., membrane fireproofing).

Importantly, buildings built prior to 1980 may contain spray-on asbestos fiber.

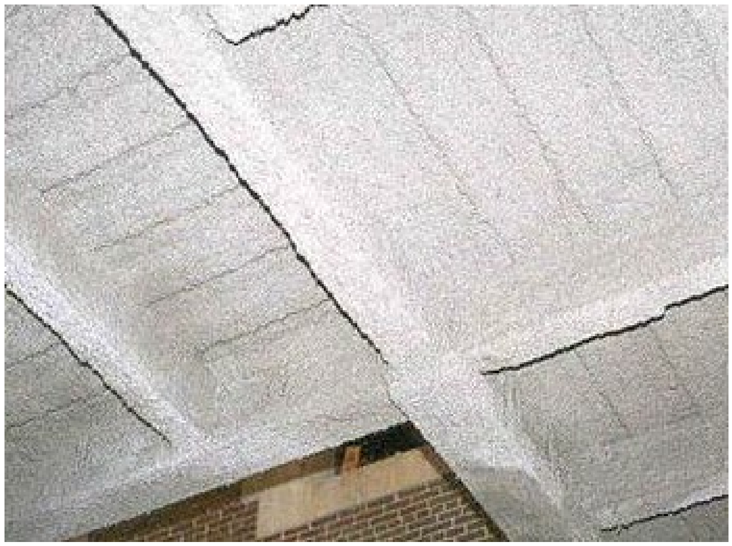

Figure 12. Spray-on fireproofing.

Fireproofing efficacy depends on its installation and the original building inspection. Fire department personnel should document and report any compromise of these systems during regular building familiarization visits.

Like other lightweight building materials in recent years, consumers have pushed builders to use lighter versions of concrete. Low-mass concrete was first patented in 1923, but it did not become popular until the early 1990s. To reduce its density, low-mass concrete, also referred to as "formed concrete," can consist of up to 20% air. In low-mass concrete, alternative aggregates replace the traditional aggregates (i.e., stone and sand) used to solidify the concrete and make it stronger. These alternative aggregates include foam polystyrene balls (i.e., super lightweight concrete) or shale, clay, vermiculite, pumice, and scoria (i.e., lightweight concrete). Low-mass concrete is 10–88% lighter than traditional concrete, depending on the mixture's proportions.

Alternative and low-mass concretes offer the same benefits as traditional concrete. They also insulate better, are easier to handle, and resist freezing, all while equaling the life expectancy of traditional concrete. Hollow-core, precast, prestressed concrete offers another form of low-mass concrete. This concrete has hollowed-out midsections that reduce the finished product's overall mass.

Traditional concrete has a density range of 150 pounds per cubic foot (pcf). Low-mass concretes can be broken down into two categories: lightweight concrete, which ranges in density from 60–100 pcf, and super lightweight concrete, which carries a density of less than

60 pcf. However, low-mass concretes provide a higher compression strength at 60,000 psi compared to traditional concretes, which provide a strength of only 20,000 psi.

Research has shown that under fire conditions, lightweight concrete failure occurs at 80% of the designed load after 45 min of fire exposure. Additional studies have shown that thermal cracks appear within 14–16 min of fire exposure. Personnel should consider lightweight concrete as a stable, fire-resistive material prior to exposure to high-temperature environments. During exposure to fire, material additives break down, altering the composition of lightweight concrete and leading to failure (see Figure 13).

Figure 13. Failed lightweight concrete.

Basements

High-rise basements or below-grade areas can serve or house multiple building functions: parking garages, trash compactors, mailrooms, dumpsters, storage areas, and utility rooms or tunnels. A fire in any of these areas can lead to a smoke-filled building.

Parking garages present several challenges:

- The garage may extend out beyond the main structure and serve the area below an adjacent structure.
- The covering slab of concrete may be designed to carry only the weight of automobiles, hindering or preventing apparatus access to the area.
- Radio operations may be difficult.
- Sprinklers may not be present, leaving only the presence of a dry standpipe.

Windows

A sun-screening plastic coating covers most windows in commercial high-rises. This coating may run from floor to ceiling and surround the entire building. Many high-rise buildings, particularly those with newer commercial construction, have fixed windows that cannot be opened to control the loss of heated or cooled air. These windows are typically made from plate glass, tempered glass, or Lexan polycarbonate.

Buildings with fixed windows should have designated breakable windows for emergencies. These windowpanes are marked with a Maltese cross or have a fire helmet etched in the lower corner of the pane. Some of these windows may also be opened with special keys or devices. This information should be included in the building preplan.

Openable windows are primarily found in residential occupancies. These can include casement and double-hung windows.

Doors

Doors that separate the various occupancies within a high-rise are either fire-rated metal or wood in metal frames. Apartment or office doors open inward (i.e., the door swings into the apartment or office from the hallway). The presence of an outward opening door indicates an electric or telephone room or another type of closet.

Doors from the stairwell to the hallways swing into the stairwell. Personnel should remember this as they plan to deploy a hoseline from a standpipe. At a minimum, any doorway a hoseline passes through should either be controlled by a firefighter or chocked open.

Doors leading from the stairwell to the hall, roof, or mechanical room may be locked above the lobby or first-floor level. The first engine, truck, or rescue squad proceeding to the fire floor should always carry keys and forcible entry tools.

In buildings with fire control rooms and electric locks on stairwell doors, the doors will usually unlock automatically when the system goes into alarm. Personnel should keep in mind that resetting the alarm system will relock the doors. If the doors are locked and personnel enter the stairwell from any floor above the first, they will have to return to the main lobby level to exit the stairwell. A stair door unlock switch, which will simultaneously unlock stairway doors without unlatching them, may be found in the fire control room.

In occupancies such as hospitals, hotels, or assisted living facilities, hallway sections are usually divided into compartments by self-releasing, fire-rated doors. Electromagnetic devices usually hold these doors open, so they may be closed manually or by fire alarm activation.

Commercial or residential high-rise entrance-level exterior doors are typically constructed of glass–aluminum with a mortise-type lock.

In buildings with balconies, the office or residence typically opens to the balcony through a sliding glass door.

Types of Stairways and Stairwells

A stairway is one or more flights of stairs leading from one floor to another; stairways include landings, newel posts, handrails, balustrades, and additional parts. A stairwell is a compartment that houses a stairway and extends vertically through a building. Several types of stairways can be found in high-rise buildings (see Figure 14). Ventilation openings may be found at the top of some stairwells, and some may be equipped with fans that can be used to pressurize the entire stairwell.

The stairwells in the building should be clearly identified on the preplan and should indicate whether natural openings are present for ventilation purposes.

Isolated stairs usually have individual entrances and access only one section of the building.

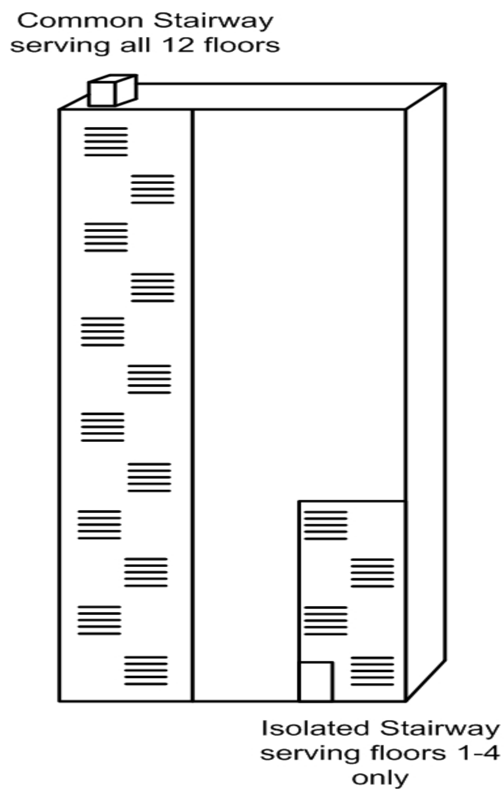

Figure 14. Stairway types.

Most high-rise buildings will have at least one stairwell that provides access to the roof through a hatch (see Figure 15) or a bulkhead door. Personnel should expect these access points to be locked. Many buildings provide signage indicating which stairwell accesses the roof. This information should be reflected in the building preplan.

Figure 15. Roof hatch.

Scissor stairs, shown in Figure 16, may be found in center-core construction, although this is rare. These independent stairwells are located on either side of the core. However, in some cases, each will only serve every other floor. In other words, one of the stairwells may serve the even-numbered floors and the other the odd-numbered floors. This type of stairwell can lead to confusion during an incident when personnel misunderstand stair access and enter the wrong floor or the wrong floor area.

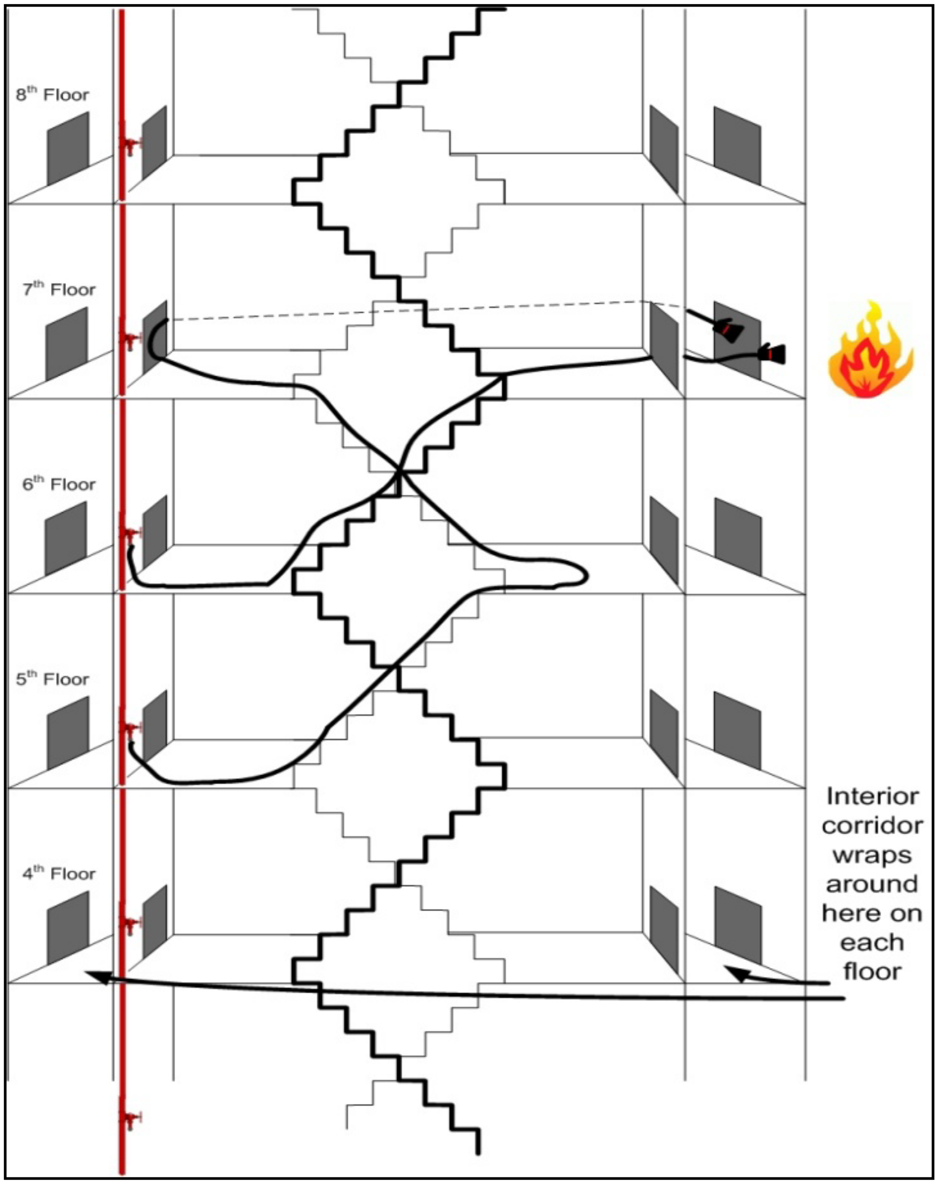

Figure 16. Scissor stairs.

Accommodation stairs, also known as “access” or “convenience” stairs, are open, unprotected stairways leading from floor to floor within a single occupant’s space (see Figure 17). They allow the tenant to move throughout their space without using public stairwells or elevators. Should a fire occur within the occupancy, it could easily spread to all floors serviced by this stairway.

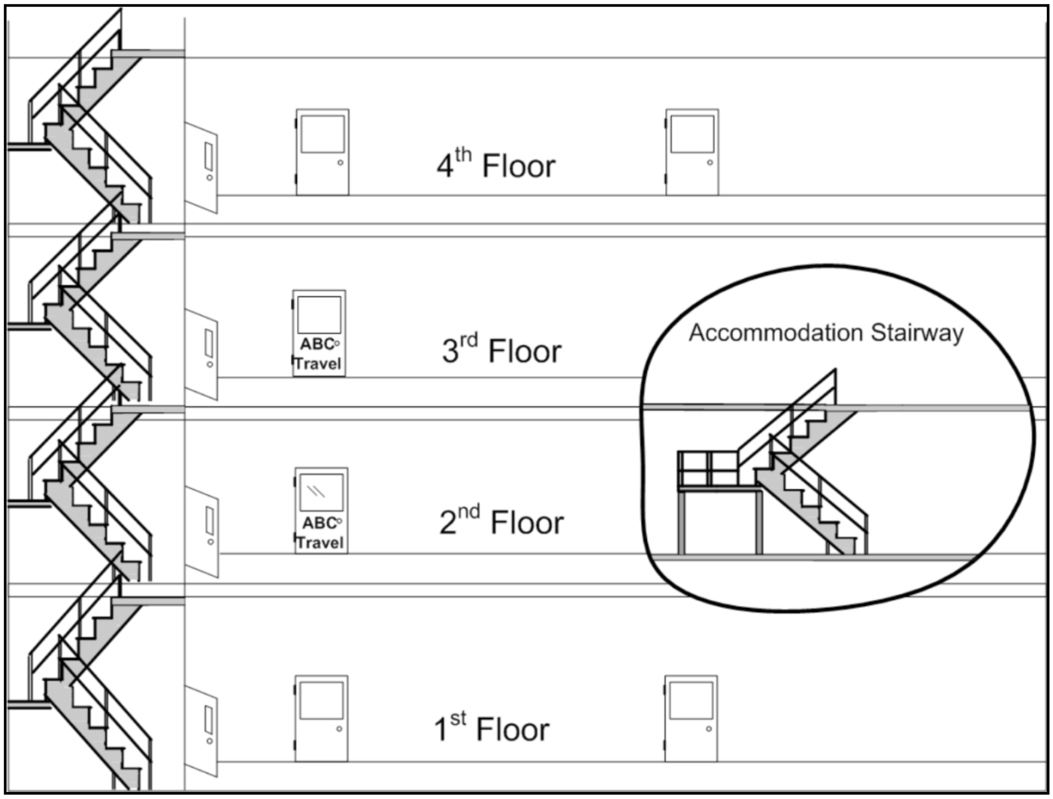

Figure 17. Accommodation stairs.

In buildings constructed after 1976, the stairways should contain hard-wired communications linked to the fire control room. These are usually in the form of a red box containing a telephone handset and are marked for fire department use only (see Figure 18).

Figure 18. Firefighter's use phone.

Newer high-rises may have a security gate installed in the stairway at the lowest level terminating at an exterior entrance (see Figure 19). Personnel should recognize this feature when attempting to exit or while evacuating civilians. The gate's presence denotes the last floor with an exterior entrance.

Figure 19. Security gate.

Standpipes and Sprinklers

High-rise buildings constructed after 1976 contain automatic sprinkler systems unless the builder chose the compartmentation option. In earlier constructed buildings, the presence of sprinklers is intermittent. Companies must know in advance whether a particular building is fully or partially sprinklered and what areas are protected.

Most standpipes found in high-rise interior applications are wet systems. However, dry sandpipes equip some older structures. Personnel should consider added time requirements and the potential for foreign objects in the connections when charging these systems with water.

Buildings with standpipe and sprinkler systems utilize a combination fire department connection (FDC) that supplies both systems (see Figure 20) or individual FDCs for each system. In some instances, fire department personnel have found these connections to be incorrectly marked. Personnel must possess knowledge of buildings, FDCs, and standpipe and sprinkler systems to conduct successful high-rise operations.

Figure 20. Combination wall FDC.

FDCs may either be mounted directly on multiple sides of a building or away from the building in the surrounding yard. The latter is called a free-standing FDC (see Figure 21). Both supply the system and must be noted in the building preplan.

Figure 21. Free standing FDC.

Hydrants installed after 1976 should be located within 100 feet of the standpipe and sprinkler FDCs (see Figure 22).

Figure 22. Hydrant located within 100 feet of FDC.

Personnel should understand that newer or remodeled structures may have installed large-diameter hose FDCs (see Figure 23). Many of these new FDCs have also incorporated locking caps, which can only be opened with a specific key (e.g., Knox; see Figure 24). This information should be included in the preplan and shared with responding companies because it is impossible to open the FDC without the key.

Figure 23. Large-diameter hose connection.

Figure 24. Locking FDC.

The location of standpipe riser outlets in stairwells can vary depending on the stairwell type and location. Some stairwells may lack standpipe riser outlets due to proximity to other risers in the building.

Depending on the floor area and stairwell location, standpipe riser outlets may be located at hallway midpoints (see Figure 25). Due to the level of protection provided by the landing door, stairwell risers should be used when feasible. Personnel should refrain from using hallway risers unless necessary.

Figure 25. Standpipe riser outlet located in hallway midpoint.

Sprinkler control valves for each floor may be found at stairwell landings (see Figure 26). Additionally, depending upon the length and size of the structure, valves may be located in hall closets or recessed above the drop ceiling. These locations should be noted in the building preplan.

Figure 26. Sprinkler control valves.

Fire department personnel may encounter pressure-regulating devices on standpipe discharge outlets in the NOVA region. Pressure-regulating devices, as defined by the National Fire Protection Association standard *NFPA 14*[2], are designed to reduce, regulate, control, or restrict water pressure. This equipment includes pressure-restricting devices (see Figure 27) and pressure-reducing valves (see Figure 28).

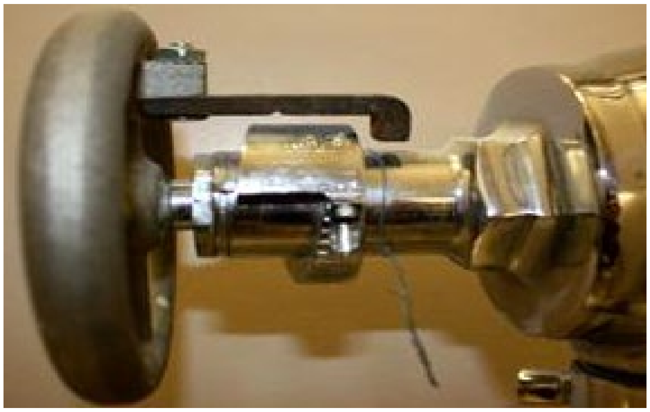

Figure 27. Pressure-restricting device.

Pressure-restricting devices reduce downstream water pressure in flowing (i.e., residual) conditions only, much like gating down a handline at the pump panel. Pressure-restricting

[2]*NFPA 14*. (Quincy, MA: National Fire Protection Association, 2016), section 3.3.13.

devices tend to be external and removable. When possible, they should be removed to allow the fire department full control of the standpipe discharge valve opening.

Figure 28. Pressure-reducing valve.

Pressure-reducing valves reduce the downstream water pressure in both flowing (i.e., residual) and nonflowing (i.e., static) conditions. The device components are internal and cannot be adjusted quickly or easily under fireground conditions, even with the proper specialized tools. Figure 28 shows a pressure-reducing valve. These valves tend to be larger than typical standpipe outlet valves to accommodate the internal components. *NFPA 14*[3] stated that when static pressures can exceed 175 psi, a pressure-reducing valve should be installed to limit both static and residual pressure to no more than 175 psi on 2 ½" standpipe discharge outlets. Pressure-reducing valves can be set to any pressure, even incorrect pressures. A too-low setting will result in a hose stream ineffective for fire attack. This occurred during the 1991 One Meridian Plaza fire in Philadelphia, Pennsylvania. In this case, personnel set the pressure-reducing valves to an incorrect pressure, and engine companies could not provide adequate pressure or water volume to fight and extinguish the fire.

If personnel finds an FDC damaged or otherwise unavailable for water supply to a building system and the engine operator chooses to supply the system via the ground level standpipe riser discharge, the presence of a pressure-reducing valve and its inherent one-way valve will render this tactic ineffective.

Pressure-reducing valves will limit pressure to a maximum of 175 psi and volume in gallons per minute (gpm) at the standpipe discharge. Both pressure-reducing valves and pressure-restricting devices should be noted in building preplans.

Many buildings are equipped with a fire pump designed to supplement incoming domestic water pressure. These pumps rely on various power sources (e.g., natural gas, diesel fuel, or electricity). Many are connected to the building's backup emergency generator. A majority are centrifugal-type pumps. Their location and power source should be indicated on the building preplan.

[3] *NFPA 14*, section 7.2.3.2.

The presence of sprinkler systems, standpipe systems, and fire pumps within a building result from changing building codes and industry standards. A building's construction and renovation dates both affect its fire protection system type. The Standpipe Roof Flow and Pressure Chart shown in Appendix A illustrates how sprinkler and standpipe system flow requirements have changed over the years.

Unless fire department personnel have specific knowledge of a building's fire protection systems, they should not assume the building's fire pump will produce the water volume or pressure required for a successful fire attack without supplemental support from an engine company via the building's FDCs.

HVAC Systems

Central air conditioning within a high-rise may interconnect 10–20 or more floors. Ducts, shafts, and poke-through holes penetrate fire-resistive floors, walls, and ceilings, allowing smoke to spread throughout the floors.

HVAC ducts at a building's perimeter windows may receive fresh air from the ducts located in the ceiling of the floor below. This permits rapid fire extension.

Many modern HVAC systems have full exhaust capabilities. Some also have dampers, a form of passive fire protection installed in the ductwork. Dampers are controlled by fusible links that limit fire spread through the ducts. Additionally, some structures have duct-smoke detection systems that automatically shut down the HVAC system when smoke is present.

Department personnel must work with building engineers and fire prevention personnel to familiarize themselves with the HVAC system features in the buildings located within their response areas.

Elevators

Electric traction typically controls elevators in high-rise structures. Control rooms reside at the top of the elevator shaft. Some shorter buildings may contain hydraulic elevators.

Elevators in some newer high-rises do not require a conventional elevator room. These elevators rely on a flat belt design that allows the machinery to be mounted in the elevator shaft or on top of the elevator car. Figure 29 shows an example of the Otis Gen2 elevator that uses a belt-driven system. The elevator penthouse may only contain electrical cabinets for the elevators, as shown in this figure.

Figure 29. Otis Gen2 elevator.

Express elevators, which bypass a portion of the building via a blind shaft, are found in many high-rises throughout the NOVA region. A blind shaft serves only a specified portion of the building and has no openings on other floors. For instance, an elevator bank will allow entry at the lobby level but may only serve floors 13–26 of a 26-story high-rise (see Figure 30). These elevators are sometimes referred to as “low-rise” and “high-rise” banks.

Figure 30. Blind shaft elevator control panel. Note lack of call buttons for Floors 2–12.

The fire control room in newer construction will typically house a master locator panel for the elevator banks. Cars installed after February 1976 include communications to the fire control room.

Independent service should not be confused with firefighter service. In independent service, the elevator car doors open automatically when the car arrives at the specified floor. In firefighter service, the doors will not open until the “door open” button has been activated. Freight (i.e., oversized) elevators may be present in an area remote from the main bank. Freight elevators should not be used during emergency operations. However, if the freight elevators are located in an area not affected by fire, smoke, or the products of combustion, personnel can exercise judgment as to their use.

Even in small amounts, fire, heat, and water can cause elevators to malfunction. This can and has occurred regardless of firefighters’ service control. Firefighters should expect that if an elevator has been subjected to any of these conditions, a malfunction could occur.

Elevators and their car number designations should be identified in the building preplans.

Elevators are essential for the vertical transportation of personnel during a high-rise fire, so personnel must have a working knowledge of their operation. All personnel should refer to the Fire Operations section of the NOVA *Elevator and Escalator Emergencies* manual for specific information on elevator use in high-rise fires.

Fire Control Room and Alarm System Features

The introduction of sophisticated electronics, sensors, and control mechanisms has altered fire monitoring and suppression capabilities in high-rise buildings. These features are incorporated throughout the building and terminate at the fire control room. High-rise fire control rooms (which are required in high-rises constructed after 1976) provide a central location for any system fire departments use for detection, fire protection, air handling, and communication. Status boards indicating building system operational modes reside in the fire control room.

Fire control rooms are usually located near or at the main lobby entrance, typically at an outside wall. Fire control rooms must be marked with a sign. However, personnel should know their location from preincident planning and familiarization.

If present, fire control rooms may contain the following:

- Annunciator panels (see Figure 31).
- A fire phone.
- Public address systems (PAs).
- Pressurization and smoke control systems. These systems will activate in the presence of an alarm. A high-rise building may contain several types:
  - Stairwell pressurization. Upon alarm activation, large fans will pressurize stairwells to reduce and eliminate entering smoke. Some systems include a smoke ventilation system, which involves a small fan at the base of the stairwell.
  - Corridor pressurization. This requires fans to pressurize the fire floor hallway to prevent smoke from entering the common area from the involved unit.
  - Elevator pressurization. Some high-rises include this feature, allowing for automatic or manual pressurization via a control switch to prevent smoke from entering elevator shafts.
- HVAC controls. Personnel can utilize these to remove areas of smoke during an incident via hand-off-auto switches in the fire control room.

- Emergency generator and standby power status. These provide emergency lighting and power when needed. The generators operate the elevators individually to bring each car to the lobby and open the doors in the event of a power failure.
- Automatic door unlocking systems. These systems activate when the building goes into alarm. Electric locks should also release with loss of electrical power and during manual override. This includes those corridor doors held open by electromagnetic devices.
- A telephone with an outside line for communication.
- A key box with multiple sets of keys.
- A copy of building plans indicating a typical floor plan, means of egress, fire protection systems, and fire department access.

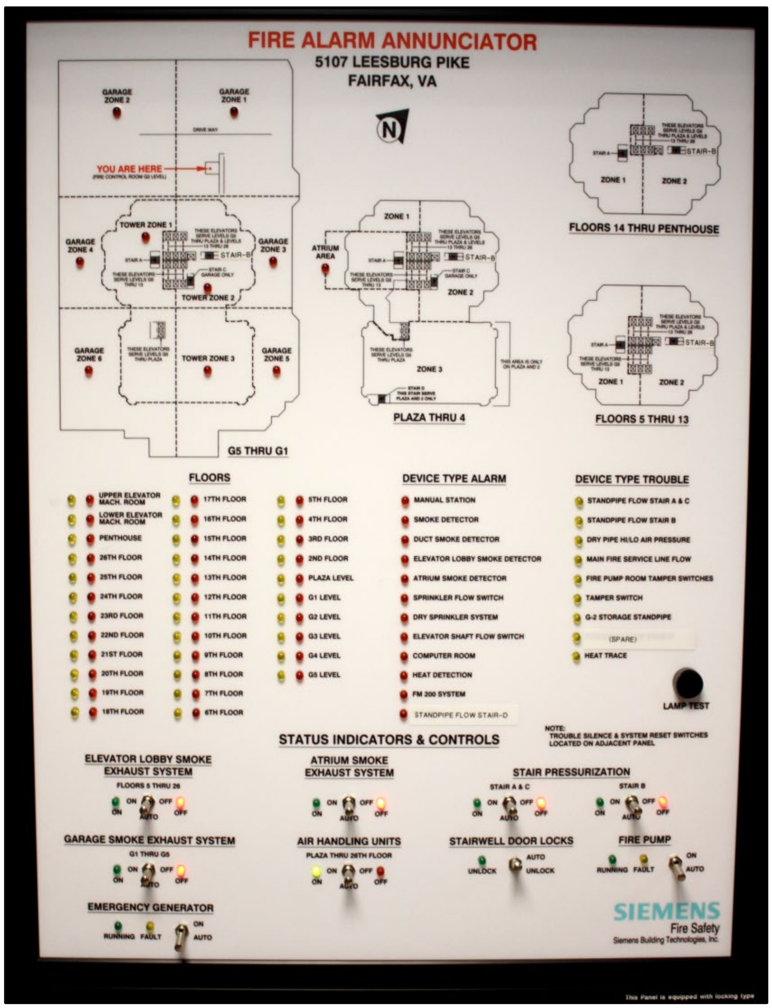

Figure 31. Fire alarm annunciator panel.

HAZARDS – HIGH-RISE BUILDINGS

This section covers the wide variety of hazards that may be present during high-rise fires and emergency incidents.

Life Hazards to Occupants

Due to the size and occupancy capacity of high-rise buildings, fires in these structures could result in significant loss of life. The 1980 MGM Grand Hotel fire in Las Vegas, Nevada, serves as an example of the disastrous outcome associated with high-rise building fires.

Fires in commercial occupancies can involve an entire floor or large portion of a floor because use of workstations or cubicles to separate office space reduces or eliminates compartmentation. Fires that occur in either hotel or residential occupancies benefit from a greater level of compartmentation. Consequently, they have significantly less potential for both horizontal and vertical fire extension.

Due to smoke contamination of stairwells, elevator shafts, and other common areas, occupants may panic as smoke spreads through the structure and elevators are recalled to the lobby. Smoke entering any floor is likely to cause occupants to attempt self-evacuation. Communication via the public address system, if available, can allay some occupants' fears.

Personnel must quickly identify and establish evacuation routes to facilitate the safe and orderly movement of building occupants to locations below the fire. Personnel should also consider that the best way to control occupants and maintain their safety may be to protect in place. That is, rather than exercise a complete evacuation of the building, personnel should only evacuate occupants on certain floors. Personnel can use the building's PA system to efficiently and effectively accomplish this tactic. Firm direction from the fire department is crucial and should be preplanned and practiced prior to an emergency incident.

Evacuation of a high-rise building requires the commitment of a substantial number of resources. If more than two floors above the fire still contain occupants, a search and evacuation branch should be established. Evacuation on a smaller scale may only require the use of a search and evacuation group.

Collapse

Historically, full or partial high-rise building collapse has not posed a significant problem. Even after engineers at the One Meridian Plaza fire in Philadelphia advised the Incident Commander (IC) that interior operations should be discontinued due to concerns about structural stability, no collapse occurred. Fire resistive construction has proven to withstand incredible fire involvement without collapse. There have been instances where portions of a ceiling, including the Q-decking, have dropped in a localized area after intense fire exposure; however, building collapse did not occur. On September 11, 2001, the World Trade Center collapsed due to the combination of flammable fuel and structural damage from the aircraft. This level of impact and subsequent fire is not typical in high-rise buildings.

However, personnel should not view a high-rise as being impervious to collapse hazards. The collapse of a suspended ceiling with its spiderweb-type maze of cross-tees can trap firefighters and render escape impossible. If a suspended ceiling's membrane has been compromised, firefighters should expect at least a partial failure of the ceiling assembly. Additionally, Internet and cable wires are often hidden behind crown molding, which can quickly fail under fire conditions and expose low-hanging wires.

Smoke Movement

The term *mushrooming* refers to the typical smoke movement found in residential and commercial high-rise structures when the smoke is uninfluenced by external environmental conditions (see Figure 32).

Mushrooming smoke rises upward from the fire floor until it reaches the roof or ceiling level. The smoke then banks off the roof or ceiling and migrates downward, back toward the fire floor.

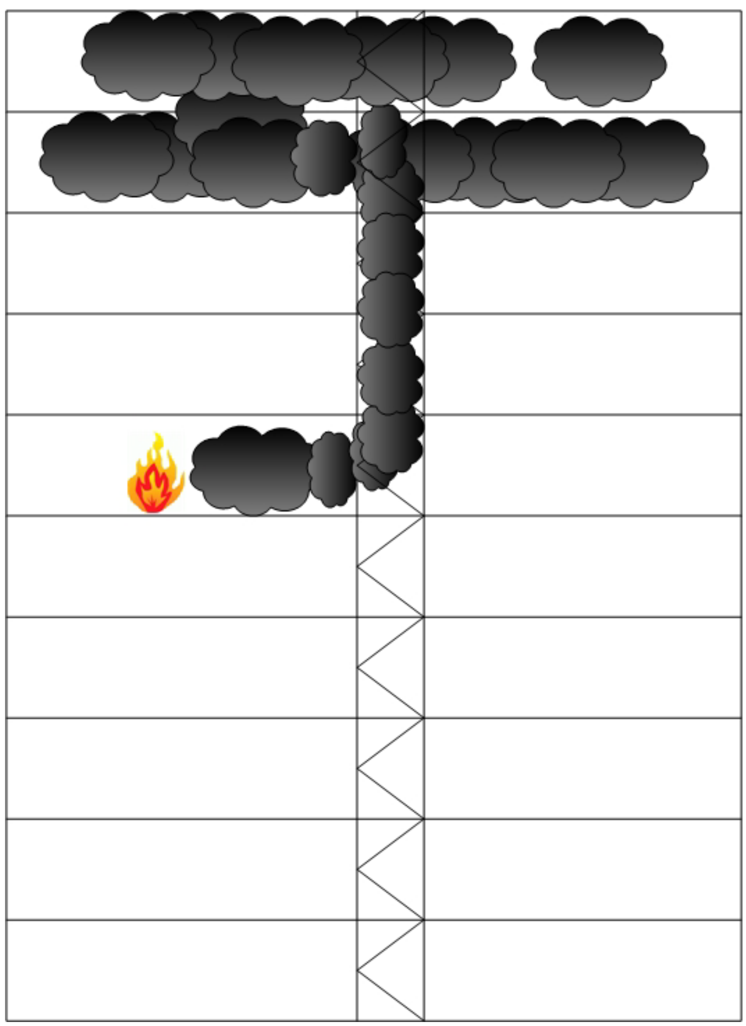

Figure 32. Mushrooming smoke.

Smoke may also move vertically through elevator shafts, stairwells, and other passageways, which can contaminate any floor above the level of the fire.

Arriving companies should also consider the effects of sprinkler activation. Cold smoke, which is cool and low-lying, characterizes fires brought under control by sprinkler systems.

Stack Effect

The stack effect is the natural movement of air within a tightly sealed high-rise building. It results from the temperature difference between the air inside and outside the structure (see Figure 33). Hot air is less dense than cold air and tends to rise through stairways, elevator shafts, and utility chases.

Smoke will rise until the temperatures balance, at which point the smoke begins to settle, or stratify. Stratification may occur in sealed buildings when the smoke temperature is not sufficient to cause it to rise all the way to the top of the building.

The stack effect occurs more noticeably in winter when considerable differences exist between inside and outside temperatures.

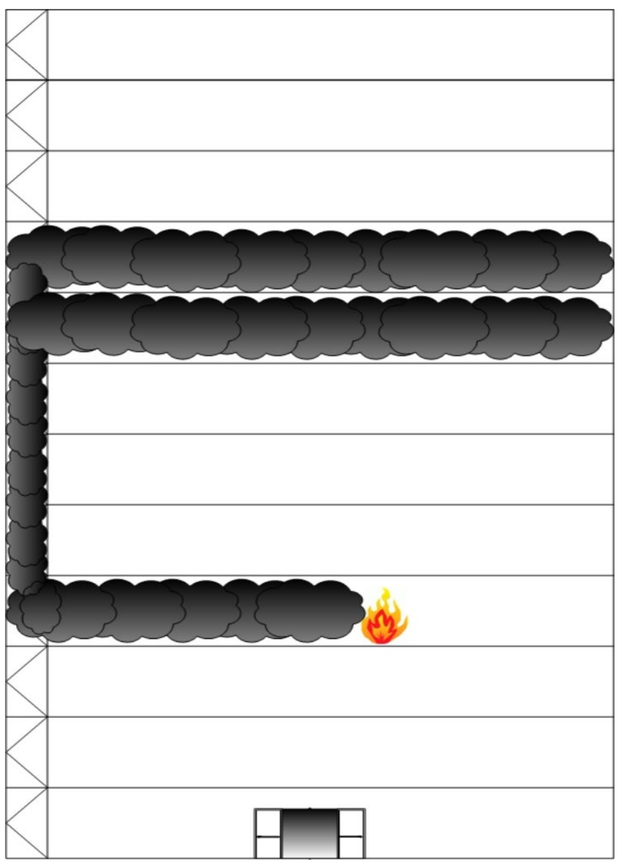

Figure 33. Stack effect.

Reverse Stack Effect

The stack effect can be reversed—known as the reverse stack effect—resulting in the downward movement of air in a vertical shaft. This occurs most often in tightly sealed, air-conditioned high-rise buildings during summer when temperatures outside exceed those inside (see Figure 34). In this case, smoke migrates to a floor level below the actual fire floor.

The reverse stack effect is less significant because the amount of stratification is proportional to the difference between the two temperatures. The temperature differential in the summer months is far less than in the winter.

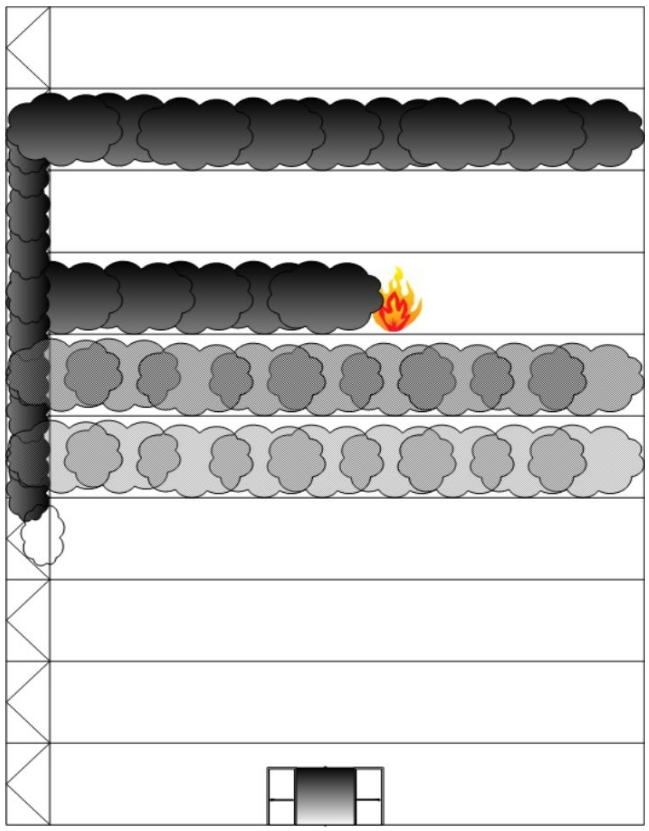

Figure 34. Reverse stack effect.

Backdrafts, Flashovers, and Wind-Driven Fires

A backdraft or flashover can occur in any structure. In a high-rise, hazards associated with these phenomena primarily relate to contents but can include interior finishes. Although fire codes have changed over the years to more closely regulate what interior finishes can be used, personnel may still encounter situations that allow rapid fire to spread over wall and floor coverings.

In office or other commercial occupancies, the lack of compartmentation exposes much of the fire loading. An advancing fire quickly heats the products that have not yet ignited, which leads to rapid fire spread. These areas are often not vented or able to be vented, so temperatures within them rise rapidly. The continued heating of contents produces large amounts of smoke and other fire gases. As these ignite, rollover extends outward from the seat of the fire, causing radiant heat to expose much more of the contents, quickly leading to flashover conditions. When an area is undivided, this phenomenon self-perpetuates until it involves a large area. This situation can rapidly spread over an entire floor, depending on the layout.

The most effective method for controlling and preventing flashover involves personnel cooling the overhead area with hose streams. They should do so using straight or solid streams to best contend with enclosed or confined spaces.

Personnel must also be aware that a backdraft can occur in any enclosed area within a structure. The plenum space, or the area above the ceiling, provides a clear avenue for a rapid collection of smoke and superheated gases. Advancing personnel must check this area with a thermal imaging camera or a physical inspection.

In addition to the possibility of a backdraft or flashover, a threat exists for wind-driven fires on upper floors where windows have been compromised. These fires may burn with such intensity that they destroy fire barriers, seriously threatening firefighter safety. Numerous firefighters and civilians have been killed or injured in this type of fire. Most wind-driven fires occur in the upper stories of high-rises but have also been documented in levels as low as the third floor. These hazardous conditions can exist with exterior winds as low as 10–20 mph.

Five conditions must exist for a wind-driven fire to occur:

- fire in the structure;
- a failed or opened window to the outside in the fire area or apartment;
- the presence of wind on the structure's exterior;
- a failed or open area or apartment door leading into a common hallway, usually caused by a fleeing occupant who left the door open; and
- an unobstructed path to an outlet where the fire can vent (e.g., open apartment door across the hall, open stairwell door, or open bulkhead door).

Street-level recognition of a wind-driven fire and proper tactical resource deployment are critical to ensuring personnel safety. To aid in wind-driven fire size-up, personnel should be aware of the following:

- presence and direction of the wind from the street level;
- failure of windows to the fire area or apartment;
- lack of or intermittent smoke and flames pushing from the failed window, depending on wind or gusts; and
- presence of a large volume of fire within the fire area or apartment.

Once personnel reach the fire floor, they must communicate the fire conditions to Command. The situation report should include the volume of fire, intensity of heat felt, and temperatures observed using a thermal imaging camera. Additionally, the first due truck should immediately advise if they can close the door to the fire area or apartment. Closing the open door will interrupt the flow of a wind-driven fire and may allow companies to advance a hoseline from the stairwell.

The first due truck or rescue should establish a haven area by forcing entry into an adjoining apartment. Personnel should not force entry or open the door of the apartment directly across the hall from the fire apartment because this will provide the wind-driven fire an outlet and increase the fire's intensity. Additionally, by forcing or opening the doors of the apartments next to the fire apartment, personnel can establish alternative means of suppressing the fire. This may be accomplished by breaching an adjoining wall and directing the stream through the wall and onto the fire. If this tactic cannot be employed, personnel can deploy their hoseline to the adjacent balcony and direct the stream into the fire apartment from there.

The National Institute of Standards and Technology demonstrated several alternative tactics that have shown positive results when personnel cannot enter the hallway. They involve executing an exterior attack using elevated master streams through the fire apartment window or conducting an exterior attack via portable ladders.

If personnel employ either of these tactics, they must ensure communication and coordination between interior and exterior companies. Exterior personnel preparing for attack must be sure no fire department personnel are present in the apartment or common hallway prior to flowing water.

Given the intensity and behavior of wind-driven fires, coordinated ventilation plays a critical role in suppressing them. If wind-driven fire conditions exist, no horizontal ventilation should be performed until directed by Command. Additionally, personnel should not vent the bulkhead of any stairwell until personnel on the fire floor can confirm that the stairwell doors are closed and controlled.

Fire Extension

Fire resistive construction limits the spread of fire without contributing to the fire load. Additionally, the extensive use of sprinkler systems in the NOVA region minimizes the threat of large-scale fires. However, concern exists for those situations where the sprinklers fail to control the fire or are turned off. Contents of these buildings have a rate of heat release that can allow a fire to double in size every 90 seconds.

Fire extension represents a significant concern for fires located on the lower two or three floors of a high-rise with mercantile occupancies (e.g., restaurants, bars, hair salons). Meeting rooms, ballrooms, and storage areas may also contribute to the fire problem. Fires in these areas can be quite severe, as the fire loading is higher than the light load in the guestrooms or residences. For this reason, personnel must locate the fire and identify what is involved to make informed strategic and tactical decisions. These same occupancies can occasionally be found in some office buildings.

Horizontal fire extension in commercial occupancies can quickly involve a large portion of a floor area because there may be little or no compartmentation. Floor areas exceeding 15,000 sqft are common. If a fire remains unchecked by sprinklers or other extinguishment systems, the involvement of large areas is likely.

Vertical fire extension can occur by fire extending

- out of one window to a window or room above (i.e., auto exposure),
- through unprotected or compromised void spaces,
- through the space between the floor and curtain wall,
- into an elevator shaft, and
- upward within an occupancy that involves more than one floor and has installed an access or convenience stairway.

Other Hazards Found in High-Rise Buildings

Floor-Length Windows

Windows in buildings of any occupancy type can extend from floor to ceiling. The position of the windowsill close to or flush with the floor poses a hazard when these large windows fail or are removed by firefighting crews. In low-visibility, personnel can inadvertently fall through the floor-level opening created by the missing glass pane. Extreme caution must be exercised when visibility is significantly reduced or nonexistent.

Open Shafts

Unfortunately, open shafts have led to serious injuries and firefighter fatalities. Personnel must remain vigilant while operating in low- or zero-visibility environments in all building locations and floor levels.

Hood System Vents

Hood system vents may be present in any place where food processing occurs. Restaurants may be located on a building's lobby or mezzanine level as well as on the top floor. However, other kitchen areas may exist for food preparation for banquet halls and ballroom facilities. All of these will have hood system ventilation leading to the outside. In some cases, this ductwork may run great distances, including the full height of the building, terminating at the roof level. A fire in these ducts can lead to fire extension far removed from the cooking area should the duct be compromised or combustibles located close to the duct ignite.

Laundry, Mail, and Trash Chutes

Laundry, mail, and trash chutes exist for building occupants' convenience (see Figure 35). However, they also provide an unobstructed path for smoke movement and fire extension that may or may not be protected by sprinklers. Smoke may be reported on a floor far removed from the actual fire location, which is most likely in the basement or first-floor loading dock area.

Figure 35. Trash chute.

An additional problem presented by laundry and trash chutes involves a bag of clothing or trash becoming suspended in the shaft. If a fire occurs and an obstruction exists at or below the shaft's access door, opening the door would allow fire or smoke to exit the shaft and enter the floor area. When this occurs, personnel should check the trash chute doors on each floor to determine the obstruction's location. To effectively suppress a chute fire with an object lodged along the chute, personnel should drop a heavy object from a level higher than the lodged object. The object will become dislodged and travel to the bottom of the shaft, where it can be extinguished and removed. Involved personnel must communicate effectively to safely carry out this operation.

Dumpsters and Compactors

These containers present a particular hazard when attached to or located inside the building. Often, trash chutes allow rubbish to be deposited from any floor level into a shaft leading directly to the dumpster or compactor (see Figure 36). Consequently, a fire in the dumpster or compactor can contaminate a large part of the building with smoke and toxic gases. Although the possibility for fire extension exists, smoke and gas contamination present the greatest concern. The impact of these contaminants can be minimized by moving the burning container away from or out of the building. After the fire has been extinguished, water can be removed from some dumpsters utilizing a 1 ½" drainage outlet.

Figure 36. Trash chute and roll-out dumpster.

Utility Shafts

As with other vertical shafts, utility shafts often run the entire height of the building. Plumbing and electrical components must enter and exit every floor level, creating access voids for fire and smoke to enter and transmit upward or downward. Fires involving kitchen and bathroom areas should signal the possibility of fire extension into one of these shafts.

Hazardous Storage

Due to the wide variety of occupancies found in high-rises, personnel may encounter many different products within these structures. However, the storage of products used in building and amenity operations poses the greatest concern. Many hotels and residential high-rise buildings have pool facilities, and the storage of the associated chemicals represents just one example of what may be encountered. Additionally, stored paints and janitorial supplies likely exist in various building locations.

Electrical Vaults

These rooms may exist almost anywhere in a high-rise building. Firefighters operating in limited visibility must take extreme care not to inadvertently enter one of these rooms. Firefighters who encounter an outward-opening metal door should suspect one of these rooms. Although no longer commercially available, carcinogenic polychlorinated biphenyls may be present.

Falling Glass and Debris

As fires become more severe and compromise the outer skin of the building, personnel should exercise great care to protect firefighters, evacuees, and spectators from falling materials. Shards of glass can be extremely dangerous and have been known to travel great distances in windy conditions. Personnel must protect firefighters who are operating apparatus, advancing hoselines, and entering and exiting the building.

Buildings Under Construction

Units that respond to fires in high-rise buildings under construction must carefully evaluate the stage of building completion.

Buildings under construction must have a riser two floors below the top-most finished floor. However, if fire conditions exist in an area with still-present concrete formwork, personnel should not undertake interior extinguishment operations. They should instead initiate the fire fight from an exterior position because fire damage to the formwork supporting the curing concrete could cause a collapse.

Exterior attack of upper floor fires will require deployment of aerial master streams. These large-caliber streams can create a falling debris hazard when construction materials, tools, and other items are washed off the building. ICs must secure the building perimeter to avoid injury from these falling items.

Personnel must also consider the possible involvement of propane cylinders. In addition to the possibility of cylinders as the fire source, they also present an explosion hazard or could drop off the building.

Personnel must also consider the potential collapse of walls or portions of walls. In high-rises under construction, builders often fasten sections or pieces of the building’s outer skin into place along the floor lines. Fire impinging on these wall sections can cause the connections to fail and drop the section. Personnel should position at the flank or at the structure’s corners.

High-Security Areas

Various businesses and agencies require high-level security. Accessing these areas for search or fire attack may present challenges and necessitate creative forcible entry. Personnel can sometimes more efficiently bypass heavily secured doors by breaching adjacent drywall-composed walls. Personnel who use this tactic and create a hole in the wall that cannot be isolated should consider the possibility of fire spread. Additionally, due to security needs, occupants of these areas may be very reluctant to evacuate.

Radio Communications

Operating units and Command must communicate for a successful outcome. However, due to the construction of high-rise buildings, fire department radios often fail or become less reliable than expected under normal circumstances. Personnel should recognize, communicate, and address this and should consider using the nonrepeated talk-around channels. In addition, personnel should consider using building communication systems such as building phones and speaker systems when available.

FIRE OPERATIONS – HIGH-RISE BUILDINGS

As discussed, high-rise buildings' unique features result in strategic and tactical challenges. An active high-rise fire is often not apparent from the building's exterior. Serious fire can develop in a location remote from the structure's exterior skin. Consequently, personnel must aggressively investigate a report of "nothing showing." Additional signals received on the fire control room annunciator panels serve as strong indicators of an advancing fire.

The need for an unusually high resource commitment makes the control and accountability processes for each unit of paramount importance. All officers and personnel should practice an exceptionally high level of discipline during high-rise operations. Failure to follow any portion of the operational plan can lead to a breakdown of the entire operation and could result in firefighter casualties.

Operational Plan

The operational plan for high-rise fires must consist of five basic actions:

1. determine fire floor,
2. verify fire floor,
3. control occupants,
4. control building systems, and
5. confine and extinguish the fire.

Officers and personnel should determine the fire floor from information on dispatch, information from building occupants, obvious smoke or fire showing from the structure, and by checking annunciator panels or fire control room indicators.

Units must investigate to verify the fire's exact location, including the specific location on the fire floor and the extent of fire involvement.

It may be necessary to evacuate the immediate fire area and facilitate movement of people already in the stairwells. Size-up may also indicate that occupants should protect in place.

Building systems must be brought under fire department control. At a minimum, this must include control of the elevators, fire pump, and any air handling systems.

Fire load characteristics present another important consideration. The 17th edition of the *Fire Protection Handbook*[4] stated that fire load in general office space is about 7.7 pounds per square foot (psf). A conference area is approximately 5.9 psf, and a file area is over 16 psf. These combustibles can release 16,000 to 18,000 Btu per pound. Moreover, fire loads are typically higher in government buildings, which are prominent throughout Northern Virginia.

[4] Arthur Cote, ed. *Fire Protection Handbook,* 17th edition. (Quincy, MA: National Fire Protection Association, 1986).

As a result, personnel must be aware that a tremendous amount of heat can be generated in a very short amount of time.

Due to the high degree of compartmentation in residential or hotel high-rise buildings, fires less often involve the entire floor. Even though compartmentation helps control fire spread, personnel must exercise extreme caution when advancing down a hallway because fire can move rapidly down a corridor from an involved occupancy's open entrance door.

Exposure protection not only involves checking the floor above but also requires assigning companies to check areas extremely remote from the fire floor. Fire can extend via hidden voids and break out many floors away from the original fire.

Ventilation, forcible entry, and fire attack must be coordinated. A significant fire may exist on a floor where it has confined itself while the structure has prevented any heat and smoke from venting to the outside. Personnel should expect punishing conditions and should determine wind conditions (i.e., force and direction) near the fire. In high-rise fires, wind conditions at the fire level can differ greatly from those at ground level.

If ventilation could possibly worsen the fire situation, companies should refrain from conducting ventilation during the fire attack.

Command Considerations

The first command officer to arrive on-scene should establish Command. Fires in a high-rise building require more resources than similar fires in other structures. After confirming a fire within a high-rise building, ICs should evaluate the need for additional resources and make requests for additional alarms and rapid intervention team (RIT) resources commensurate with the situation's severity.

Additional command officers may be used in tactical positions. ICs should assign tactical command positions early in an incident to establish and build an effective and efficient command structure. The second arriving command officer will typically be assigned as the fire floor division supervisor. Additional command officers should be used in strategic positions that include the following:

- division supervisors,
- group supervisors,
- branch directors,
- lobby control, and
- logistics and planning.

Hoseline Selection and Advancement

Most hoseline operations in high-rise buildings involve the use of standpipes. However, for fires located below grade or on the first, second, or third floors, personnel may choose to stretch preconnected lines from the engine because they are faster to deploy and place in service. Often, the engine can be positioned at or near an entrance, providing quick and easy access to the fire without taking the time to locate and connect to a standpipe outlet. This tactic must be communicated when utilized. Also, when employing this tactic, the engine operator must remain at the pump panel rather than abandon the apparatus and assist with standpipe operations on the fire floor.

Personnel must still supply the standpipe system, even if the initial attack was made with handlines stretched directly from the apparatus. Later hoselines may be deployed from the standpipe if needed. All other roles and responsibilities outlined in this manual shall be assigned regardless of how the initial hoseline is deployed.

Prior to advancing hoselines into areas with suspended ceiling assemblies, firefighters should always check for fire in the plenum, either physically or with a thermal imaging camera. The ceiling assembly could fall on the crew, trapping firefighters in a web of cross-tees, hanging wires, and cables. Firefighters have died in situations where a suspended ceiling assembly dropped and prevented escape.

As in all structures, crews must contend with a wide variety of obstacles while advancing hoselines in a high-rise fire. Office layouts with workstations present a maze of furniture and partitions for crews to negotiate. Other areas of the building can contain stored and stacked items such as furniture, inventory, and food handling or luggage carts.

The fire load in residential occupancies is considered low and requires a fire flow of 10 gpm per 100 sqft of involved area. If the fire occurs in a residential or hotel building, use of the 1 ¾" hose standpipe pack is preferred. This provides 185–210 gpm, and one or two lines of this size should suffice to handle the fire load expected in residential settings. It also provides more mobility, which is necessary to negotiate all the turns inherent to compartmentation.

Officers should consider 2 ½" lines in advanced fires or fires in the upper floors of residential high-rises. A significant fire will require the use of 2 ½" lines, and command officers will need to pair two engine crews to deploy and operate these lines. For fires occurring on a building's windward side with the fire apartment door blocked open, personnel should expect extremely heavy fire conditions in the public hallway. In this case, the higher flow from the larger line may be required to overcome the conditions caused by the wind blowing into the fire apartment.

The fire load in commercial occupancies is considered moderate and requires a fire flow of 20 gpm per 100 sqft of involved area. If the fire occurs in a commercial occupancy, engine companies should work in pairs and attack with 2 ½" lines. This requires a minimum of two engine companies, each carrying 100 ft of 2 ½" hose. Use of a smooth bore nozzle will provide better reach and penetration. In another option, personnel can operate two 1 ¾" lines side-by-side with smooth bore nozzles. This requires the same amount of personnel but provides better maneuverability. In compartmentalized office structures, the 1 ¾" lines offers a better option.

Personnel should select hoselines for high-rise firefighting with great care. They should practice standpipe operations and become intimately familiar with advancing all hoseline sizes. If a high-rise fire is not quickly extinguished, it can rapidly overwhelm a smaller line's flow capability. Officers should consider this when selecting hoses and nozzles for a reported high-rise fire.

The advantages of 2 ½" hose and smooth bore nozzles are clear; they provide more flow and reach at lower pressures when compared to 1 ¾" hose and fog nozzles. An inherent disadvantage of 2 ½" hose is the amount of energy and personnel required to move and operate the hoseline. The 2" hose with a smooth bore nozzle provides another option. A handline composed of 2" hose retains much of the mobility associated with 1 ¾" hose yet delivers flow capacities closer to that of a 2 ½" line at approximal pressures.

Standpipe Operations

The standpipe provides a great deal of flexibility for fire department operations in a high-rise. Personnel should learn about and drill on hoseline deployment and operation from standpipes. Stretching and charging hose in an enclosed stairwell can create numerous issues that include multiple kinks, hose sticking between railings and steps, and the creation of a tripping hazard that impedes the progress and operations of other companies.

The reported location of a fire in a high-rise building provides the first indication of which stairwell fire department personnel should utilize for fire attack. The fire's location on the fire floor should be determined as best as possible before the initial engine officer designates an attack stairwell. Blindly designating the attack stairwell before determining the fire location or reaching the fire floor could cause companies to stretch short. ICs should be patient and allow companies a reasonable amount of time to pinpoint the location. The initial engine company officer must communicate which stairwell will be used for fire attack after verifying the fire's specific location within the building.

Departments should consider providing engine companies with portable flow meters or pressure gauges for standpipe operations. The installation of pressure-regulating devices could restrict the needed pressure from a standpipe discharge. Flow meters are preferable over pressure gauges because they provide an accurate reading of gpm discharge in addition to discharge pressure. However, either piece of equipment could aid units on the fire floor with troubleshooting water supply problems.

Officers should consider the advantages of deploying hose from a standpipe discharge below the fire floor. Using the floor below to deploy hose regardless of the conditions on the fire floor not only prevents exposure to heat and smoke by allowing the hose to be stretched and charged in a tenable atmosphere, but it also minimizes tripping hazards at the fire floor entrance.

Stretching a dry line onto the fire floor must be performed with caution. Personnel should only implement this technique if they observe no smoke and fire upon opening the fire floor's stairwell door. Company officers should be mindful of the fire compartment door. If the door fails or opens before the line is charged, conditions in the hallway could quickly deteriorate, including rapid fire spread.

The use of gated wyes in standpipe operations can create significant challenges. The following potential issues should be considered when using a gated wye during standpipe operations:

- The valve handle on the unconnected side of the wye could be inadvertently opened, creating water loss in the attack line.

- The valve handle on the connected side of the wye could be inadvertently closed (partially or fully), leading to water loss in the attack line.
- When two hoselines operate off a gated wye and one hoseline is shut down, the other hoseline experiences significantly increased nozzle reaction.
- When one hoseline operates off a gated wye and a second hoseline is opened, the initial hoseline experiences a loss in flow and pressure.

The perceived benefit of using a gated wye during standpipe operations is the ability to place two hoselines in service from the same standpipe discharge. However, doing so can congest the stairwell and associated landing, creating significant trip hazards, hoseline kinks, and entanglements. These dynamics can impede hoseline advancement. Additionally, the use of gated wyes lacks water supply redundancy for the fire attack.

Departments and officers should consider not using gated wyes during high-rise standpipe operations. Loss of water flow or pressure on a hoseline during a high-rise fire attack can lead to rapid-fire growth and firefighter injury.

Vehicle Fires in Attached Parking Garages

Parking garage fires are relatively routine incidents in the NOVA area. However, when the garage connects to a high-rise, the hazards increase. Parking garages can easily exceed several thousand square feet, and the variable number of vehicles parked within them can create a considerable fire load.

Firefighters should prepare to confront parking garage fires at grade, below grade, and above ground. Easy pedestrian access into the common stairwell and occupant areas represents a particular hazard. This design could provide an unimpeded path for smoke migration from the garage into the high-rise.

Additionally, identifying and locating a vehicle fire and stretching the hoselines to extinguish the fire requires an extended reflex time. It may take several companies to accomplish this task, quickly taxing the resources deployed. Considering these factors, personnel should treat a reported vehicle fire in a parking garage attached to a high-rise as a high-rise building fire rather than a simple vehicle fire.

Vehicle fires in attached parking garages typically occur in one of two building configurations: adjacent and underground. Successful mitigation of these incidents requires replanning. Personnel should familiarize themselves with the location and operation of the parking garage ventilation system. These large fans activate upon receipt of an alarm; however, if automatic activation does not occur, personnel can manually initiate the ventilation system.

Personnel should consider the following tactical options:

- Deploy hoseline directly from the engine to the vehicle fire. Command must be notified, and the FDC still supplied (see Figure 37).
- Operate standpipe hoseline from the fire floor. Charge the FDC and operate the hoseline off the riser on the fire floor (see Figure 38).
- Operate the standpipe hoseline on the below-grade floor. Charge the FDC and operate the hoseline off the riser on the below-grade fire floor. Use a combination of positive pressure ventilation (PPV) and the garage ventilation system to keep the attack stairwell clear of smoke (see Figure 39).

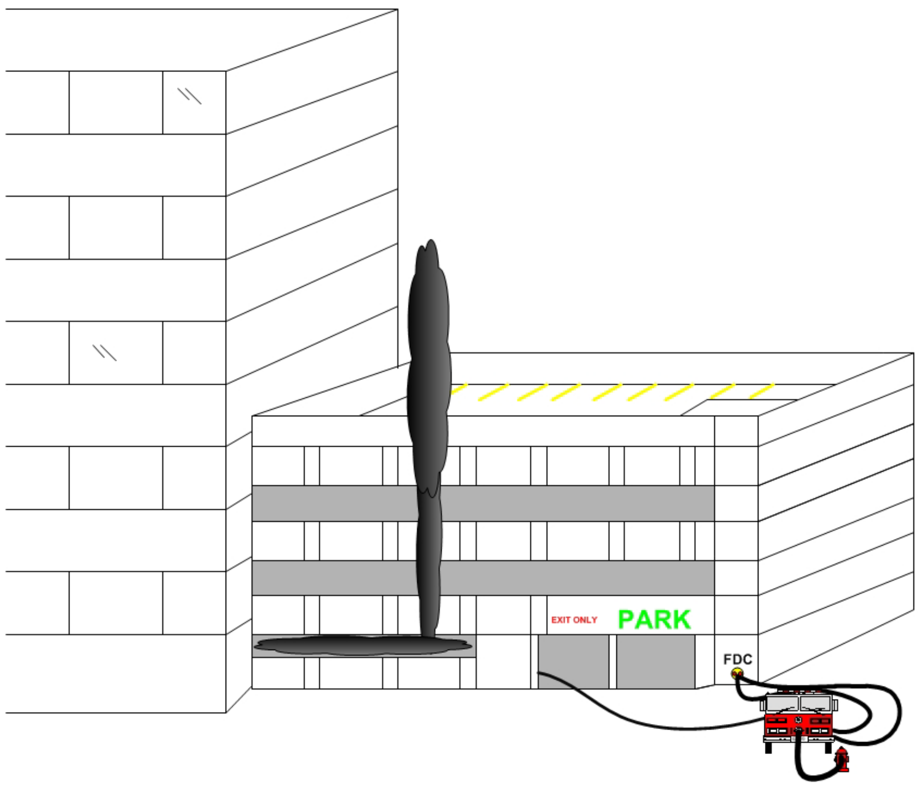

Figure 37. Hoseline deployed directly from engine to vehicle fire.

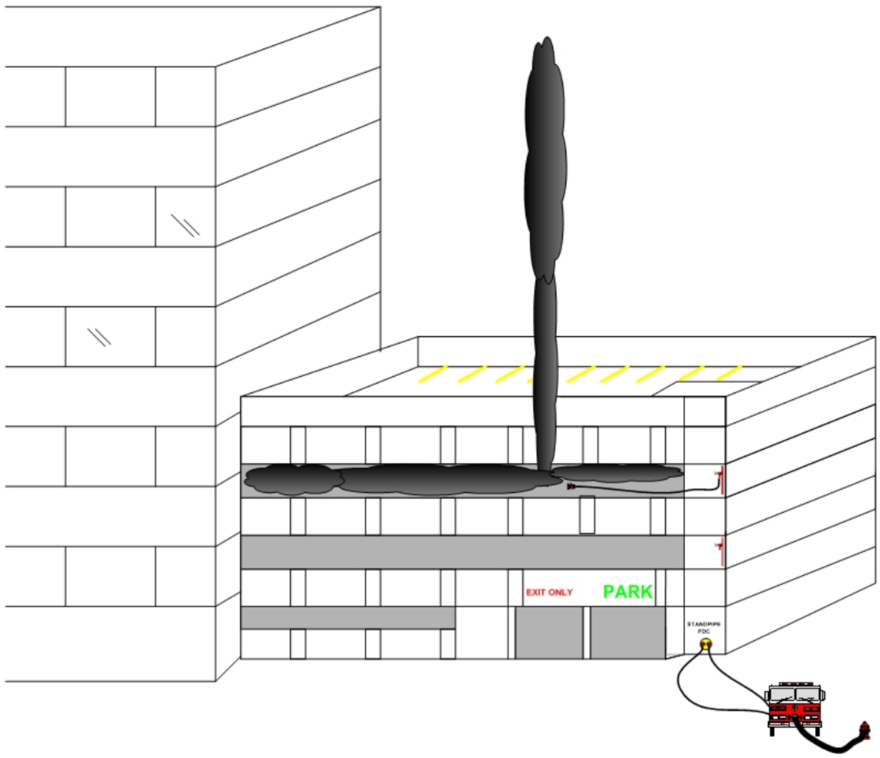

Figure 38: Hoseline operating off the riser on the fire floor.

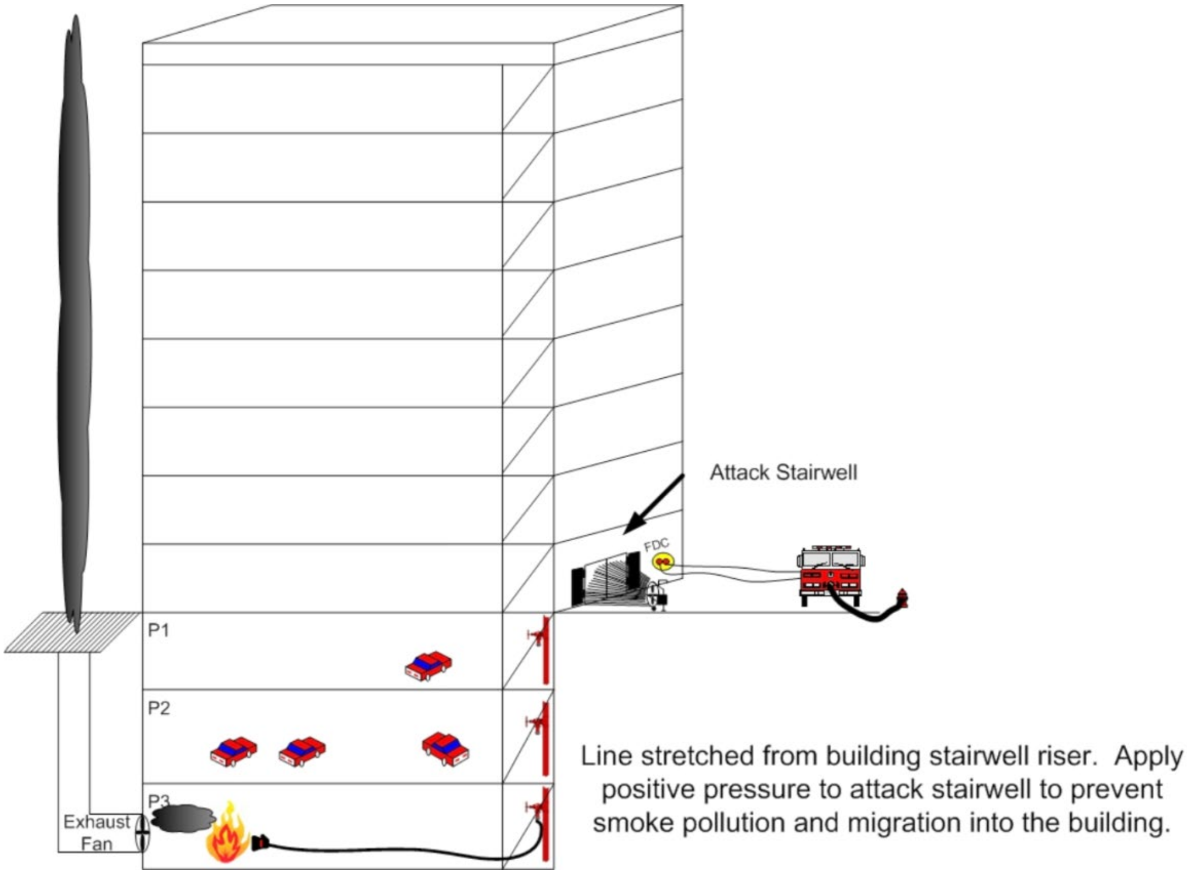

Figure 39. Using exhaust fan to keep attack stairwell clear of smoke.

RESOURCES – HIGH-RISE BUILDINGS

The minimum initial alarm assignment for a high-rise fire consists of

- five engines,
- two trucks,
- one rescue squad,
- one emergency medical services (EMS) unit,
- two battalion chiefs,
  and
- one EMS supervisor.

The unit assignments outlined in this document are based on typical common tasks in a logical order. Officers may need to adjust any assignment as deemed necessary based upon the specific problems encountered at an incident.

Unless otherwise directed by the IC, companies should position and report according to the following sections.

First Due Engine

The first due engine's responsibilities are as follows:

- View as much of the structure as possible during approach.
- Upon arriving on-scene, take note of evident conditions (e.g., fire/smoke location, number of floors, and persons in distress). When determining floor numbers, it may be quicker to identify the fire floor relative to the roof (e.g., three floors down) if the fire is on the building's upper floors.
- Park in proximity to the building without blocking access for subsequently arriving fire department apparatus.
- Provide on-scene report to first due command officer.
- All crew members abandon the vehicle and proceed to the lobby to continue size-up.
  - Note wind direction and strength.
  - Bring rapid entry keys (e.g., Knox) and retrieve building keys in the fire control room or other designated location.
  - Gather information from building occupants and employees. If building maintenance or security is present, determine whether they have been on the reported fire floors or any of the floors immediately above and below.
  - Gather information from the fire control systems. Check the fire control station or annunciator panel to determine what has been activated (e.g., manual pull station; heat, smoke, or duct detector; water flow, or more than one device).
  - In a commercial high-rise, check the lobby's building directory for the occupancy type on the floors involved.
  - Determine if the stairs will be used to reach the fire floor or if an elevator will be used to reach two floors below the reported fire floor.

    - Recall elevators if they are going to be used to reach the upper floors and place them in fire-fighter service Phases 1 and 2.
- Provide lobby report to first due command officer communicating fire alarm status, reported fire location, evacuation status, and route of travel to fire floor.
- Proceed to the anticipated fire floor along with the crew of the first due truck or rescue. If the truck or rescue is delayed, the engine should proceed up to the reported fire floor alone. The officer must exercise discretion when committing to an attack position prior to another company's arrival on the fire floor.
- Provide a fire floor report to the first due command officer verifying the fire floor, describing conditions on the fire floor, and identifying the attack stairwell.

It is the first due engine officer's responsibility to identify and verify the fire floor. The officer should also advise if the entry level is other than the first floor or if the floors have an odd configuration. Taking a moment to quickly gather this pertinent information will save time in the long run.

The first engine and all other engine companies should bring forcible entry tools with their hose packs and accessory equipment because they could end up operating without a truck or rescue company's assistance.

If personnel find smoke conditions in the lobby, they must determine if the fire is located on the lobby level, on a floor below, or in the elevator pit. Elevators equipped with automatic recall will stop at an alternate floor above this area. The location of these cars must be determined and the cars checked for occupants by later arriving units. Additionally, if personnel encounter smoke in the stairwell, they must determine its origin before continuing upstairs.

Units should utilize stairwells to access below-grade fires and above-grade fires up through the sixth floor. If a fire is reported on Floor 7 or above and personnel determine the elevators are functioning properly with no smoke or fire reported in the elevator machine room, they can take the elevator to two floors below the reported fire floor utilizing fire-fighter service. Personnel should reference the Fire Operations section of the NOVA *Elevator and Escalator Emergencies* manual for detailed information about elevator use and how to place them in fire-fighter service, Phases 1 and 2.

Upon arriving two floors below the reported fire floor, personnel should proceed to the floor below the reported fire floor using the stairs. Due to the size of high-rise buildings, the initially reported fire floor might be incorrect. Personnel must thoroughly inspect the surrounding areas.

Whether the stairs or elevator have been used, companies should quickly assess the floor below the reported fire floor, checking for smoke and fire conditions and surveying the area to note the floor layout, contents type, mechanical room locations, window type, and presence of access stairways. In a residential building, locating the apartment on the floor below the reported fire floor can help locate the fire room on the fire floor in low visibility. This information benefits personnel and can aid in estimating the hoseline stretch. Commercial buildings have less uniformity among floors, so floor layout on one floor may not be as helpful for gaining information about layout on another floor. Regardless, conditions on the floor below the fire should be checked.

Personnel may also have familiarity with the building's layout from previous incidents, preplanning, or walk-throughs.

The first due engine, truck, and rescue officers must understand the importance of working as a team. Unless the truck or rescue's arrival will be significantly delayed, the engine officer is expected to proceed to the fire floor with the truck or rescue crew. Once on the fire floor, the truck or rescue crew should commence reconnaissance operations, locating and identifying the extent of fire. The engine crew should be prepared to connect to the standpipe outlet but must remain disciplined and maintain the ability to relocate to a different stairwell if new information about the fire location requires them to do so. The attack should begin from the standpipe in the stairwell closest to the fire. Failure to do so can result in the hoseline falling short of the fire area.

The officer of the first engine should identify the standpipe outlet providing the best means for fire attack. The engine officer must then communicate to Command via radio which stairwell has been identified as the attack stairwell.

Before the attack commences, personnel should consider the possibility occupants may be present in the stairwell above the point of attack. Once the door to the fire floor has been opened and the line advanced, the door will remain open, and the stairwell may become polluted with smoke. If possible, this area should be confirmed clear of building occupants prior to commencing attack.

If personnel determine the door to the fire floor feels hot or if they encounter fire and smoke conditions, they should charge the attack line before opening the door. If the fire is on the windward side of the building and winds are strong, personnel may not be able to conduct the attack through the apartment's entrance door and should consider alternatives. It is imperative to assess the wind's potential effect and control the door to the fire area.

Second Due Engine

The second due engine company's responsibilities are as follows:

- Establish water supply. The driver or operator must stay with the apparatus.
- Report to the fire floor to help the first engine place the first hoseline in service before placing the second line in service.
- Prepare to deploy a second hoseline. This hoseline can be advanced onto the fire floor as a second attack line or backup line. It could also be redirected to the floor above, depending on fire conditions.

Upon arrival, the second due engine driver should establish a water supply and stretch the supply hoseline to the FDC. The FDC should be charged when a company reports fire or visible smoke or if deemed appropriate by other considerations. All connections except test connections (see Figure 40) at the in-use FDC should be supplied. If FDCs exist at other locations on the building, Command must ensure they are also supplied.

Figure 40. Test connections. These should NOT be used by fire department personnel.

The officer should obtain keys, if available, and check the status of the fire control station or annunciator panels to note any changes that may have occurred because the first engine checked. The officer should then proceed to the first engine's location.

The crew should take their hose packs and forcible entry tools and help the first engine deploy the initial hoseline before deploying the second line. The officer should be positioned at the standpipe outlet if the crews are paired up on one line. This will provide communications between the officer supervising the line and the officer at the outlet to ensure proper nozzle pressure. One firefighter should work at the stairwell door to feed the hose as it moves. Additional firefighters should position themselves at obstacles, pinch points, and turns.

Once the first and second hoselines are deployed and operating, the second engine may be used in different roles, depending on the situation:

- Continue to staff the initial hoseline.
- Standby in the stairwell, preserving their air supply and remaining ready to relieve the first engine.
- Provide a rescue team until the initial RIT (I-RIT) crew is in place.

Third Due Engine

The third due engine company's responsibilities are as follows:

- View the opposite side of the structure from where the first due engine is positioned. Take note of and report via radio fire and smoke locations, number of floors, evident conditions, and persons in distress.

- The driver or operator will remain with the apparatus and establish a water supply to the secondary FDC if one is present.
  - When no secondary FDC exists or is found to be damaged, the driver or operator can position at a hydrant and prepare to supply a ground-level stairwell standpipe discharge to provide a secondary water supply.
  - Engine drivers or operators may need to use adaptors to connect supply hose to the ground-level standpipe riser.
  - Pressure-regulating devices installed on standpipe discharge outlets will not allow water to enter the standpipe, causing this tactic to be ineffective.
- Proceed to the floor above the fire to work with the second truck company; check for extension and distressed occupants.
- Deploy a hoseline to extinguish any fire found on the floor above.

The first and second hoselines are typically deployed from the same stairwell standpipe riser. If this standpipe riser is also used to establish the third hoseline and is subsequently damaged or fails, all operational hoselines will become ineffective. Personnel should deploy the third hoseline from another stairwell standpipe riser. When possible, the riser in the evacuation stairwell should not be used.

The third due engine hoseline should reach the area directly above the seat of the fire. If the evacuation stairwell presents the only reasonable option, the following steps can minimize stairwell contamination and reduce interference with occupant evacuation.

- Deploy and stage the hoseline in the stairwell.
- Keep the stairwell door closed and the stairwell isolated while the second truck checks for extension.
- Direct personnel staffing the hoseline to help occupants around the hoseline if necessary.

Fourth Due Engine

The fourth due engine company’s responsibilities are as follows:

- Park away from the building.
- Abandon the vehicle with hose packs and RIT equipment.
- Proceed to one floor below the fire floor via the attack stairwell and establish I-RIT. If the fire floor is below grade, the I-RIT should position outside the area immediately dangerous to life or health (IDLH) while still in proximity to the fire floor. This may be one floor above the fire floor but not below the fire floor.
- The I-RIT should proactively help with moving hoselines while standing by in the stairwell.

Fifth Due Engine

The fifth due engine company's responsibilities are as follows:

- Help the third due engine establish a secondary water supply if needed. The driver fulfills this task.
- Bring hose packs and forcible entry tools.
- Report directly to the command post, confer with the IC, then report to the building's lobby area to assume lobby control.

The crew should proceed to the lobby with their complement of tools. Lobby control represents a vital operation in a high-rise and requires coordination among personnel. A detailed explanation of lobby control operations appears in the Other Considerations section of this manual.

First Due Truck

The rescue and truck company's functional duties closely parallel one another. Tasks such as searching for victims, locating the fire, forcible entry, ventilation, and utility control may be carried out by either of these units. Certain assignments are specific to the apparatus (e.g., laddering or the use of extrication tools or other specialized equipment carried on the apparatus). If the rescue squad arrives on the fire floor well before the first due truck, the rescue squad crew assumes the first due truck responsibilities on the fire floor. If this occurs, the rescue company officer must announce the change via radio, and the first due truck must acknowledge it.

The first due truck should park on side alpha unless the fire location can be readily identified. If so, the truck should then park on the fire side of the building if it is accessible.

If smoke, fire, or victims appear within reach of the aerial device, the crew should perform the following as appropriate:

- Raise the aerial to access the unit or location involved in a manner that maximizes the aerial's scrub area.
- Avoid placing the ladder to a window or balcony showing fire unless an occupant in that location requires rescue or the elevated master-stream tactic is being used for fire attack.
- Raise the aerial to an adjoining unit if the apartment or unit is totally involved.

Officers should consider several factors when deciding whether to use the aerial:

- Commercial buildings tend to have windows that cannot be opened or broken easily. When broken, the heavy falling glass from these windows creates a hazard for personnel and civilians below.
- Without some exterior indication of smoke or fire, it can be difficult to determine the most advantageous position for the aerial apparatus.
- The irregular shape (e.g., H, T, Y, L) of commercial buildings can make it difficult to position aerial apparatus within reach of the fire area.
- Occupants' reports of smoke on one or more floors may be inaccurate and should not be relied on until verified by interior fire department personnel.
- The first truck company has critical responsibilities on the fire floor that, in most cases, require at least three personnel. If only three personnel are assigned to the apparatus, leaving the driver or operator at the vehicle could impede the crew's ability to perform necessary tasks.

Command must be advised whenever the aerial will be placed in operation to affect an obvious rescue or to conduct fire attack. If a situation requires immediate rescues within reach of the ladders, one or both truck crews may have to conduct removal operations.

If the first due truck has a tower ladder, the crew may ride the bucket up to the fire floor. Depending on conditions, the officer should determine whether to directly enter the involved unit or enter by way of an adjoining apartment. The officer should communicate this tactic to the first engine and IC.

If there is no need for the aerial or if the fire floor is out of reach, the officer should consider taking the entire crew into the building. The truck officer should help the first due engine officer gather information in the lobby or fire control room. Personnel should proceed to the reported fire floor with the first engine. Generally, crews should perform the following tasks:

- Deploy a search rope.
- Determine and communicate the location of the fire. If the fire location is not readily apparent on that floor, the truck should advance to determine the location while the engine prepares the line to be stretched. At this point, the engine crew operates as the rescue team for the truck, if needed.
- Forcibly enter the fire unit.
- Initiate primary search in the fire unit.
- Coordinate the evacuation of fleeing occupants.
- Remove obstructions hindering fire attack and hoseline deployment.

As in any structure, opening a door separating personnel from the fire without a charged hoseline in place presents a hazard. If personnel decide to enter a fire compartment without a charged line in place to perform an immediate rescue, the truck crew should close the door behind them. This will minimize the amount of air provided to the fire and may limit fire growth if an exterior glass window or door fails.

The truck crew's tasks are crucial to the engine crew's safe operation. The truck crew should open the ceiling on the fire floor to expose the plenum area, if present, and check for fire before the engine begins their attack. Crews should not advance under fire in the plenum area. It must be knocked down as the attack commences.

Once personnel have located the fire and crews are preparing to advance the hoseline, the truck crew must begin to search the rest of the floor for victims. Crews should consider using a search line, which is a necessity in commercial occupancies with large open areas to search.

In residential occupancies, search priority is as follows:

1. the fire unit,
2. exit hallways,
3. units next to the fire unit, and
4. all other units on the fire floor.

In nonresidential occupancies, search priority is as follows:

1. the immediate fire area and floor;
2. the floor above the fire area;
3. the top floor, including the involved hallways, stairwells, and elevators; and
4. the floors between the floor above the fire and the top floor.

Second Due Truck

The second due truck company's responsibilities are as follows:

- View as much of the structure as possible, noting fire or smoke locations, number of floors, evident conditions, and persons in distress.
- Assess the need for elevated master streams.
- Note wind direction and strength.
- Bring rapid entry keys (e.g., Knox) and retrieve building keys in the fire control room or other designated location.
- Ensure an evacuation stairwell has been identified and is clear of smoke.
- Communicate any previously unreported conditions.
- Check the floor above the fire for extension and civilians in distress.
- Assist with hoseline advancement on the floor above when needed.

If the aerial can reach the fire or victims, it should be raised to the fire floor. Otherwise, the entire truck crew should enter the building together.

If the second due truck is a tower ladder and operating with a crew of three, the operator can provide power to the bucket, enter the bucket, raise the tower to the level of the fire, and remain ready for placement as needed. The operator should not raise the bucket to a point above the fire except to make an immediate rescue. If the tower ladder has a crew of four, the officer can split the crew into interior and exterior teams to accomplish the same objectives. If this action is taken, it should be communicated to the IC.

Rescue (or Third-Due Truck if No Rescue Is Dispatched)

The rescue squad and truck company's functional duties closely parallel one another. Either of these units may carry out tasks such as searching for victims, locating the fire, forcible entry, ventilation, and utility control. Certain assignments are specific to the apparatus (e.g., laddering or the use of extrication tools or specialized equipment carried on the apparatus). If the rescue arrives on the fire floor well before the first due truck, rescue assumes the first due truck responsibilities on the fire floor. If this occurs, the rescue company officer must announce this change via radio, and the first due truck must acknowledge it.

The rescue squad must park away from the building, and the entire crew should proceed to the fire floor with the first due engine unless redirected by Command. The rescue squad must park away from the building to allow access for the engine company supplying the building's systems, trucks positioning for aerial use, and ambulances moving in and out of the area with patients.

The rescue squad will perform the same initial functions as the first due truck company until personnel reach the fire floor. Once on the fire floor, the rescue squad takes responsibility for the following:

- deploying a search rope,
- forcibly entering the adjacent units for primary search and possible alternative fire attack options,
- coordinating occupant evacuations, and
- assessing fire extension into the adjacent units.

Depending on the number and type of handlines deployed, rescue personnel may assist in hoseline movement and operation. Specifically, the 2 ½" hoseline will demand additional personnel to successfully deploy.

EMS Units

The EMS units should park away from the building in an area that allows for rapid egress for patients needing transport. The crew should assemble their EMS equipment onto the stretcher and identify an area that provides rapid access to potential civilian or fire department members needing treatment. Crew members should also canvas the crowd for injured victims.

If the initial EMS unit engages in firefighting operations at the direction of the IC, an additional EMS crew should be dispatched to fulfill EMS duties.

Command Officers

Upon arrival on-scene, the first due chief officer should gather all available information and assume or establish Command. The chief officer should exchange information with the initial IC and then determine the command post location. The chief can elect to use their vehicle or an area of the lobby near the fire control room if access can be controlled.

The second due chief officer should report to Command for a briefing. This chief officer is expected to assume division supervision of operations on the fire floor.

Additional Alarms

The need for additional resources has been demonstrated at high-rise building fires in Northern Virginia and around the country. A serious fire in a high-rise building can easily require three alarms or more.

Every alarm after the first will bring at least three engines, one truck, and one battalion chief. Additional alarms may also include deputy or assistant chiefs, light and air units, and other special response units as needed. These additional units may be used for relieving first alarm units or filling essential roles on the fireground, including the following:

- RITs,
- search and evacuation,
- stairway support,
- base,
- staging,
- EMS branch or group,
- safety,
- rehabilitation,
- logistics,
- planning, and
- reconnaissance for fire extension and smoke migration.

Additional Engines

The sixth due engine, which is typically the first engine on the second alarm, should establish the base area. In a high-rise fire, this area will become a parking area for fire apparatus. If not already identified, the sixth due engine officer should announce this location.

The driver of the sixth due engine should become the base manager. The IC will later assign an officer to this position as the command structure expands. The designated officer should check in with the IC for assignment. The remaining personnel of the sixth due engine should prepare to set up staging two floors below the fire floor unless otherwise directed by Command. Subsequent engines should park at the designated base location and be prepared to take additional equipment to staging when required. A detailed explanation of staging and base operations appears in the Other Considerations section of this manual.

Given the criticality of air supply in high-rise firefighting operations, each engine company on the second alarm and greater should bring two spare air cylinders per unit to the staging area.

Greater Alarm Trucks and Rescue Squads

Type of occupancy, fire conditions, and severity of the evacuation problem dictate the assignment of later arriving companies. Trucks or rescue squads may need to cover the floors above the fire for search and evacuation operations. Checking for further fire extension is required, as is control and direction for occupants who are being protected in place. Situations involving large-scale evacuation will require multiple units.

Given the criticality of air supply in high-rise firefighting operations, trucks or rescue companies on the second alarm and greater should bring two spare air cylinders per unit to the staging area.

Mobile Air Unit

The mobile air unit is included with the second alarm and should be positioned at a forward location (i.e., close to the building) with stairwell access to staging. Most of these units carry a 250-ft air hose as well as extra air cylinders for staging. ICs should consider calling for multiple light and air units as well as other sources of spare cylinders during major operations.

OTHER CONSIDERATIONS – HIGH-RISE BUILDINGS

This chapter identifies additional considerations specific to high-rise operations.

Lobby Control Operations

Lobby control takes responsibility for a variety of critical tasks:

- Accountability.
- Building systems control.
- Elevator operations.
- Stairwell identification for attack and evacuation.
- Civilian evacuation coordination. Due to the possibility of displaced civilians congregating in the lobby, personnel may need to evacuate civilians to an alternate designated area.

Given the number of tasks required, the engine crew assigned to lobby control will generally need to split up to accomplish them in a timely manner. The initial officer assigned to lobby control should deploy their crew in a manner that simultaneously addresses the primary responsibilities of lobby control. The following sections address suggested procedures for organizing lobby control responsibilities with detailed descriptions of the associated tasks.

Accountability

Personnel assigned to accountability in a high-rise fire should locate in a position highly visible to incoming units and should record all pertinent information on a command board or tracking sheet (see Figure 41). Units entering the incident's operational area should check in with the accountability function.

Unit Identification	Task and Location	Time Entered	# of Personnel	Air Level @ Entry
Engine 208	Second hoseline, 10th Fl	1930	3	4500 psi

Figure 41. Sample lobby control worksheet.

Building System Control

Personnel assigned to gain control of high-rise building systems should attempt to contact a building engineer with a strong knowledge of the building system controls. Personnel and the building engineer should proceed to the fire control room to take control of the following:

- Fire pump. Determine if the fire pump is operating and, if not, activate via remote switch and notify Command. If activated, communicate the fire pump's discharge pressure to the engines supplying the FDCs.
- Fire alarm system. Continually monitor the fire alarm system for changing activations and relay to Command (e.g., multiple floors go into alarm after suppression efforts commence).
- Sprinkler system. Monitor the floor and location where sprinkler heads have activated. Additionally, notify Command if the sprinkler system is in trouble or indicating water flow.
- PA system. Prepare to deliver messages to building occupants or firefighters via the building's PA system. The PA system can be used to direct occupants on specific floors to evacuate or stay in place. These systems can also be used to communicate with firefighters operating throughout the building.
- Fire phones. Constantly monitor and answer the fire phones. The respective floor should illuminate on the panel when a fire phone is removed from the receiver.
- HVAC. Initially, shut down the HVAC to limit smoke migration and fire travel. Upon coordination between the building engineer and IC, the HVAC may be activated using the exhaust function.
- Pressurization system status and control. Monitor and prepare to control any pressurization systems. If smoke quantities and environmental conditions warrant it, the pressurization system may be used in conjunction with PPV.
- Elevator status and location. Determine the status and location of all elevators, if present. If all cars were not recalled to the lobby, communicate this to Command so the missing cars can be located and searched.
- Nonambulatory residents. Notify Command if the building representative has a list of nonambulatory residents.
- Keys. Retrieve the sets of keys for fire service operations and give them to the officer for dissemination among incoming companies.

Elevators can be used to deliver personnel and equipment to staging and the fire floor. They can also be used to remove patients quickly from upper floors. Personnel should reference and follow the Fire Operations section of the NOVA *Elevator and Escalator Emergencies* manual for detailed information about elevator use and placing them in firefighter service, Phases 1 and 2. To be effective, efficient, and safe, the firefighter assigned to elevator operations must perform the following tasks:

- Obtain a set of keys, including the elevator recall key, from the fire control room or Knox box.
- Proceed to the elevator lobby and attempt to recall all elevators (i.e., firefighter service Phase 1) if not done already. If the fire helmet icon is flashing, a smoke detector

activation has been received from the elevator machine room, hoistway, or pit. Firefighters should not use the elevators in that hoistway.

- Determine which elevators have firefighter service.
- Check the shaft for any fire, smoke, or water. If clear, enter the car and take control of the car operations (i.e., firefighter service Phase 2).
- Based on direction from Command or Lobby Control, deliver companies to the appropriate floors.
- Remain cognizant of the fire floor and ensure personnel do not take the elevator above the fire floor.
- Know the attack and evacuation stairwell locations so this information can be passed to incoming companies.

Staging

Staging refers to the area used for assembling resources close to operations on the fire floor, ideally two floors below the confirmed fire floor in a high-rise fire. The IC can change this location as they deem appropriate. Command should designate a staging officer. As the incident escalates, companies will likely engage quickly. However, Command cannot ignore the need for establishing staging. The assignment may be delayed until a unit from the second or third alarm arrives, but that does not diminish its importance.

The staging area will encompass significant activity related to assembling air cylinders, hose, tools, and equipment. To ensure a clean air environment, the staging officer should ensure a functioning air monitor or meter capable of detecting carbon monoxide is present.

The staging officer should assemble and maintain a pool of available firefighting crews and equipment. Once established, staging personnel should maintain a minimum number of ready resources, as determined by the IC, at this location.

Base

Base refers to the area where incoming fire apparatus and other vehicles park. The driver of the first engine arriving at base may serve as the initial personnel coordinating base activity in a high-rise fire. Using the driver for this role leaves the officer and the remaining crew available for other duties.

The base manager should begin organizing units by function and parking them in an orderly fashion. This includes parking units in diagonals along one side of the street to allow for easy egress and to keep a travel lane open. Parking all engines, trucks, medics, and rescue squads in groups of like vehicles facilitates the operation. Equipment, particularly air cylinders, should be taken from the apparatus and assembled for movement up to the fire building as needed.

Once Command establishes logistics, they may send logistics crews to retrieve tools and equipment from the apparatus parked at base.

Search Considerations and Procedures

Typically, commercial high-rises are most populated during regular work hours. Conversely, residential high-rises normally have higher occupancy during the evening and nighttime hours. However, it is not uncommon to find occupants in commercial occupancies after hours or in residential occupancies during the day.

Searching smoke-filled floors above the fire can be time-consuming and can require multiple crews per floor. Crews operating on the floor above the fire floor must search for signs of life and vertical extension and communicate these findings.

Personnel must know the evacuation stairwell location for both ambulatory and nonambulatory occupants. They must also use search ropes in commercial occupancies, even for small fires, as conditions can change rapidly.

Personnel should search all areas compromised by smoke. Officers assigned to search functions should ensure accurate tracking of areas where a search has been completed and communicate this information to Command and subsequent officers assigned to search functions.

Ventilation

Ventilation in a high-rise building presents particular challenges. However, personnel must find ways to remove the heat, smoke, and gases that build up during a fire. Personnel should coordinate these operations with attack, search, and evacuation activities in communication with Command.

There are several tactical options available to accomplish ventilation. In choosing one of these options, ICs and fire officers must consider the impact of wind and stack effect on the operation. Most often, it is better to have the fire knocked down before attempting to ventilate in a high-rise.

The three basic tactics include ventilating

- horizontally through the windows,
- vertically through stairwells, or
- through the building's HVAC system.

Horizontal Ventilation Through Windows

Horizontal ventilation in a commercial high-rise is challenging. Floor-to-ceiling windows, Lexan polycarbonate construction that is extremely hard to break, the unpredictability of a window falling from the building, and the likelihood of increasing the fire intensity all make this a poor option.

When ICs or fire officers decide to conduct horizontal ventilation, companies must understand wind conditions can be stronger at a high-rise's upper levels and can be unpredictable at any level. The number of windows ventilated should be limited and coordinated while observing the basic guidelines associated with horizontal ventilation. This includes opening windows on the leeward side first and the windward side last and isolating any smoke-free areas prior to this operation.

Where possible, personnel should open rather than break windows. Falling glass from broken windows presents a danger to crews and civilians entering and exiting the building. Windows should not be broken until the IC has taken the appropriate measures to evacuate the area below. Ideally, personnel should strike the glass from the outside with a tool, which will help direct the glass inward. If the area is beyond the reach of present aerial devices, truck and rescue squads could attempt venting from the floor above if conditions permit.

Crews must understand wind currents can create strong drafts in or out of the opening, so they should back each other up or secure each other with tag lines before a window is opened or broken.

The stack effect can interfere with horizontal ventilation. In a normal stack effect situation, the heated smoke and gases escaping into a stairwell proceed up and out. The effect of opened windows may violently blow fire toward the stairwell without smoke exiting through the vented window. Nothing is gained in this situation.

The preferred way to horizontally ventilate is to use the pressurized attack stairwell to pressurize the fire floor hallway and fire apartment to force smoke out the fire apartment window (see Figure 42). Additionally, personnel should place a positive pressure fan in the other stairwells to pressurize them and preclude smoke from entering. This operation depends on coordinating the placement of positive pressure fans with the venting of the fire apartment windows. If smoke has already polluted the attack stairwell and is not contained or venting out the fire apartment windows, the exhaust opening (e.g., bulkhead, scuttle) at the top of the stairwell must be opened.

Personnel must vigilantly monitor smoke movement to ensure that smoke vents out of the fire apartment windows without collecting in the common hallway and attack stairwell.

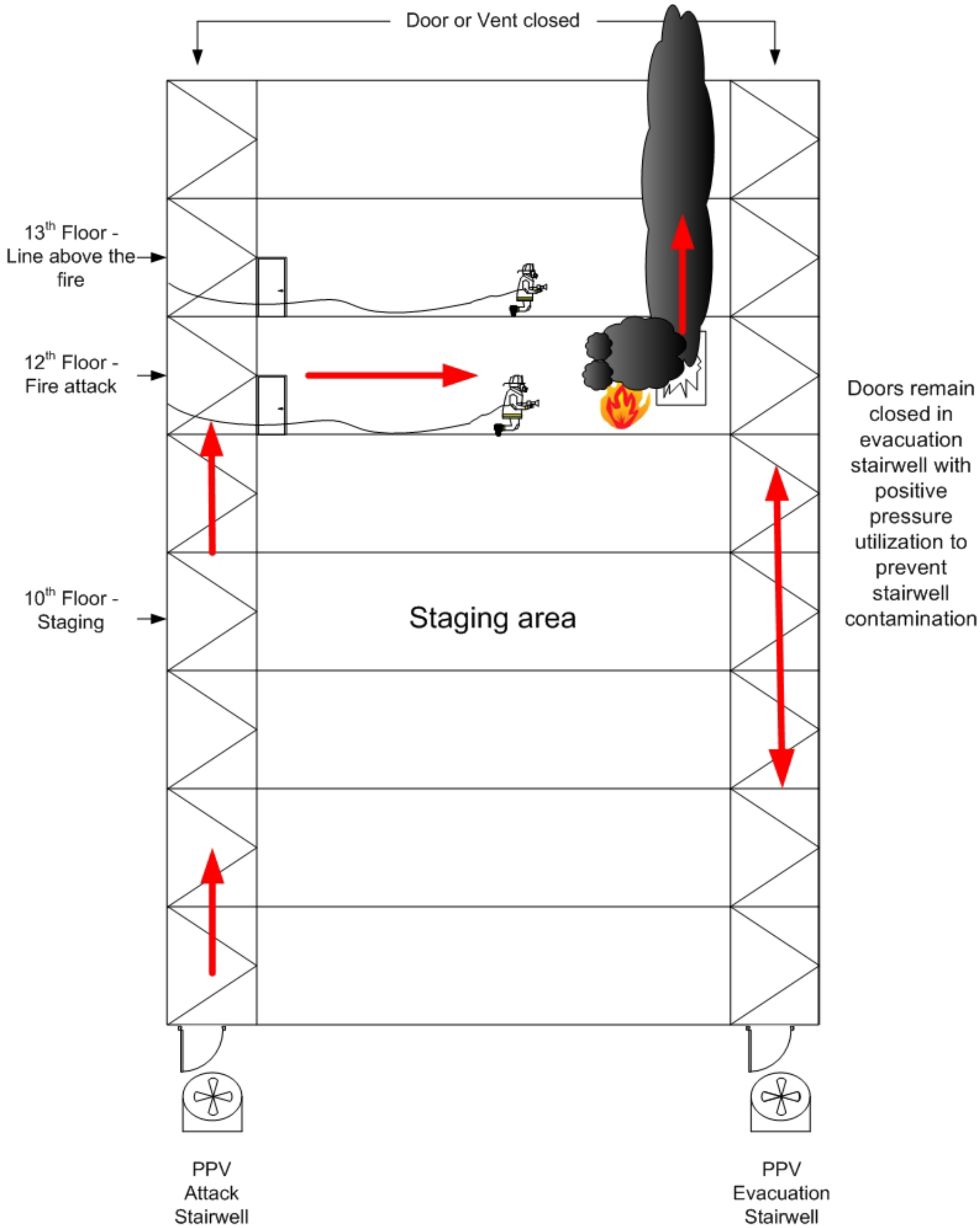

Figure 42. Use of pressurized stairwells and PPV to accomplish horizontal ventilation.

Vertical Ventilation Through Stairwells

The attack stairwell can become needed for ventilation efforts. This hinges on the fire's stage and volume and must be coordinated with the attack officer to avoid fire coming back onto advancing crews. However, personnel must remember that a stairwell still in use for evacuation cannot be used for ventilation, so they should only use PPV in the evacuation stairwell for pressurization (i.e., with the bulkhead closed).

Crews advancing to the top floors must assess the stairwells for occupants to help determine which stairwells are suitable for pressurization, ventilation, and evacuation. The ventilation stairwell must have a suitable opening (e.g., bulkhead, scuttle, exhaust fan) at the top that must be secured in the open position.

Personnel should initially shut down the HVAC in the affected area and not actuate it until they have coordinated with Command and the crews operating in the IDLH (e.g., fire attack, ventilation). Command must inform all crews operating in the building of the ventilation strategy, including the location of the ventilation and pressurization stairwells.

Personnel should only open doors to the stairwells on the floors affected by fire or smoke.

Vertical Ventilation Through Elevator Shafts

Vertical ventilation using elevator shafts represents the least desirable option. The openings at the shaft's top are typically inadequate, and on higher buildings, the shaft may not extend to the building's roof. Additionally, the elevators' mechanical room is typically located at the top of the shaft, requiring the smoke to move up and through this room to escape the building. Open shaft doors on affected floors create an additional hazard for firefighters and occupants.

If elevator shafts are used for vertical ventilation, personnel should ensure an adequate top opening, move the elevator car below the floors to be vented, open and secure the hoistway doors on the floors to be vented, and secure ladders across the front of all open hoistway doors.

HVAC System Ventilation

Some high-rise buildings contain sophisticated HVAC systems, which should shut down in the area under alarm if the systems are set in the auto mode in the fire control room. These systems can be placed in the exhaust mode to remove smoke on one or more floors. If the IC elects to use the exhaust mode, they should consult the building engineer.

The IC must also advise truck and rescue squads in the building when the HVAC system is used for this ventilation method. Conditions must be monitored and Command informed. If any company on the fire floor or floor above the fire detects that the HVAC system has remained on, they must communicate this back to Command so it can be shut down. Otherwise, the HVAC system could greatly increase the rate of smoke migration or fire extension.

Search and Evacuation

The purpose of a search and evacuation operation is to control occupants. To do so, personnel operating in this assignment must prevent panic, control evacuation, and properly complete primary and secondary searches. Additionally, they must monitor changes in smoke, heat, or fire conditions and report them to Command through the search and evacuation supervisor.

The evacuation process can present hazards to high-rise building occupants. Fire department personnel must supervise evacuee movement down the stairwells, providing firm and clear direction all the way to the point of assembly. Personnel must prevent excited building occupants, particularly those in a residential setting, from stopping and talking while exiting a stairwell into the lobby or other point of exit by continually guiding them to a safe assembly place as directed by the group supervisor.

Command should establish a search and evacuation branch or group if more than two floors above the fire still contain building occupants. Command should assign a chief officer, if available, to serve as the group supervisor. This officer should set up the search and evacuation post at least two floors above the highest fire floor. This post should be located inside the floor and near the evacuation stairwell. Command should consider using an alternate radio channel for this group and should announce its location once established. The location information should include floor number and closest stairwell (e.g., “Battalion 401 to Command, the search and evacuation group is located on Floor 15 at stairwell Charlie.”). Items such as portable radios, extra air cylinders, handlights, pens and paper, grease pencils or markers, and a command board should be available.

The group supervisor should assign at least one company to thoroughly inspect each floor—including the top floor—and the stairwells to assess smoke and heat conditions, size of the floor area, and the potential number of occupants. Based on the first company’s assessment, the group supervisor may determine additional units are needed to carry out proper search and evacuation.

All units operating under the search and evacuation branch or group should use the evacuation stairwell to ascend and descend and remove victims. Crew members must keep the evacuation stairwell clear of as much smoke and heat as possible to facilitate the evacuation operation and prevent evacuees from becoming patients after entering the stairwell. Consequently, personnel must ensure the doors between the fire floors and the evacuation stairwell remain closed. The exception would be to rescue a trapped or injured firefighter.

Establishing a search and evacuation branch or group does not make the complete evacuation of the floors above the fire imperative. Rather, the group supervisor must take responsibility for the control and safety of occupants above the fire floors. This officer should make decisions on evacuation or protect-in-place tactics based on each individual floor’s conditions, progress fighting the fire, and consultation with Command.

The group supervisor should use the fire service telephones to communicate with the fire control room or lobby officer. Then personnel in the fire control room can communicate pertinent information and directions to building occupants on selected floors via the PA system.

Stairwell Support

Stairwell support represents one of firefighting’s highest priorities during the early stages of a high-rise building event. If a fire occurs in a building where crews cannot use the elevators, stairwell support becomes the lifeline for operations at and above the fire.

Fires involving more than one apartment or occurring in an office high-rise require a large number of resources to be moved upward in the building. At minimum, stairwell support requires a firefighter positioned every two floors to effectively shuttle equipment.

Air cylinders represent a priority. Personnel should anticipate no more than 15 to 20 min per air cylinder during firefighting operations. The first alarm units will not be able to take up spare cylinders, so the IC must take immediate steps to begin moving air cylinders upstairs.

Personnel should expect to deliver the following to the fire area:

- spare self-contained breathing apparatus cylinders,
- extra self-contained breathing apparatus packs,
- the supplied air line from the mobile air unit,
- water for personnel hydration,
- standpipe packs,
- flashlights and portable lighting, and
- portable radio batteries.

EMS Branch

The EMS branch manages all civilian patients. Command should assign an EMS supervisor to manage the EMS branch. If units encounter civilian patients upon arrival, they should assume more patients will come. At a fire in an occupied high-rise where the first due units encounter patients, additional EMS resources should be ordered to the scene.

Medical Unit

The medical unit cares for and treats fire department personnel. Command should assign an EMS supervisor to manage the medical unit; however, if the incident escalates, this position should be staffed by a chief officer. The medical unit is responsible for developing the medical plan, which should include a rehabilitation component.

The medical unit, including rehabilitation, should set up one floor below staging to ensure they can properly evaluate personnel. The rehabilitation manager reports to the medical unit leader.

Safety

The safety officer reports directly to Command. Exterior safety issues include concerns such as controlling the building perimeter, evaluating danger from falling glass and other objects, and controlling or denying access to the danger area, as necessary.

Safety personnel must constantly check for hazardous conditions that operating crews should know about. Examples include open elevator shafts or windows broken out flush with the floor.

Given the complexity and sheer size of a high-rise incident, Command should consider requesting a second safety officer. With two safety officers, one each could be directed to interior and exterior safety.

Planning

Planning represents another command post function that must be staffed for serious high-rise fires. Command should recognize that a high-rise fire requires the planning section to be implemented early.

The battalion aide or an EMS supervisor normally serves as the initial planning section officer. Responsibilities include assisting with creating the incident action plan, updating situation and resource status, identifying needs for specialized resources, and maintaining incident status and records using Command worksheets or boards.

Logistics

The logistics section is a command post function. Command must assign this position early in a high-rise incident. The logistics and planning functions might be initially performed by one officer. However, as an incident develops, they should be separated.

The logistics officer must primarily ensure the availability of adequate personnel and equipment. One of the most important tasks of this section is to establish, staff, and supervise the stairwell support unit. This role is crucial to ensure sustained operations on and above the fire floors.

In addition to supporting the incident's operational needs, the logistics officer must also address supporting services. Operations that extend several hours or more may require the provision of meals, fuel, and additional relief personnel.

ADDENDUM

MIDRISE BUILDING FIRES

DESCRIPTION – MIDRISE BUILDINGS

General Characteristics

A midrise building is three to six stories high and measures less than 75 ft from the lowest level of fire department vehicle access to the highest occupiable floor.

Midrise building construction can allow for more occupant density than garden apartments without the regulations or fire-code and construction requirements of high-rises. Midrise buildings can include commercial or residential occupancies or a combination of commercial and residential (i.e., mixed-use) occupancies. Midrise buildings can have large footprints or unusual designs that result in long hose stretches and significant distances between stairwells.

These structures may have many garden apartment characteristics, such as the following:

- full, partial, or no sprinkler protection;
- no standpipe system;
- ordinary construction (i.e., masonry bearing walls, wood floor and roof);
- lightweight wood construction; and
- large attic space.

Midrise structures may also have many high-rise characteristics, such as the following:

- full, partial, or no sprinkler systems;
- a standpipe system;
- riser connections located in hallways;
- firefighter service to the elevators;
- standby and emergency power systems;
- noncombustible construction;
- hallways to access work or living areas;
- fire doors in hallways to compartmentalize the fire;
- center core floor plan;
- commercial occupancy on lower levels; and
- parking garages.

Construction

Three factors drive a building's construction characteristics: the time period when the structure was built, the building code in place at the time, and the original occupancy intent (e.g., retail, residential, office).

Builders of commercial midrise buildings generally employ noncombustible construction methods dependent on steel and concrete.

Residential midrises built in the 1950s were frequently constructed using ordinary methods, with masonry walls and dimensional wood floors and roofs. Modern residential midrises are typically built utilizing lightweight wood construction.

Mixed-use buildings with both commercial and residential occupancies often utilize a hybrid construction method that incorporates a mix of lightweight wood and noncombustible materials, widely known as podium construction.

Podium Construction

Podium construction (see Figure 43), also known as pedestal or platform construction, utilizes multiple stories of light framing over a single or multistory concrete or steel podium. The upper slab of the concrete podium typically acts as both a fire separation and structural transfer slab for the framing above.

Common configurations include four or five stories of residential occupancies over retail, commercial, or office space and sometimes parking.

When midrise buildings have utilized a combination of construction methods, personnel should treat them according to the method with the lowest fire rating.

Figure 43. Podium construction used to build a lightweight, residential midrise over a noncombustible parking garage.

Midrise Building Design

The design and interior layouts of midrise buildings vary with the era of their construction, associated building codes, and original intended use. No standard or typical midrise building type exists; however, broad building design categories can be identified and found throughout the region.

The distinction between construction methods and building design should be noted. Although these characteristics are related in terms of operational assessment, personnel should not make assumptions about a building's construction methods based on its external appearance or design.

Commercial Midrise

Traditional commercial midrise buildings, also referred to as low-rise buildings, are typically occupied by businesses that use them for office space or industrial needs (see Figure 44). institutional or medical organizations also occupy these buildings.

Other than total overall height, these buildings strongly resemble high-rise buildings, with which they share similar layouts and building and fire protection systems. Like many high-rises, commercial midrise buildings typically have central hallways, center core floor plans, or open space on each floor.

Figure 44. A commercial midrise.

Assisted Living Midrise

Midrise buildings designed as assisted living facilities appear throughout the region. These structures incorporate characteristics of residential, commercial, and medical facilities. They often have an open atrium design with a central stairway in the lobby (see Figure 45). The hallways often resemble those in a residential midrise.

Figure 45. Lightweight midrise building occupied as an assisted living facility.

Walk-up

Walk-up, or tuck-under, midrise buildings (see Figure 46) typically serve residential occupancies, stand three to four stories high, and provide living space above ground-level parking garages. Occupants access upper floors through individual private stairways or, in some instances, shared hallways with elevator access. Walk-up midrises are typically built using only lightweight wood frame construction methods.

Figure 46. Side Alpha (left) and side Charlie (right) of a walk-up midrise building.

Wrap-Around

The wrap-around midrise design, also known as the "Texas donut," consists of a centralized multistory concrete parking structure surrounded by multiple stories of wood-frame units built from the ground up. Wrap-around midrise buildings provide accessible parking for occupants as well as security and visual appeal because the parking structure cannot be seen easily from the street.

Alternatively, this design may be built around a communal swimming pool or courtyard instead of a parking garage. In these instances, it is not uncommon to find ground-level and below-grade parking.

Wrap-around midrise buildings are often mixed-use occupancies with retail and commercial units inhabiting much of the first floor and residential apartments or condominiums situated above (see Figure 47). Lower floors typically have exterior access and provide interior stairways and elevators that give residents access to upper floors.

These large structures house 60 to 80 units per acre. Due to their size, some buildings will carry multiple addresses. Interior fire doors may divide addresses, and the apartment numbering may not be sequential.

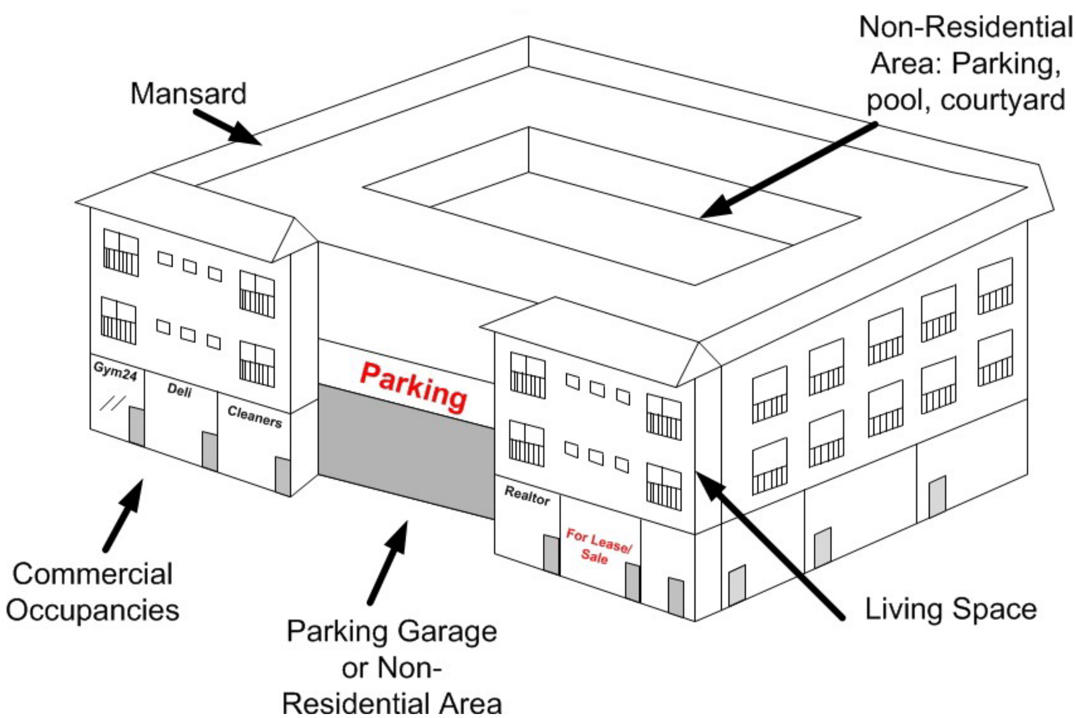

Figure 47. A wrap-around residential-over-commercial midrise design.

Roofs

Midrise building roofs vary greatly in design. Commercial buildings and older residential buildings typically utilize a flat roof, and newer residential occupancies often incorporate peaked roofs with large cross gables and dormers. Some building designs enclose typical attic spaces to create loft areas that increase the interior living area.

Interior Layouts

The interior layouts and floor plans of midrise buildings differ greatly according to size, design, and occupancy. Some buildings have long straight hallways like many high-rise buildings, and others may incorporate I-, T-, or Y-shaped connected hallways. Wrap-around midrise buildings often have circumferential hallways.

Such long hallways are typically equipped with self-closing fire partition doors that divide the hallway and slow the lateral spread of fire and smoke (see Figures 48 and 49). Many newer buildings also have an FDC riser on each side of the door to accommodate hallway length. In older midrise buildings, these doors may not be self-closing. Personnel should also be cognizant that some midrise buildings may also have standpipe connections on either side of the fire partition doors.

Interior apartment numbering may not be consecutive within large midrise buildings carrying multiple addresses. These changes are not always noted or identifiable from the structure's interior.

Figure 48. Long hallways are common in midrise buildings.

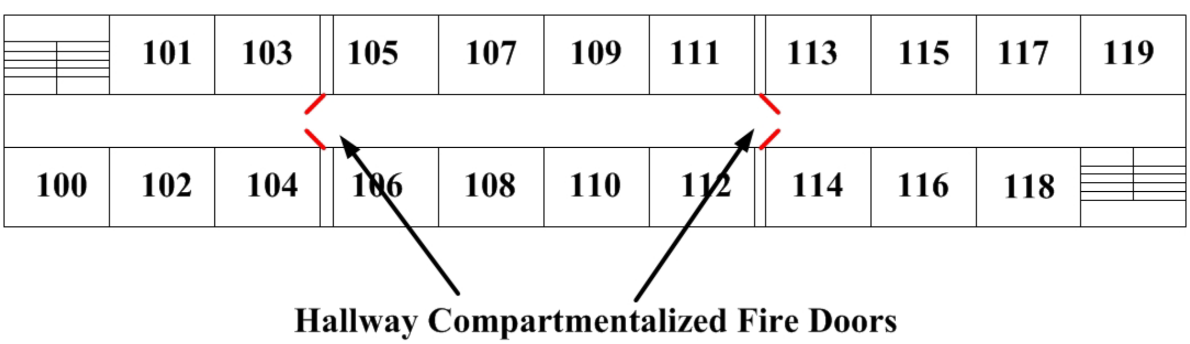

Figure 49. Long hallways equipped with self-closing fire partition doors.

Parking Garages

Midrise parking garages may reside beneath, adjacent to, or encircled by the building (see Figures 50 and 51). Garages may be open to the elements or fully enclosed, and fire protection systems may or may not be present.

Parking garages beneath or encircled by the building are typically sprinklered and have a wet or dry standpipe. Residents may access these garages from an elevator or stairway inside the building; one or both may be enclosed in a lobby within the garage.

Mechanical, utility, or trash rooms or other service-related areas may also reside in the garage. A vehicle or contents fire in a garage may cause rapid fire and smoke extension into other areas of the structure. The presence of a finished living area over the garage presents a serious life hazard.

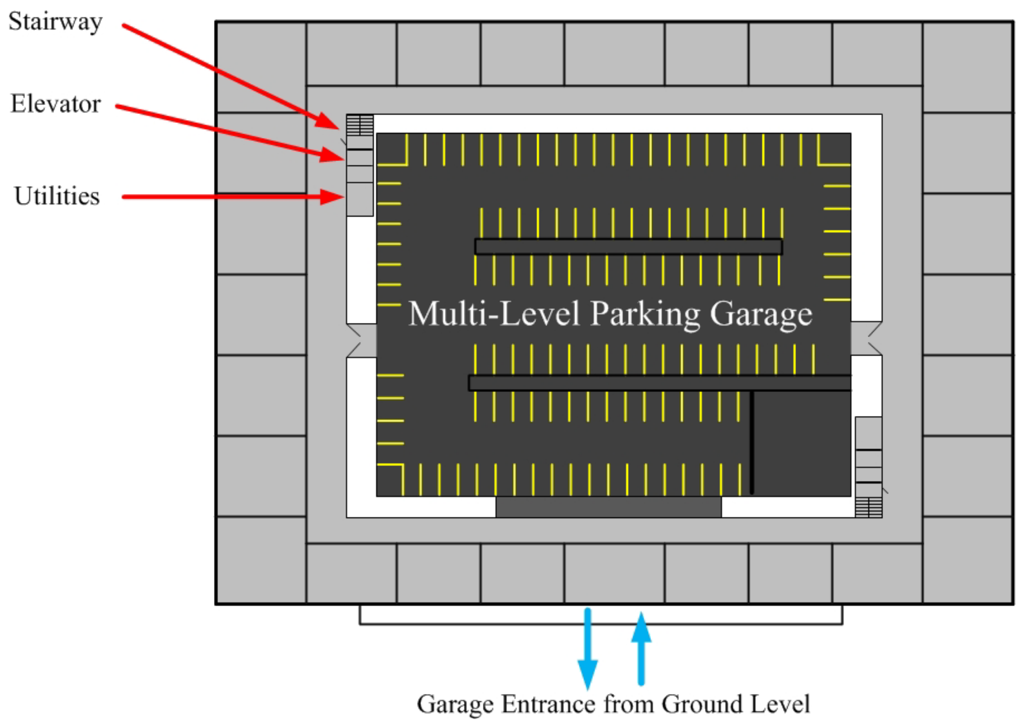

Figure 50. Wrap-around style midrise encircling a parking garage.

Figure 51. Parking garage access.

In many cases, a doorway directly connects the occupied living areas with the vehicle parking areas (see Figure 52). Although such doors must be fire-rated, they are often found propped opened or not fully closed. In such instances, a relatively minor vehicle fire can spread large amounts of toxic smoke into the stairways, hallways, and occupied areas of the building.

The type and construction of parking garages adjacent to and detached from midrise buildings range from freestanding multistory garages to individual carports. These may or may not have fire protection systems.

Figure 52. Garage access via the interior of the midrise building.

Balconies

Balcony support systems, floor coverings, and railings can be constructed of wood, metal, concrete, or a combination of these materials.

Older, ordinary-construction midrise buildings frequently have regular hinged doors on the balconies rather than the sliding glass doors found in more modern buildings. In newer construction, balcony door frames are typically aluminum or vinyl and incorporate insulated tempered glass into sliding or French-opening doors.

Newer constructed balconies may have a dry sprinkler system.

Three general types of midrise balconies commonly exist: cantilevered, recessed, and hinged. Cantilevered balconies project out over the load-bearing wall. These balconies are open to the exterior on three sides and extend away from the building (see Figure 53).

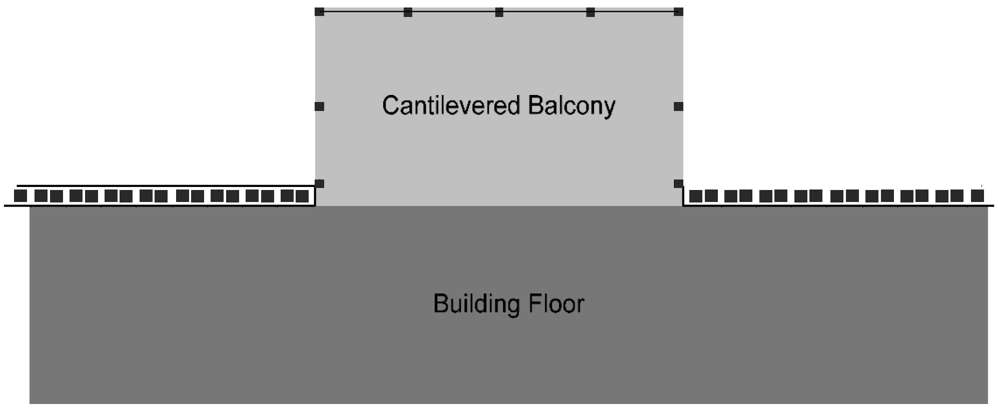

Figure 53. Cantilevered balcony.

Recessed balconies are supported on three sides by bearing walls. A railing extends between the two walls, and the balcony is open on only one side (see Figure 54).

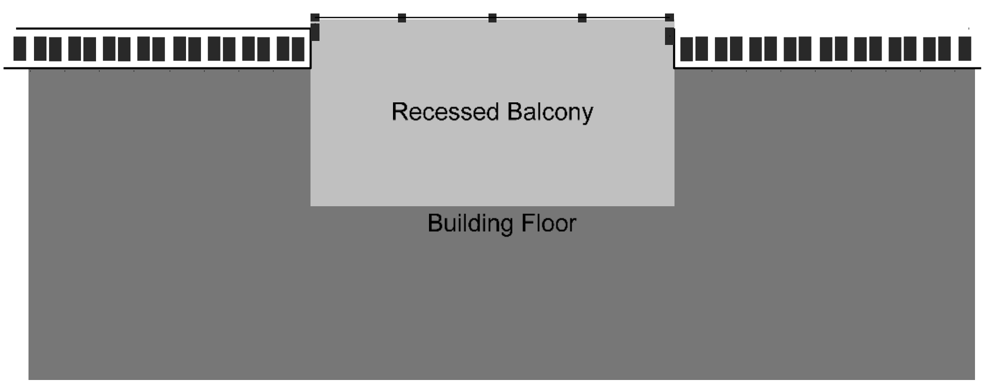

Figure 54. Recessed balcony.

Some corner units have hinged balconies supported on two sides by bearing walls and corner columns extending from the ground to the roof (see Figure 55).

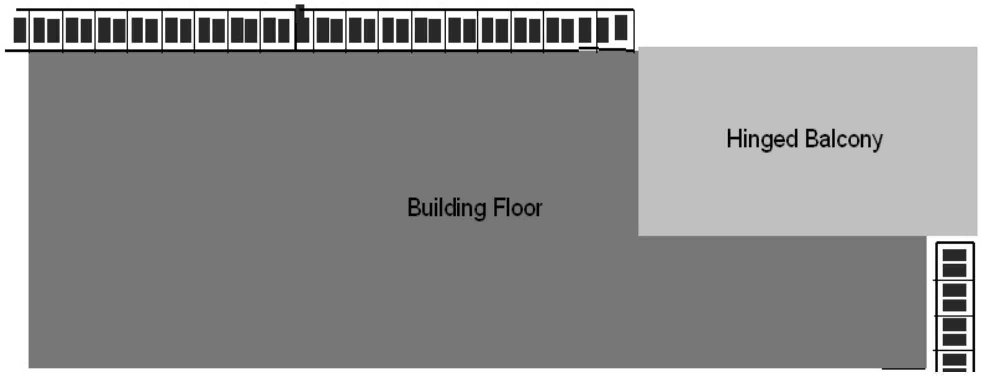

Figure 55. Hinged balcony.

Fire Protection Systems

Commercial, residential, and mixed-use midrise buildings typically have some form of monitored fire alerting system with smoke detectors.

FDCs

Large wrap-around midrise buildings may utilize multiple addresses under one common roof. Such buildings can be equipped with multiple FDCs. Personnel should note that any one FDC connection on the exterior may only provide water to a specific corresponding section or address of the building and not the entire building.

Standpipe Systems

Midrises may or may not have standpipe systems. Depending on the floor area and stairway location, standpipe riser outlets may be located at hallway midpoints. Due to the level of protection provided by the stairway landing door, personnel should give preference to using risers in the stairway where feasible. Personnel should refrain from using the riser located in the hallway unless necessary.

Residential Sprinklers

Many lightweight midrise buildings use National Fire Protection Association standard NFPA 13R residential sprinkler systems. These systems are designed to contain a fire but may not completely extinguish it. NFPA 13R sprinkler systems are constructed using polyvinyl chloride (i.e., PVC) plastic pipes that are usually orange.

Preaction Systems

Preaction fire sprinkler systems employ the basic concept of a dry pipe system in that the extinguishing agent is not normally contained directly behind the discharge orifice. The difference, however, is that an electrically operated valve (i.e., a preaction valve) holds the suppression agent from the piping. Independent flame, heat, or smoke detection controls the valve’s operation.

Two separate events must occur to initiate discharge. First, the detection system must identify a developing fire and then open the preaction valve. This allows the extinguishing agent to enter the system piping. Second, individual discharge orifices must open to deploy the extinguishing agent.

Localized preaction systems are often found in commercial midrise buildings housing information technology (IT) and data server equipment, where the inherent risk and cost associated with an accidental discharge or leak from a conventional wet pipe, water-based sprinkler system is too great.

Water can be used as the extinguishing agent in a preaction system; however, oxygen displacing gases and other chemical compounds are common.

Gaseous systems use either inert gas or clean agent gas. An inert gas system uses a mixture of argon and nitrogen gases to decrease oxygen levels present in the room, which naturally puts out the fire. A drawback to inert systems involves the large footprint created by the number of gas cylinders needed to effectively saturate a given area.

The two common clean agent gas systems are 3M Novec 1230 and Chemours FM-200. These agents suppress the fire by reducing the fire’s heat through absorption. Clean agent gases are electrically nonconductive, noncorrosive, and leave no residue upon evaporation. This makes them the ideal fire suppression agents for IT equipment.

HAZARDS – MIDRISE BUILDINGS

Fire Hazards

Midrise buildings have many of the same hazards associated with high-rise buildings (e.g., long hallways and hundreds of occupants), but because of their relatively low height, midrise buildings may not have all or any of the fire safety equipment found in modern high-rise structures. Lightweight wood-constructed midrise buildings may not be equipped with standpipes, sprinkler systems, HVAC control, a fire control room, communication systems, or stairway pressurization fans.

Midrise buildings may also have many of the same fire hazards associated with garden apartments, such as large open attic or cockloft areas, utility shafts with void spaces, combustible exterior walls, and lightweight construction. A midrise building's increased occupancy load and larger footprint can exaggerate these hazards.

Vertical void spaces, such as pipe chases in kitchens and baths, allow interior vertical fire extension from floor to floor and into attics and cocklofts. Fire that has extended into void spaces can damage structural components and cause collapse. Personnel should open void spaces adjacent to areas of fire involvement to check for extension.

Buildings Under Construction

Fires in midrise buildings under construction present particular challenges to firefighting operations, so they require strategies and tactics specific to the building's state of construction and the extent of fire involvement.

Buildings still under construction may have several protective elements not yet in service or installed.

- Fire-rated materials that slow fire extension may be missing.
- Building sprinkler and standpipe systems may not be operable.
- Water supply systems may not be installed or readily accessible to fire apparatus.

In the framing stages of construction, a building several stories high may not yet have installed drywall. This lack of protection can allow a fire to quickly spread and damage structure components, leading to rapid collapse.

Fires in buildings under construction tend to become well-developed, large-volume fires before the first fire department units arrive. When faced with these conditions, officers should prioritize exposure protection and recognize the need for high-flow master-stream attacks in lieu of handline deployment.

Construction sites pose inherent hazards. Flame impingement or hose-streams can cause scaffolding around the site to collapse or fall over. Also, paint and other flammable or combustible liquids used in the building process can accelerate fire spread.

When operating at construction-site incident scenes, firefighters should watch for trip hazards and impairments to hoseline deployment caused by concrete form work and support bracing, exposed rebar rods, piles of construction debris, and uneven ground.

Raised Floor Systems

Raised floor systems, sometimes referred to as a computer access flooring system, elevate a room's flooring structure to allow infrastructure-related utilities to be routed and rerouted without interfering with a room's interior occupiable space. A raised floor system uses a grid structure, pedestals, and raised floor tiles, which create a gap above the substrate.

Pedestals support the grid of a raised floor system, which can be adjusted vertically to attain the desired space above the subfloor. Pedestals can be affixed to the substrate using several mechanical or adhesive options.

Fires can occur within the space beneath a raised floor system housing electronic equipment, wires, cables, HVAC equipment, and other combustible materials. When responding to IT-related occupancies, personnel should look for raised floor systems and be sure to check for fire beneath them in the same way they check for fire in plenum spaces above drop ceilings. Fire can damage the structural integrity of a raised floor system, leading to failure and firefighter entrapment.

FIRE OPERATIONS – MIDRISE BUILDINGS

Midrise buildings share characteristics found in both high-rise buildings and garden-style apartment buildings. As such, the tactics appropriate to combat fires in midrise buildings can overlap with tactics employed during fires in garden apartments or high-rise buildings.

When considering operational tactics for fires in midrise buildings without standpipe systems, personnel should refer to those outlined in the NOVA *Garden-Style Apartment Fires* manual.

When considering operational tactics for fires in midrise buildings with standpipe systems, personnel should refer to those outlined in the Standpipe Operations section of the high-rise portion of this manual.

A detailed knowledge of specific building characteristics achieved through preincident planning is essential for accurately and efficiently determining tactics after arriving on-scene at a midrise building fire.

Command Considerations

The first command officer to arrive on-scene should establish Command. Fires in a midrise building require more resources than similar fires in other structures. After confirming a fire in a midrise building, ICs should evaluate the need for additional resources and make requests for additional alarms and RIT resources commensurate with the situation's severity.

Additional command officers may be used in tactical positions. ICS should assign these positions early in an incident to establish and build an effective and efficient command structure. Strategic positions for additional command officers include the following:

- division supervisors,
- group supervisors,
- branch directors, and
- section chiefs.

Operational Communications

Personnel should reference the NOVA *Field Communications* manual for information about operational communications. Related information specific to fires in midrise buildings is provided in this section.

Water Supply Report

The decision to utilize garden-style apartment tactics or high-rise building tactics will affect the water supply report and the responsibility for establishing the incident's primary water supply.

If the unit officer of the first-arriving engine company decides to utilize preconnected hoselines for their initial fire attack, they should communicate a water supply report to the second due engine company, identifying the location and method of the hose lay. A forward (i.e., straight) hose lay should be utilized, when possible, with care given to maintaining unimpeded access to subsequently arriving truck companies.

If the unit officer of the first-arriving engine company decides to utilize the building's standpipe system and high-rise tactics, they should communicate the need for the second due engine company to establish the primary water supply and then supply the building's FDC.

On-Scene Report

The first-arriving unit officer, typically that of the first due engine company, should provide the following information to the first due command-level officer in the on-scene report:

- unit identification and side of structure where the apparatus is positioned,
- building height (i.e., number of stories above ground),
- occupancy type, and
- a detailed report of evident conditions (to include side of structure conditions are evident, quadrant located, and description of conditions).

On-scene reports for midrise building fires should resemble the following: "Battalion 404 from Engine 430, Engine 430, on-scene, side Alpha of a 4-story, mixed-use midrise, fire showing from a balcony, side Alpha, Floor Number 3, all units take high-rise assignments."

Size-Up and Situation Report

During the size-up, unit officers should assess the location and extent of smoke and fire as well as rescues, access points, number of floors, utilities, and exposures.

If structure size or layout makes a 360-degree lap impractical, first-arriving unit officers should coordinate with other units to complete a size-up of all structure sides and identify the lowest level of fire involvement.

Topography and other grading-related issues can also significantly impact an officer's ability to complete a midrise building lap (see Figure 56). The number of floors visible from the addressed side of a midrise building can differ by several stories from those visible in the rear. Units arriving on different sides of a building can have significantly different views and develop conflicting understandings of a building's size and layout. Such discrepancies can lead to communication problems and inefficient resource deployment.

Officers should use the information gathered during their size-up to determine their initial strategies and tactics. This information, as well as actions needed by other units and the need for additional resources should be communicated to the first due command-level officer in a situation report. Situation reports should resemble the following:

"Battalion 404 from Engine 430. Unable to complete a lap, confirmed four in the front, four to the rear over an underground parking garage. Floors will be labelled garage, 1, 2, 3, 4. Garage is clear of smoke and fire. The fire is located on side Alpha, Floor Number 3, quadrant Alpha.

Building is being evacuated. Engine 430 with a crew of four to Floor Number 3 for fire attack and search. Dispatch RIT taskforce. Requesting to transfer Command."

When high-rise tactics have been selected, the first due engine company officers should provide lobby reports and fire-floor reports to the first due command-level officer as described in the First Due Engine section of the high-rise portion of this manual.

First due engine company officers should also provide conditions-actions-needs reports and progress reports as needed.

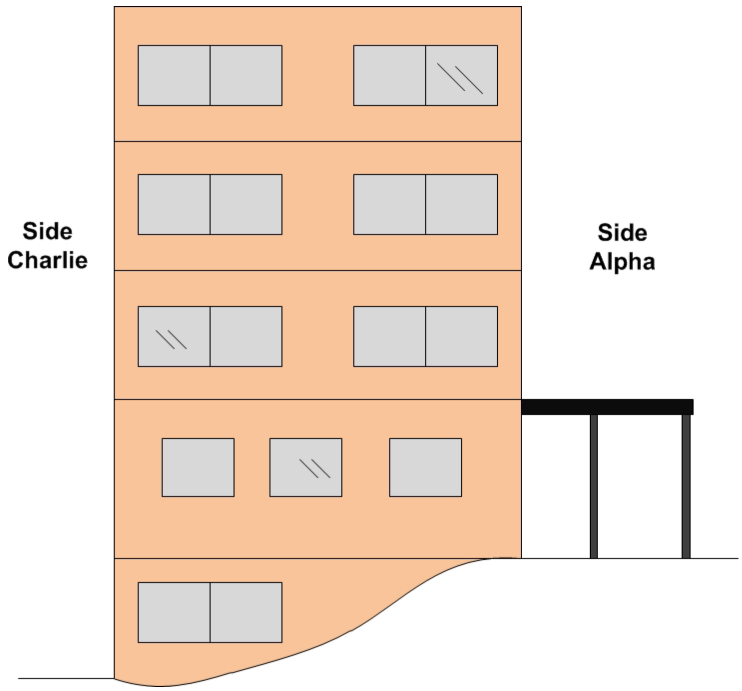

Figure 56. Differing number of floors visible from side Alpha and side Charlie of a midrise building.

Hoseline Selection and Advancement

Strategic considerations and the selection of appropriate tactics for midrise building fires closely relate to those described in the Fire Operations – High Rise Buildings section of this document and in the NOVA *Garden-Style Apartment Fires* manual. Personnel should refer to these materials for information applicable to midrise buildings regarding initial and secondary hoseline deployment, hoseline advancement, standpipe operations, and master streams.

Related information specific to fires in midrise buildings appears in this section.

Initial Attack Line

Fire location determines whether the initial attack line is stretched from the engine directly to the fire area or from an available standpipe. Companies may consider using other means (e.g., a balcony, window, or patio) for advancing lines to the fire.

For below-grade or first- through third-floor fires in buildings without a standpipe, personnel may choose to stretch preconnected lines from the engine because they are faster to deploy and place in service. Often, personnel can position the engine at or near an entrance that provides quick and easy access to the fire without taking time to locate and connect to a standpipe inlet.

Before committing to preconnected hoseline stretches, personnel must determine the fire location, ideally by noting visible smoke or fire through a specific window from the exterior. When making the stretch from the apparatus and not a standpipe, personnel must communicate this to other units and Command. Also, when employing this tactic, the engine operator must remain at the pump panel rather than abandoning the apparatus to assist with standpipe operations on the fire floor.

If present, the standpipe system must still be supplied, even if crews make the initial attack with handlines stretched directly from the apparatus. Later, personnel can deploy hoselines from the standpipe if needed. All other roles and responsibilities outlined in this manual should be assigned, regardless of how personnel deploy the initial handline.

In buildings without standpipes, companies must preplan their attack operations. Personnel may need to use longer hoselines, deploy hoselines up and over ground ladders, or use rope to hoist hoselines from the exterior to upper floors.

Exposure Lines

The purpose of an exposure line is to prevent or extinguish fire spreading to an adjacent structure. Midrise buildings can be closely spaced and susceptible to fire spread. Hoselines and fire streams deployed for exposure protection can also serve exterior fire attack (see Figure 57). Thoughtful positioning allows personnel to alternate the direction of these fire streams from the burning building to the exposure.

Personnel should position exposure lines outside the building’s collapse zone.

Due to high radiant heat, it may be necessary to apply cooling streams directly to apparatus and the firefighters operating the exposure line.

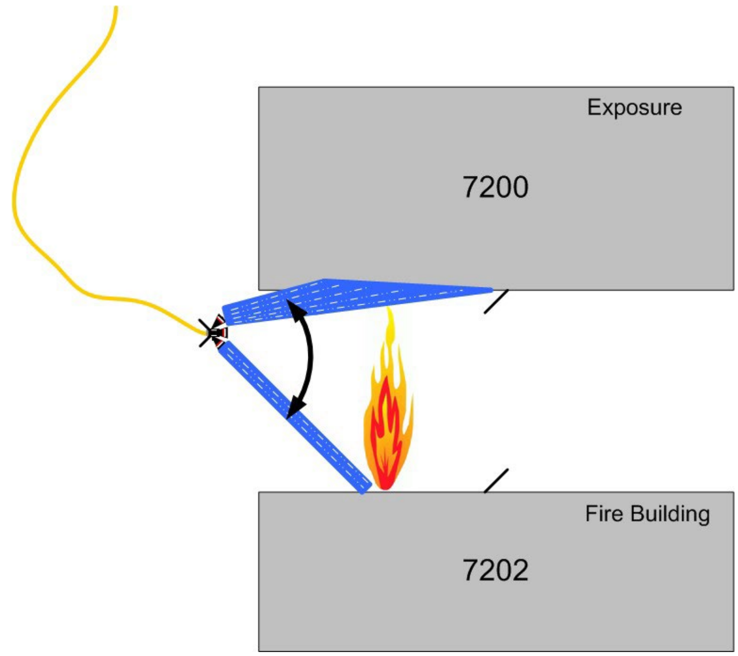

Figure 57. Position of a ground monitor for exposure protection and fire attack.

Attic, Below-Grade, Parking Garage, and Large-Volume Fires

Appropriate tactics for attic, below-grade, parking garage, and large-volume fires in midrise buildings closely align with those described in the Vehicle Fires in Attached Parking Garages section of this manual and the NOVA *Garden-Style Apartment Fires* manual. Personnel should refer to these materials for information applicable to midrise buildings.

Related information specific to fires in midrise buildings appears in this section.

When personnel encounter a large volume of fire (see Figure 58), the first-arriving officer must define the mode of operation and implement tactics consistent with that mode. An important facet in making this tactical decision involves determining if sufficient gallons of water per minute are available to overcome the Btus created by the fire. It may be appropriate for the first-arriving officer to address the most severely threatened exposures immediately after life safety concerns are addressed. It may be necessary for the first-arriving engine company to perform a holding action or a quick knockdown on the units of origin using the engine company's deck gun.

Early in the incident, Command should consider requesting additional alarms at a large-volume midrise building fire.

Figure 58. Large-volume residential midrise fire.

RESOURCES FOR FIRES IN MIDRISE BUILDINGS

The minimum initial alarm assignment for a midrise building fire consists of:

- five engines,
- two trucks,
- one rescue squad,
- one EMS unit,
- two battalion chiefs,
- one command aide, and
- one EMS supervisor.

The unit assignments outlined in this document are based on typical common tasks in a logical order. Officers may need to adjust any assignment as deemed necessary based on the specific problems encountered at an incident.

Engine Companies

Responding units should position and operate according to the initial tactical plan communicated by the first-arriving officer. The initial tactical plan and associated unit assignments will generally align with either those described in the Resources – High Rise Buildings section of this manual or with those described in the NOVA *Garden-Style Apartment Fires* manual, depending on the characteristics of the midrise building and the location of the fire. Personnel should refer to these materials for information applicable to midrise building fire unit assignments.

The assignment of the fifth due engine company in response to a fire in a midrise building without a fire protection system or when initial tactics do not incorporate standpipe operations is discussed in the next section.

The fifth due engine company's responsibilities at a building without a standpipe may include the following:

- Help the third due engine establish a secondary water supply, if needed. The driver fulfills this task.
- Bring hose packs and forcible entry tools.
- Report directly to the command post; confer with the IC; then report to the building's lobby area to assume lobby control.

If no lobby exists, the crew should assess if the building has any fire protection systems and advise Command. Alternatively, the IC may assign this unit to a specific operational task.

Special Service Companies

Truck and rescue companies' functional duties closely parallel one another. Either of these units may carry out tasks such as searching for victims, locating the fire, forcible entry, ventilation, and utility control. Certain assignments are specific to the apparatus (e.g., laddering or the use of extrication tools or other specialized equipment carried on the apparatus).

If incident dynamics do not indicate the need for aerial device deployment, the truck company should operate according to the initial tactical plan communicated by the first-arriving officer. The initial tactical plan will generally align with those described in the Resources – High Rise Buildings section of this manual and the NOVA *Garden-Style Apartment Fires* manual. Personnel assigned to special service companies should refer to these materials for information applicable to midrise building fire unit assignments.

First Due Truck

The first due truck should park on side Alpha unless the fire location can be readily identified. In the latter case, the truck should park on the fire side of the building if accessible.

If smoke, fire, or victims appear within reach of the aerial device, the crew should perform the following as appropriate:

- Raise the aerial to access the unit or location involved in a manner that maximizes the aerial's scrub area.
- Avoid placing the ladder to a window or balcony showing fire unless an occupant in that location requires rescue or the elevated master-stream tactic is being used for fire attack.
- Raise the aerial to an adjoining unit if the apartment or unit is totally involved. Position in front of the involved structure to maximize aerial's scrub area for roof access and master-stream deployment.

EMS Units

Transport personnel should not routinely be assigned to suppression duties or non-EMS functions such as RIT. Transport units should park as close as possible to the incident, allowing for rapid care of any injured persons, emergent departures, access to equipment, and provision of a sheltered environment, if needed.

Transport personnel should not routinely don personal protective equipment and self-contained breathing apparatus unless the IC deems, and they are needed for a necessary suppression task. When responding to incidents with reports of a Mayday or trapped or injured individuals, EMS personnel should leave their personal protective equipment and self-contained breathing apparatus on the unit and rapidly report to the incident scene with their EMS equipment.

Command Officers

After arriving on-scene, the first due chief officer should gather all available information and assume or establish Command. The chief officer should exchange information with the initial IC and then determine the command post location. The chief can elect to use their vehicle or a lobby area near the fire control room if access can be controlled.

The second due chief officer should report to Command for a briefing. This chief officer is typically assigned division supervision of operations on the fire floor.

OTHER CONSIDERATIONS – MIDRISE BUILDINGS

Forcible Entry

Personnel should reference the NOVA *Truck Company Book 2 – Forcible Entry* manual for information about various forcible entry techniques appropriate for midrise buildings.

Ladder Deployment

Personnel should reference the NOVA *Truck Company Book 3 – Ladders* manual for information about various forcible entry techniques appropriate for midrise buildings.

Search and Rescue

Personnel should reference the NOVA *Truck Company Book 4 – Search and Rescue* manual for information about various forcible entry techniques appropriate for midrise buildings.

Related information specific to fires in midrise buildings appears in the high-rise Search and Evacuation section of this manual.

Ventilation

Personnel should reference the NOVA *Truck Company Book 5 – Ventilation* manual for information about various forcible entry techniques appropriate for midrise buildings.

APPENDIX

STANDPIPE ROOF FLOW AND PRESSURE CHART (AUGUST 2014 – REV 6)

DATES COVERED	REFERENCE	REQUIRED ROOF FLOW	RESIDUAL PRESSURE REQUIRED	CODE SECTION REFERENCE
1955 – 1962	National Building Code 1955 ed.	250 gpm per outlet	20 psi	809.7(b)
1962 – 1970	BOCA 1965	200 gpm	50 psi	1208.0
1970 – February 1976	BOCA 1970 w / 1972 Supp.	200 gpm	50 psi	1208.0
February 1976 – August 1978	BOCA 1975	250 gpm per outlet	65 psi	1211.7
August 1978 – July 1982	BOCA 1978	500 gpm	65 psi	1211.7
July 1982 – April 1986	BOCA 1981	500 gpm except 250 gpm for Buildings < 75 feet w / Sprinklers	65 psi	1711.7.1
April 1986 – March 1988	BOCA 1984	500 gpm except 250 gpm for Buildings < 75 feet w / Sprinklers	65 psi	1711.3
March 1988 – March 1991	BOCA 1987	500 gpm except 250 gpm for Buildings < 75 feet w / Sprinklers	65 psi except sprinkler pressure in buildings with sprinkler systems	1012.3
March 1991 – April 1994	BOCA 1990	500 gpm except 250 gpm for Buildings < 150 feet w / Sprinklers	65 psi except sprinkler pressure in buildings < than 150 feet	1012.4
April 1994 – April 1997	BOCA 1993	500 gpm except 250 gpm for Buildings < 150 feet w / Sprinklers	65 psi except sprinkler pressure in buildings < than 150 feet	914.4
April 1997 – October 2003	BOCA 1996	500 gpm except 250 gpm for Buildings < 150 feet w / Sprinklers	65 psi except sprinkler pressure in buildings < than 150 feet	915.4
October 2003 – November 2005	NFPA 14 / IBC 2000 – VUSBC	*500 gpm for most hydraulically remote and 250 gpm for all other risers	**100 psi for 2 ½ inch and 65 psi for 1 ½ inch except buildings w / sprinklers (NFPA 13) < than 150 feet	*NFPA 14 / **905.2
November 2005 – May 2008	NFPA 14 / IBC 2003 – VUSBC	*500 gpm for most hydraulically remote and 250 gpm for all other risers	**100 psi for 2 ½ inch and 65 psi for 1 ½ inch except buildings w / sprinklers (NFPA 13) < than 150 feet	*NFPA 14 / **905.2
May 2008 – March 2011	NFPA 14 / IBC 2006 – VUSBC	*500 gpm for most hydraulically remote and 250 gpm for all other risers	**100 psi for 2 ½ inch and 65 psi for 1 ½ inch except buildings w / sprinklers (NFPA 13) < than 150 feet	*NFPA 14 / **905.2
March 2011 – July 2014	NFPA 14 / IBC 2009 – VUSBC	*500 gpm for most hydraulically remote and 250 gpm for all other risers	**100 psi for 2 ½ inch and 65 psi for 1 ½ inch except buildings w / sprinklers (NFPA 13 / 13 R) < than 150 feet	*NFPA 14 / ** 905.2
July 2014 – Present	NFPA 14 / IBC 2014 – VUBC	*500 gpm for most hydraulically remote and 250 gpm for all other risers	**100 psi for 2 ½ inch and 65 psi for 1 ½ inch except buildings w / sprinklers (NFPA 13 / 13 R) < than 150 feet	*NFPA 14 / ** 905.2

* NFPA 14 established flow rate.

** If building is protected by a NFPA 13 or 13R system, standpipe does not have to meet any pressure requirement per the Virginia Construction Code.

Figure A1. Standpipe roof flow and pressure chart. Compiled by A. Maurice Jones, Jr., Alexandria Fire Department Fire Protection Systems Supervisor.