United States Fire Administration

Technical Report Series

Operational Considerations for Highrise Firefighting

SPECIAL REPORT

Federal Emergency Management Agency

United States Fire Administration

United States Fire Administration
Major Fire Investigation Program

The United States Fire Administration develops reports on selected major fires throughout the country. The fires usually involve multiple deaths or a large loss of property. But the primary criterion for deciding to write a report is whether it will result in significant "lessons learned." In some cases these lessons bring to light new knowledge about fire -- the effect of building construction or contents, human behavior in fire, etc. In other cases, the lessons are not new, but are serious enough to highlight once again because of another fire tragedy. In some cases, special reports are developed to discuss events, drills, or new technologies or tactics that are of interest to the fire service.

The reports are sent to fire magazines and are distributed at national and regional fire meetings. The reports are available on request from USFA. Announcements of their availability are published widely in fire journals and newsletters.

This body of work provides detailed information on the nature of the fire problem for policymakers who must decide on allocations of resources between fire and other pressing problems, and within the fire service to improve codes and code enforcement, training, public fire education, building technology, and other related areas.

The Fire Administration, which has no regulatory authority, sends an experienced fire investigator into a community after a major incident only after having conferred with the local fire authorities to insure that USFA's assistance and presence would be supportive and would in no way interfere with any review of the incident they are themselves conducting. The intent is not to arrive during the event or even immediately after, but rather after the dust settles, so that a complete and objective review of all the important aspects of the incident can be made. Local authorities review USFA's report while it is in draft form. The USFA investigator or team is available to local authorities should they wish to request technical assistance for their own investigation.

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Operational Considerations For Highrise Firefighting

(April 1996)

SPECIAL REPORT

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This is Report 082 of the Major Fires Investigation Project conducted by Varley-Campbell and Associates, Inc./TriData Corporation under contract EMW-94-C-4423 to the United States Fire Administration, Federal Emergency Management Agency.

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OVERVIEW

Highrise buildings exist in virtually every mid- to large-size city and even in some relatively small jurisdictions across the United States. Highrises vary in age, size, height, construction, occupancy type, and design features, including the types of fire protection systems that are installed in them. Fires in highrise buildings can present severe challenges to all types of fire departments. Every fire department that could respond to this type of incident should be prepared to operate in this complex environment.

Fires in highrise buildings generally require more complicated operational approaches than most structure fires. Tasks that are normally considered routine for most fire departments, such as locating and attacking the fire, evacuating occupants, and performing ventilation can become very difficult in highrises. Operations are affected by several specific challenges:

- Access to floor levels that are beyond the reach of aerial apparatus is generally limited to the interior stairways. The use of elevators is usually restricted or prohibited because of safety concerns.

- Hundreds or even thousands of occupants may be exposed to the products of combustion while they are evacuating or unable to descend past a fire on a lower floor. Their exits may be limited to two narrow stairways, which are also the only access for firefighters coming up to assist with evacuation and to fight the fire.

- The ability to contain and control the fire is increasingly dependent on the construction of the building and the ability of sprinkler and/or standpipe systems to deliver water to the fire area.

- Ventilation can be much more complicated and critical in highrises than in other types of structures. Vertical ventilation is often limited to stairways or elevator shafts, both of which may also have to be used to evacuate occupants. Horizontal ventilation, by breaking out windows, presents the risk of falling glass to those outside the building. The stack effect causes smoke to rise rapidly through the vertical passages and accumulate on upper floors.

- Reflex time, or the amount of time it takes to react and take action, is usually much higher in highrise buildings than in non-highrise buildings. It often takes longer to travel from the ground floor to the fire floor than it takes to respond from the fire station to the building. Firefighters may have to climb dozens of floors before they can even reach the fire floor.

- Communications, command, and control can be very difficult in a highrise fire. Radio transmissions through a building's concrete and steel infrastructure may be compromised. The size and complexity of these buildings require large forces of firefighters and well coordinated operations in a very complex tactical environment. Effective coordination and control of strategy and tactics are essential.

Firefighters must rely on the built-in fire protection systems to help them control a fire and protect occupants. It is essential for highrise building fire protection systems to work properly. Several major fires have occurred in highrise buildings where fire protection systems failed to work properly, creating situations where some of the most experienced and well-equipped fire departments could not control the fires. Several of these fires presented extremely challenging tactical and logistical problems.

The lessons learned from these and other highrise fires have established that automatic sprinklers are the most effective way to prevent a major highrise fire. Fire departments must work to ensure that all highrise fire protection systems are tested regularly and function properly. They must prepare for the challenges of highrise fires by developing distinct standard operating procedures for highrise incidents and conducting realistic training.

This report first provides a brief overview of several major highrise fires that have occurred over the past decade. The second section discusses three problem areas of which have been noted in several recent highrise fires:

1. Water supply
2. Functionality of fire protection systems
3. Occupant evacuation

The third area of this report discusses how some of these problems can be addressed and even eliminated through the use of highrise standard operating procedures, inspection programs, and occupant evacuation training.

SUMMARY OF KEY ISSUES

ISSUE	COMMENT
Highrise SOPs	Standard operating procedures (SOPs) are needed for highrise buildings because of the special challenges presented and the strategies and tactics that must be employed to perform safely and effectively in a highrise environment.
Highrise Operational Training	The infrequent occurrence of highrise fires relative to other types of fires in most cities necessitates special highrise training drills for firefighters.
Knowledge of Fire Protection Systems	Fire departments must be familiar with the capabilities, limitations, and designs of the fire protection systems that they will rely on during a fire. Effective tactical operations may depend on the functionality of these built-in systems.
Pre-fire Plans for Highrises	Pre-fire plans are essential for highrise buildings. These plans should address, at a minimum, the types and capabilities of the mechanical fire protection systems, the layout of the building, locations of stairwells and elevators, and evacuation considerations.
Inspection and Testing of Fire Protection Systems	Fire departments should work closely with building management to ensure that all fire protection systems are tested on a regular basis.
Failure of One or More Components of a Highrise Fire Protection System	Fire departments should anticipate what would happen if one or more components of a highrise's fire protection system were to fail. They should have contingency plans in place in case a system fails to work properly.
Pressure Reducing Devices	Problems with pressure reducing devices have been noted in several major highrise fires in the United States. The consequences of these problems have been inadequate water pressure or volume from the standpipe systems to fight the fires.
Highrise Hose and Nozzle Combinations	Many highrise standpipe systems are designed around the concept of the fire department using a specific combination of hoses and nozzles. The use of other combinations can create serious problems.
Highrise Automatic Sprinklers	Very few fire departments have the capability to rapidly

SUMMARY OF KEY ISSUES	
ISSUE	**COMMENT**
	extinguish a large volume of fire that is above the reach of aerial streams. Properly maintained sprinkler systems have proven successful in controlling and extinguishing these fires and protecting building occupants.
Compartmentation	Compartmentation in highrise buildings is important to help contain a fire, but sprinklers provide the best protection.
Evacuation of Occupants	Highrise building occupants rely on the construction of the building and the functionality of fire protection systems to protect them during a fire. Occupant evacuation training is essential to a workable response in an emergency. Such training should include existing drills, information on building layout, when to stay in place, and so forth.

PART I: BACKGROUND INFORMATION ON RECENT MAJOR HIGHRISE FIRES

Between 1977 and 1996, 16 firefighters died from traumatic injuries suffered in highrise fires in the U.S.[1] Even though this figure is small compared to the total of 2,277 firefighters who have died in the line of duty since 1977, it is significant because of the relatively small proportion of actual highrise fires to other fires. (Table 1 lists traumatic firefighter fatalities in highrise fires between 1977 and 1996 compiled by the NFPA.)

Several major highrise fires in the past decade have demonstrated the complexities of fighting these fires and the potential for major problems due to the failure of one or more components of the building's fire protection systems. These incidents also show how the presence of a properly maintained and functioning automatic sprinkler system could have minimized the damage and the number of firefighter and occupant fatalities.

Meridian Plaza Fire – On February 23, 1991, a fire in the 38-story Meridian Plaza building in Philadelphia killed three firefighters and one occupant. It was the largest and most costly highrise office building fire in modern American history, destroying eight floors before being extinguished by ten sprinkler heads on the 30th floor.

The fire broke out on a Saturday evening on the 22nd floor in a pile of oil-soaked rags. A smoke detector on the 22nd floor detected the fire, but due to incomplete coverage, the fire was already well advanced before the detector was activated. The building was partially sprinklered, but none of the floors between the 22nd and 30th had sprinklers.

Suppression operations were compromised by problems with pressure-reducing valves, which were improperly set and provided inadequate pressure for fire attack using 1 3/4 inch hose and automatic fog nozzles. Firefighters attempted to resolve this problem by boosting the pressure in the standpipe system using pumpers, but the valves prevented the standpipe outlet pressure from increasing. Firefighters did not have the tools or expertise needed to adjust the valve settings.

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[1] *Traumatic Firefighter Fatalities in Highrise Office Buildings in the United States, 1977 - Present.* National Fire Protection Association, February, 1995.

They then stretched 5" supply line up the stairwell to the 22nd floor, which took nearly one hour. By this time, the fire was extending vertically by lapping from window to window.

Firefighting operations were also compromised when the fire burned through the building's main electrical feed, short circuiting the building's entire power system. The primary and back-up electrical feeds were installed in a common, unprotected shaft. All lighting, elevators, pumps, fans and other electrical devices were rendered inoperable as a result of this system failure.

A crew of three firefighters conducting ventilation operations became disoriented and ran out of air on the 28th floor before rescue teams could locate them. These three firefighters died from asphyxiation above the fire floors.

Once a water supply was established, using the 5" hose line as a standpipe, firefighters attempted to knock down the fire, but the volume of fire on multiple large area floors was too large for handlines to be effective. Ten hours after the fire began, all crews were withdrawn from the building. Efforts were made to control the fire using masterstreams directed from adjacent buildings, but the fire continued to extend vertically until it reached the 30th floor. Nine hours later, the fire was controlled by 10 sprinklers that had been installed on the 30th floor. The estimated total dollar loss from this fire was over $2 billion, including litigation costs.

First Interstate Bank Fire – On the night of May 4, 1988, a fire destroyed five floors of the 62-story First Interstate Bank building in downtown Los Angeles. The fire department arrived on the scene to find heavy fire on the 9th or 10th floor which was spreading vertically. The department's response had been delayed by several minutes due to late notification by building personnel who had unsuccessfully attempted to reset the building's alarm system three times.

Firefighters initiated an interior attack from the stairwells, but were initially hampered by low water pressure. On the night of the fire, contractors working on the installation of a sprinkler system on an upper floor had shut down the building's fire pump and drained the risers. Three fire pumpers charged the standpipe system. The building fire pumps were reactivated by contractors soon thereafter.

Even after the attack began, conditions deteriorated rapidly as smoke filled the stairwells. While crews tried to extinguish the fire on floors 12 and 13, additional crews were deployed above the fire to prepare to stop the vertical advance. Fire department officials estimated that over 2,500 gallons per minute was delivered via multiple handlines and that it took nearly 400 firefighters rotating through attack and support functions to control the fire.

At the time of the fire, contractors were connecting a new sprinkler system on the 58th floor to the riser and had shut down the building's fire pump and drained the riser. The retrofit installation was 90 percent completed including the floors that burned. However, the valves were closed between the standpipe riser and the sprinkler system on each floor. Building officials and the contractors had decided not to activate the system until it was fully installed, even though installation had been completed on most floors. After the water supply was restored, firefighters had to contend with problems involving some of the pressure reducing valves which were installed on standpipe risers to control outlet pressures (the building had a single zone system for all 62 floors). Improperly set pressure reducing valves allowed excess pressures to reach the hose lines; some of them burst handlines, while others were difficult to control.

Firefighters could not use elevators because fire department policy prohibited their use. All equipment (including over 300 air cylinders) had to be carried up stairs to fight the fire. The building's electrical system and internal communications systems also failed, primarily due to water damage.

Several occupants were rescued from the roof by helicopter. A crew of firefighters was flown to the roof to access the stairwells and rescue other trapped occupants. These efforts were unsuccessful because the stair shafts had become virtual chimneys. The electrical failure shut down stairwell pressurization fans. Stairwell doors, kept ajar by handlines, allowed for infiltration of smoke. One of the rescue teams had to be rescued by a second team.

A civilian security guard who took an elevator to the fire floor to investigate the alarm was the only fatality. Fourteen firefighters were injured in the fire. The fire caused an estimated $450 million in damages.

Bankers Trust Fire – On the night of January 31, 1993, a fire destroyed two floors of the unsprinklered 42 story Bankers Trust building in New York City. The fire is believed to have broken out in the plenum space on the sixth floor. Fire quickly spread through the common plenum space and involved the floor area as the ceiling collapsed.

Firefighters initiated an aggressive interior attack, but despite the aggressive efforts of over 400 very experienced highrise firefighters, the fire extended vertically to the next floor through exterior windows. Doors held ajar by hoselines allowed smoke and heat to enter the stair shafts. Heavy fire, heat, and smoke conditions forced firefighters to withdraw and an exterior attack was mounted. Elevated streams directed from aerial platforms ultimately controlled the fire. Firefighters probably would not have been able to control this fire had it occurred several floors higher, above the reach of exterior aerial apparatus. The fire caused an estimated $10 million in damage.

World Trade Center Bombing – On February 26, 1993, a terrorist truck bomb exploded in the underground garage of the 110 story World Trade Center in New York. The massive explosion sparked several car fires and destroyed most of the building's primary and backup emergency systems. Smoke infiltrated the stair shafts because doors at the basement level were blown off and pressurization fans could not operate due to the destruction of the electrical systems.

This event demonstrated the magnitude of problems that result when there is a complete failure of the emergency systems in a highrise building. Thousands of occupants were trapped on office floors, many of which were filling with smoke that was rising through the stair shafts. Others were trapped in elevators which stopped when the power was interrupted. Many of the occupants suffered smoke inhalation while descending from as high as the 110th floor in the smoke-filled stairways. In these conditions, the majority of the occupants would have been safer staying in their work areas where smoke conditions were less severe.

The FDNY was able to control the fires in about one hour which eliminated the source of the smoke. The incident could have been much worse had there been other fires on higher level floors. These fires probably would have been very destructive and difficult, if not impossible, to extinguish since the main water supply systems were incapacitated by the explosion.

Table 1. Traumatic Firefighter Fatalities in Highrise Buildings in the U.S., 1977 – 1996		
Date	***Location***	***Description***
May 10, 1977	Baltimore, Maryland 37 story office building	Firefighter found dead in elevator stopped on the fire floor. He was not wearing protective clothing or carrying or using SCBA. Elevator malfunction possibly involved.
May 19, 1977	Omaha, Nebraska 8 story vacant hotel	Firefighter who was assisting in the lobby of the hotel after performing interior operations without SCBA died from a heart attack.
June 14, 1979	New York City, New York 20 story department store	Firefighter became separated from other crew members and ran out of air and died from asphyxiation. The search for the lost firefighter was hampered by extreme heat and smoke conditions.
September 22, 1981	Chicago, Illinois 38 story office building	Two firefighters died after becoming lost in extreme heat and smoke conditions. One fell into an elevator shaft, and the other also fell while attempting to rescue his comrade.
August 12, 1984	Newark, New Jersey 14 story office building	A firefighter became disoriented and lost in heavy smoke conditions, and ran out of air.
December 1, 1984	New York City, New York 13 story office building	A firefighter performing search and ventilation operations on the floor above the fire died after running out of air.
February 23, 1991	Philadelphia, Pennsylvania 38 story office building	Three firefighters became disoriented on the upper floors of the building and died after running out of air.
February 5, 1992	Indianapolis, Indiana 9 story hotel	Two firefighters operating handlines on the third floor died of injuries suffered when caught by rapid fire growth.
February 24, 1993	White Plains, New York 12 story apartment building	A firefighter died from asphyxiation after becoming trapped in an elevator while trying to gain access to the fire floor.
August 14, 1993	San Francisco, California 20 story apartment building	A firefighter died from burn injuries suffered while forcing entry to a third floor apartment.
April 11, 1994	Memphis, Tennessee 11 story apartment building	Two firefighters died from smoke inhalation after exiting an elevator on the fire floor and becoming disoriented.
January 6, 1996	New York City, New York 13 story apartment building	One firefighter died from facial and respiratory injuries suffered while forcing entry to an apartment.

PART II: MAJOR PROBLEMS NOTED DURING RECENT HIGHRISE FIRES

Three major problems have emerged from recent major highrise fires across the country. These areas are:

1. Water supply
2. Functionality of fire protection systems
3. Occupant evacuation

This section provides background information on each of these problem areas, and discusses how these problems affected operations at recent major fires.

WATER SUPPLY IN HIGHRISE BUILDINGS

All highrise fire protection systems involve water. To fight a fire, the water must be delivered to the floor where it is needed via standpipes.

Classes of Water Supply Systems – Standpipe systems are the main source of water supply for fighting fires in highrise buildings. There are three classes of standpipe systems:

Class I – 2 1/2 inch outlets for fire department use

Class II – 1 1/2 inch hose outlets for occupant-use hose

Class III – Combination standpipe, incorporates both Class I and II into a single system

A **Combined Sprinkler/Standpipe System** incorporates a water supply for automatic sprinklers with a Class III standpipe system (in some cases the occupant hose connections are not required when automatic sprinklers are provided.)[2]

[2] Note that a "combined" system is different from a "combination" system. Combination refers to a system with both Class I and Class II outlets, whereas a combined system is an integrated standpipe/sprinkler system.

Until the 1970s, many building codes required either separate Class I and Class II standpipes, or a Class III system. Many jurisdictions allowed Class II standpipe outlets for occupant use to be supplied by the building's domestic water system and permitted dry standpipes to meet the Class I requirements. The dry standpipe risers would only be charged with water when hose lines were connected to the fire department connection (FDC). Other jurisdictions required a built-in water supply for the Class I or Class III standpipes, which generally required one or more fire pumps to boost the pressure from the public water system.

Since the 1970s, the trend has been to require automatic sprinkler systems in almost all new highrise buildings. There has also been a trend to encourage or require sprinklers to be installed in existing highrise buildings. Most new systems are installed as combined sprinkler/standpipe systems, and many older Class I or Class III standpipe systems have been converted to combined systems to supply water for retrofit automatic sprinkler systems.

Combined sprinkler/standpipe systems generally require a fire pump to increase the pressure coming in from the public water system, in order to deliver adequate pressure at the upper levels of the building. These pumps may be electrically driven or powered by internal combustion (generally diesel) engines. Some codes require a backup water supply system on the premises, in case the public water system is out of service due to an earthquake or other disruption.

Virtually all standpipe, sprinkler, or combined systems require fire department connections so that the water supply can be augmented by fire department pumpers. In most newer buildings a single set of connections supplies water to all of the fire protection systems in the building, while older buildings may have a multitude of different connections that each supply water to a different area or system within the building.[3] Therefore, it is important for fire departments to have information about the water supply and connections for each specific building. This information should be available through a pre-fire plan system.

Pressure Reducing Devices – Pressure reducing devices prevent dangerously high discharge pressures from hose outlets. There are two major types of pressure reducing devices that can be installed on standpipe outlets: flow restricting devices and pressure reducing valves.

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[3] It is not unusual to find these connections mislabeled or without labels to indicate where to connect to supply more water to which systems.

Flow restricting devices control the discharge pressure by restricting the flow to a reduced opening, which must be sized to a specific pressure and discharge rate. The most common type of flow restricting device is an orifice plate (see Figure 1). Flow restricting devices do not reduce the static pressure (pressure with no water flowing), thereby allowing higher pressures at lower flow rates. Some jurisdictions require flow restricting devices to be adjustable or removable by the fire department.

Pressure reducing valves (see Figure 2) limit the pressure on the downstream side at all flow rates. The valve is set to deliver a specific pressure which will not be exceeded under any flow condition (i.e. static and flowing pressures will remain constant). A pressure reducing valve must be set for the specific pressure condition and is usually not adjustable without special tools. These valves are often installed on the connections between the standpipe risers and the automatic sprinklers on the individual floors of a highrise building, in addition to hose outlets.

Pressure Control Requirements – The pressure and volume of water that are available at a standpipe outlet must be sufficient to supply hoselines that are expected to be connected to them and must not exceed a safe operating pressure. The required flow rate and the maximum and minimum pressure requirements used by most jurisdictions are specified in NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*.

Figure 1. Orifice Plate

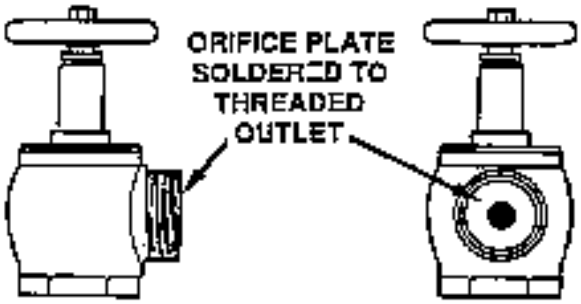


Figure 2. Pressure Reducing Valve

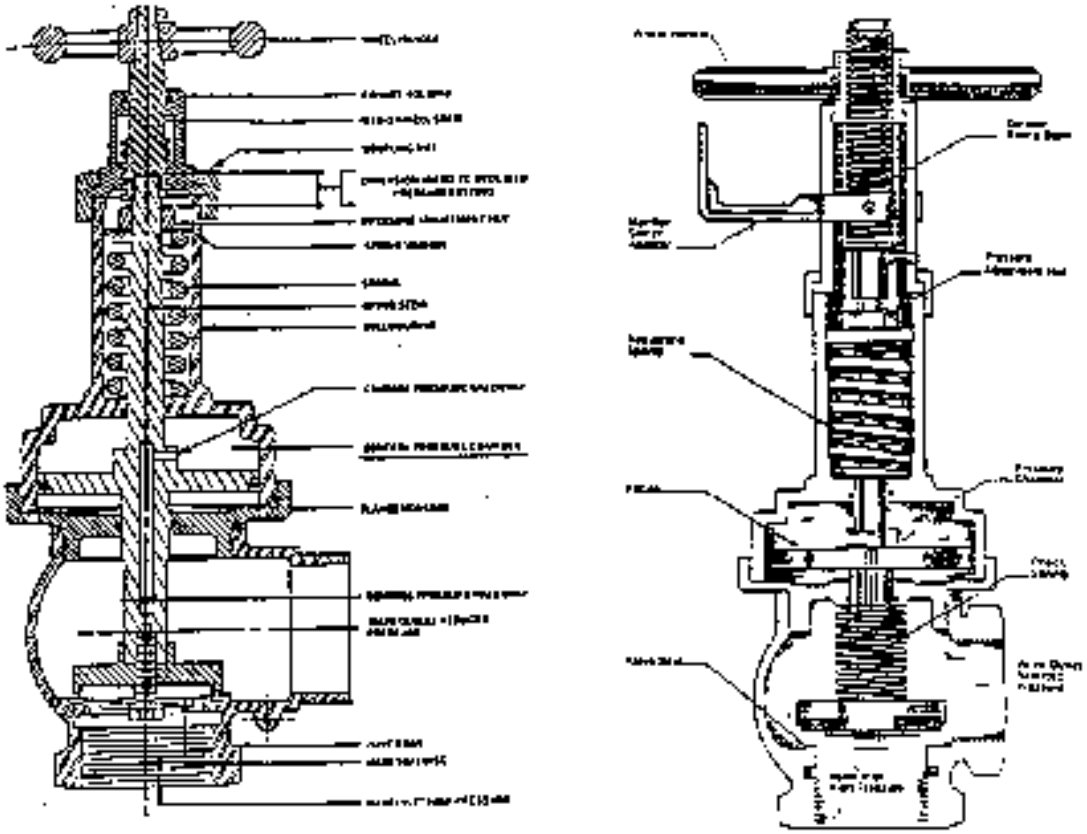
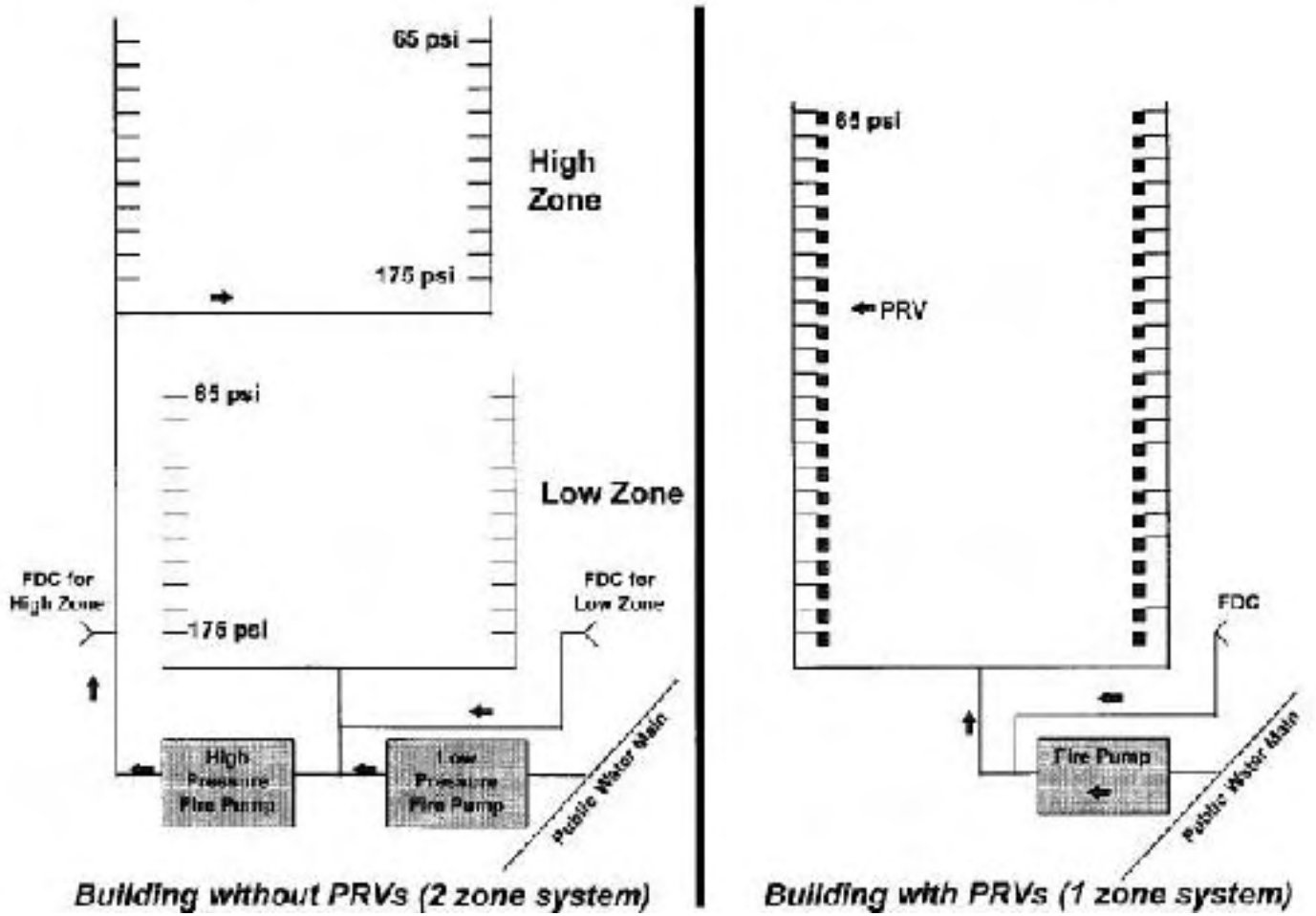


Figure 3. Standpipe Systems with and without PRVs



Prior to 1993, the minimum pressure required by NFPA 14 was 65 psi at the required flow rate at the highest outlet in the system (see Table 2). This requirement anticipated that the fire department would utilize 2 1/2 inch hoses with smooth bore tips, which require approximately 50 psi nozzle pressure to operate (i.e. 65 psi minus 15 psi for friction loss). The maximum pressure allowable at an outlet was limited to 100 psi at the required flow rate, and the maximum static pressure at any outlet was limited to 175 psi. The same limitations applied to both 1 1/2 inch and 2 1/2 inch outlets.

The minimum and maximum pressure limitations were revised in 1993, after several reports of fires where crews had difficulty operating effective hose streams due to inadequate pressures (see Table 3). A large number of fire departments were found to be using 1 3/4 or 2 inch attack hose with combination fog nozzles, especially automatic nozzles, which require at least 100 psi at the nozzle to operate properly. As a result, in 1993 the pressure limit for all outlets greater than 1 1/2 inches was increased to 100 psi minimum flow pressure and 175 psi maximum static pressure. The standard also specified that pressure reducing devices must be installed on 1 1/2 inch outlets that would exceed 100 psi flow pressure at the required flow rate.[4] Pressure reducing valves, which control water under flowing and static conditions, must be installed on all outlets that exceed 175 psi static pressure.

Table 2. NFPA 14 Requirements Prior to 1993

Outlet Size	***Allowable Flow Pressure***	***Flow Restricting Device Required if:***	***Pressure Reducing Valve Required if:***
1 1/2"	65 psi min 100 psi max	residual pressure between 100 psi and 175 psi	static pressure greater than 175 psi
2 1/2"	65 psi min 100 psi max	residual pressure between 100 psi and 175 psi	static pressure greater than 175 psi

[4] The 1 1/2 inch valves were limited to 100 psi residual pressure because these lines are usually considered occupant attack lines. Pressures exceeding 100 psi may overwhelm occupant users.

Table 3. NFPA 14 Requirements 1993 Edition			
Outlet Size	***Allowable Flow Pressure***	***Flow Restricting Device Required if:***	***Pressure Reducing Valve Required if:***
1 1/2"	65 psi min	residual pressure between 100 psi and 175 psi	static pressure greater than 175 psi
2 1/2"	100 psi min 175 psi max	(Optional as long as static pressure less than 175)	static pressure greater than 175 psi

The higher pressures that are required today for 2 1/2 inch and larger outlets are intended to provide sufficient pressure for hoselines to be operated with 100 psi nozzle pressure. Nozzles that are designed to operate at lower pressures (70 psi) have also been developed and may be particularly useful for fire departments that respond to buildings that have standpipe systems that were designed to meet the pre-1993 standards.

Advantages and Problems of Pressure Reducing Valves – As stated previously, pressure reducing valves (PRVs) regulate both residual (flowing) and static pressure. Prior to their development, the only type of pressure reducing devices were the flow restricting devices which do not regulate static pressure. In tall buildings, standpipe systems which utilized flow restricting devices were limited to approximately 20 stories per zone, to stay within the limit of 175 psi maximum static pressure (see Figure 3). Each 20 story zone required its own fire pump(s) and fire department connections.

Today, however, standpipe zone heights are no longer restricted if PRVs are used. PRVs simplify the design and installation of sprinkler and standpipe systems by allowing their installation without a height limitation. The pressure in the risers may be very high in a tall building (particularly on the lower level floors), however, the pressure reducing valves should ensure that the static and residual pressures that are available at an outlet valve are within the required range for safe and effective hose stream operations.

The rationale for PRVs is the concern that firefighters would be exposed to dangerous operating pressures and forces if they connected hoselines to outlets near the base of standpipe risers of substantial height, particularly those supplied by stationary fire pumps.[5] For example, in a 275-foot high standpipe zone, a pressure of 234 psi is required at the base of the riser to overcome elevation and produce the minimum required outlet pressure of 115 psi at the riser's top outlet.[6] At this pressure, a standard 2 1/2 inch fire hose fitted with a 1 1/2 inch straight bore nozzle would produce a back pressure (reaction force) in excess of 500 pounds.

Some fire departments have encountered problems where the pressure reducing valves were not properly set for the required discharge pressure. In these cases, firefighters faced either inadequate or excessive handline pressures. The NFPA standard now requires a test/drain riser to be installed adjacent to the standpipe risers that are equipped with pressure reducing valves so that the flow and discharge pressure can be set and checked during regular inspections.

Highrise Hose and Nozzle Ensemble – Since standpipe outlet pressures may be as low as 65 psi in systems designed prior to the 1993 version of NFPA 14, or lower due to an improperly set PRV, fire departments should be prepared to make an attack under low pressure conditions. A smooth bore tip requiring only 50 psi nozzle pressure should be used in these situations (see Table 4). Also, the greater friction loss in 1 1/2 hose could reduce the nozzle pressure to a level below the 50 psi needed for the nozzle. Therefore, it is preferable for fire departments to carry 2 inch or 2 1/2 inch hose with a smooth bore tip for highrise operations.

Another option is to carry a nozzle designed specifically for highrise standpipe operations. A highrise "break-apart" nozzle provides the combined benefits of a fog nozzle and a smooth bore nozzle, both designed to operate at limited pressures. Firefighters can use the fog nozzle (designed to deliver its rated flow at 75 psi), or remove the fog tip, leaving a smooth bore tip (designed to operate at 50 psi).

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5 Routley, J. Gordon. *Highrise Office Building Fire, One Meridian Plaza, Philadelphia, Pennsylvania.* U.S. Fire Administration Technical Report Series, February, 1991, pg. 25.

6 NFPA Alert Bulletin 91-3, Pressure Regulating Devices in Standpipe Systems. National Fire Protection Association, May, 1991.

Table 4. Comparison of Nozzles		
Type	***Approximate Nozzle Pressure Required***	***Advantages/Disadvantages***
Straight Stream Nozzle	50 psi	Excellent penetration and good reach at low operating pressure; no fog pattern available
Combination (Fog) Nozzle (Automatic or Adjustable Gallonage)	100 psi	Good penetration and reach with straight stream; capable of producing fog pattern; high pressure needed to operate nozzle may not always be available
Highrise ("Break-Apart") Nozzle	75 psi (for fog portion) 50 psi (for straight tip)	Combines reach and penetration features listed above depending on which portion of the nozzle is used; fog portion requires less operating pressure than some combination nozzles; provides greatest flexibility for highrise firefighting

FAILURE OF COMPONENTS OF A FIRE PROTECTION SYSTEM

Each of the major highrise fires discussed earlier in this report presented special challenges to firefighters because of the failure of one or more components of a building's fire protection systems. These incidents emphasize the possibility that fire departments may have to contend with unanticipated problems with these systems while fighting a highrise fire.

Fire departments can never be sure that every component of every system will work 100 percent of the time. Regular inspection, maintenance and testing programs are essential.

Water supply systems can fail under many circumstances. Closed valves may block the water supply to the system, as happened at the First Interstate Bank fire. A fire pump will fail if the main power supply or a backup supply fails. Fire department connections may be obscured from view, blocked, or relocated, especially during construction.

Pressure reducing valves may be improperly set or improperly installed, as discussed previously. At the Meridian Plaza fire in Philadelphia, the pressure reducing valves were found to be improperly set and would not deliver sufficient pressure for a functional hose stream. At the First Interstate Bank Building in Los Angeles, some of the pressure reducing valves failed and allowed pressures estimated at 500 psi to reach handlines. In each of these cases the fire department operations were severely hampered in attempting to control major fires that destroyed multiple floors and caused million of dollars in damage.

Electrical system failure can be catastrophic since many components of a highrise fire protection system are powered by electricity. Many buildings have emergency generators, in case the main feed to the building is lost. However, even with the presence of backup power systems, the entire system may fail if fire impinges on the main feed, as happened at the Meridian Plaza fire.

Stair shafts may become filled with products of combustion, even in buildings designed with protected, pressurized stairs. The First Interstate Bank fire, Meridian Plaza fire, and World Trade Center fire all demonstrated that positive pressure protection can be quickly lost when stairway doors are opened by evacuees and firefighters, or held ajar by hoselines going into the fire floor. Protected stairways intended to provide a safe exit path for both occupants and firefighters are transformed into chimneys carrying smoke and toxic gases.

Elevator failures have hampered operations in many highrise fires. Some departments prohibit the use of elevators, especially when the bank serves the affected floor, while others allow firefighters to use separate unaffected banks to transport personnel and equipment to staging areas. Firefighters are particularly dependent on elevators when the fire is on an upper level floor. The Meridian Plaza fire demonstrated how firefighting efforts were hampered and delayed when an elevator system failed due to a power loss.

Each of the major fires described in this report demonstrates how the failure of one or more systems can hinder fire department operations enough to result in a very large fire. The failure of one component often leads to the failure of other components, generally because the failure allows the fire to grow so large that it impinges on other components, or overpowers the ability of other components to function properly. Fire control is virtually impossible when multiple components fail.

EVACUATION OF OCCUPANTS

The recent major highrise fires have shown that fire departments are likely to have serious problems evacuating occupants from a highrise – particularly if systems fail – when there is a large volume of fire and no built-in sprinkler system, when occupants are not trained properly, or when the fire is not controlled rapidly. The World Trade Center bombing demonstrated the problems with evacuation when stairway pressurization systems failed. Even when pressurization systems work properly, however, stairshafts may become filled with the products of combustion because doors on the fire floor are propped open by hose lines and the effect of pressurization is lost as occupants open stairway doors to exit.

Both the First Interstate Bank fire and the Meridian Plaza fire could have trapped thousands of occupants had the fires occurred during weekday hours. The best way to protect highrise building occupants from smoke and fire is to control the fire rapidly, and this is best achieved by a sprinkler system. Unfortunately, many existing buildings do not offer this protection, which means that fire departments may have to contend with large fires that pose serious evacuation problems.

In some cases, occupants may be safest if they remain in place or evacuate to a floor beneath the fire floor instead of exiting the building. Firefighters should determine as quickly as possible in a fire incident whether a full, partial, or no evacuation is necessary, and communicate their evacuation plan to occupants by using a public address system or other means. Experience shows that occupants will need guidance with evacuation. This will require the assignment of companies to assist specifically with evacuation.

PART III: ADDRESSING MAJOR HIGHRISE FIREFIGHTING PROBLEMS

The problems associated with operations at highrise fires, as described in the previous section, may not always be avoidable, but the chance of their occurrence can be minimized by developing and following standard operating procedures. Inspection, maintenance, and training programs, along with public education also contribute to safety and to risk reduction.

HIGHRISE STANDARD OPERATING PROCEDURES

Standard operating procedures play an integral role in establishing order and consistency in operations at any emergency scene. They are especially important in highrise incidents because of the inherent complexities of fighting a highrise fire. SOPs should be written to achieve these purposes:

- Establish chain-of-command and command sectors
- Establish levels of response (i.e. number of units assigned on each alarm)
- Establish roles and responsibilities of arriving companies and company officers
- Establish a system of operations familiar to all members of the organization

SOPs provide the framework of a fire department's response to an emergency incident. They establish a degree of order to emergency scenes which by nature are usually chaotic. Generic topics to cover in highrise SOPs are listed below.

- Level of response (i.e. number and type of apparatus dispatched)
- Duties of incoming apparatus (1st, 2nd, 3rd due)
- Establishment and structure of command
- Accountability
- Safety
- Use of elevators and stairwells
- Evacuation and rescue
- Water supply

- Hoses and nozzles for interior operations
- Ventilation
- Contingency plans for failure of fire protection systems

Highrise SOPs from several medium and large size cities were reviewed for this report. Below is a discussion of different topics that can be included in highrise SOPs and an overview of some of the different procedural approaches being taken by fire departments from across the country.

Levels of Response – Specific levels of response should be developed for highrise structures. The number of units dispatched to a highrise emergency will vary from locality to locality depending upon the size of the department, the types and number of units in the department, and the nature of the call.

Most departments establish three levels of response for highrise structures based on three common scenarios: an activated alarm only, a report of smoke in the structure, or a working fire. New York City, for example, dispatches one engine to investigate an automatic fire alarm in a highrise. If there is any indication of smoke or fire, a box alarm is transmitted, providing three engine companies, two ladder companies, one rescue squad, and one Battalion Chief. A working highrise fire upgrades the box assignment to include a total of four engine companies, four ladder companies, two rescue squads, four Battalion Chiefs, one Division Chief, one Highrise Company, one Command Post Company, one Field Commander, and one Mask Service Unit.

Some departments dispatch special teams when a working fire is declared. Phoenix, for example, is revising its SOPs to include the dispatch of a specially trained highrise unit to working fires. In addition to its normal box assignment complement, Memphis dispatches a "Rapid Intervention Team" on working highrise fires.

Command – Most departments utilize a version of the Incident Command System (ICS) to manage resources and coordinate operations at major fires. All of the highrise SOPs reviewed for this report include ICS. The command structure for highrise fires includes several functions that are not used at other structure fires: Interior Staging (Resource) Sector, Stairway and

Support, and Lobby Control Sector. In cases of major highrise fires, most SOPs expand the structure to utilize the full Incident Command System, which includes the four major ICS sections, Planning, Finance, Logistics, and Operations.

Some SOPs direct the first arriving Battalion Chief to proceed to the fire floor to lead the Fire Attack Sector or Operations Sector, while the second arriving Battalion Chief takes command of the incident; other SOPs reverse these responsibilities.

Phoenix lists the following priorities for first arriving units and command officers:

- Identify fire floor
- Provide an attack on the fire floor with at least three companies
- Provide for the life safety of persons in immediate danger
- Provide water supply for the initial attack
- Establish lobby control
- Make a size-up of the fire floor and the floor above
- Call for additional resources
- Begin to establish support systems (staging, resources, etc.)
- Establish a ventilation sector

Most SOPs allow the IC to establish the command post in the most suitable position, either inside or outside, while some cities, such as Los Angeles, require the command post to be at least 200 feet from the building. Phoenix's SOPs, however, state that "the need for establishing Command 'in the street' is secondary to the urgency of getting an officer and crew up to the fire area...The first arriving company should...pass command to the next arriving officer." The SOPs further explain that this policy should not preclude the initiation of a personnel accountability system from the outset. They also emphasize the importance of assigning a company to the building's fire control room to manage and monitor systems, and to direct evacuation using public address systems.

The *Fire Attack Sector* is generally assigned to the first arriving engine company. This sector may be termed "Attack Sector," or "Fire Floor (Number) Sector," and it is usually commanded by the officer on the first due engine. Some departments require the fire attack team

to minimally comprise an engine and truck company before personnel are allowed to ascend, while others allow a single engine to assume this position.

FDNY assigns two engine companies and one ladder company per attack position. Its SOPs generally require the Fire Attack Sector officer to communicate which stairway is being utilized by the attack team. Chicago established a priority that a crew with hose lines be positioned above the fire floor to control any lapping or vertical extension. The first due truck or squad is generally assigned to assist with fire attack while the second due truck or squad performs search and rescue above the fire floor.

The *Interior Staging (Resource) Sector* is usually formed at large fires where multiple companies will need to be rotated through the attack and rehabilitation sectors. Most SOPs state that this function will be established one to two floors below the fire floor. Usually, several companies are assigned to manage personnel and equipment assigned to this function. Very few of the SOPs pointed to the importance of establishing this sector in the early stages of a major highrise fire, or to who will establish this sector. In many cases, once this area is established, it will take time to stockpile the equipment (especially spare air bottles) in the interior staging area. Memphis requires all incoming crews on a working fire to take spare equipment and one spare SCBA cylinder per firefighter into the building. The companies fighting the fire will rely on this sector within the first 15 to 20 minutes in, then 15 to 20 minutes to rehabilitate the personnel and change cylinders. The relief crew and air cylinders must be ready at the Resource Sector when the first wave is ready to rotate out of the incident as they retreat for new air bottles and equipment. The Chicago Fire Department requires the officer of this sector to maintain enough personnel to staff its "three man relief" system, whereby one crew is attacking the fire, one is on backup line, and one is in position to replace the backup team when the attack team withdraws. Memphis also requires a standby crew in this sector at all times.

The *Exterior Staging (Base) Sector* is the area where incoming forces gather outside of the highrise. Some departments, such as Milwaukee, assign this task in their SOPs to the first arriving engine on the second alarm. Other departments assign it to a chief's aide. Most SOPs call for the exterior staging area to be set up several blocks from the scene so that staged units are not confused with on-scene units, and to keep streets around the incident as open as possible. Generally, staged personnel are not allowed to leave the staging area until requested by the IC.

The officer in charge of this area must keep track of staged resources and let the incident commander know when additional resources are needed in staging.

The *Lobby Control Sector* is one of the most important sectors on the fireground. Some SOPs give this sector a small area of responsibility, but others give it many vital duties. Philadelphia, for example, assigns lobby control on dispatch to the third due ladder truck. Eventually, the officer on the ladder truck is relieved by an incoming Battalion Chief. Some of the duties commonly assigned to the Lobby Control Sector include:

- Securing the elevators and ensuring they have all been recalled
- Assisting with evacuation through the lobby area
- Making announcements and directing evacuation over the building's public address system
- Making an accountability list of incoming firefighters
- Acquiring building floor plans and keys
- Locating security guards or engineers
- Verifying functionality of building HVAC system, fire pump, emergency generator, etc., and shutting down the HVAC system if necessary
- Monitoring the fire alarm annunciator panel

Several cities have added specific responsibilities to this sector. Los Angeles requires this sector to report to the Incident Commander the number of floors in the building and to ensure that stairwells are positively pressurized. This sector also establishes a stockpile of equipment in the lobby which can be transported to the interior staging area. Philadelphia gives the Lobby Control Sector the responsibility of acquiring tools which can be used to adjust pressure reducing valves on the standpipe system.

The *Top Sector* is established one or two floors above the fire. It is responsible for, among other things, conducting search and rescue above the fire, preventing vertical spread, and ensuring that ventilation hatches are open in stairwells. This sector is usually headed by an officer from the third arriving engine or a unit on the second alarm.

The *Rehabilitation Sector* is responsible for rehydrating firefighters and monitoring the physical condition of firefighters at a major incident. Some departments establish this sector on the same floor as interior staging, while others establish it one floor below. Usually an EMS officer heads this sector. Dallas and Fairfax County require Rehabilitation Sector personnel to take a full set of firefighting protecting equipment and SCBA with them into a highrise.

Other sectors can be established at a highrise fire. Dallas' SOPs include a Safe Refuge Area five floors below the fire floor. Floors below the fire floor in a highrise building are generally considered safe areas. This area is staffed by one engine company which assists with the evacuation. A Safe Refuge Area usually is established in the tall buildings where occupants may have difficulty descending all the way to the ground level.

Los Angeles City includes an Air Operations Sector in their highrise SOPs. In some cases, the fire department may call on one of its helicopter to evacuate persons or firefighters from the roof of a highrise. The SOPs strictly specify that the helicopter landing zone be at least one-half mile from the incident and that the helicopter not fly within 500 feet of portions of the building affected by fire. Previous experience has shown the problems created when wind generated by the helicopter literally fanned the flames.

Size-up and Verbal Communications – Size-up is an assessment of the emergency scene. It provides a firsthand account by fire department personnel to incoming units and units on the fireground. Incoming units base their actions upon arrival on information communicated in the initial size-up. All of the highrise SOPs reviewed require the first arriving engine to provide a size-up but only a few describe what information is to be communicated. Items to communicate in a highrise size-up may include:

- Evidence of smoke or fire
- Number of floors in the building and location of smoke or fire (count floors from top of building down)
- Presence of persons trapped at windows or on balconies
- Whether or not building is being evacuated
- Which side(s) of building have been surveyed

Very few of the SOPs assign a particular company with size-up of all sides of a structure; Fairfax County, however, assigns this task to the third arriving engine company noting that "the officer may see a critical situation and communicate information that could change the whole situation." After the size-up is performed, the engine is to report to the incident commander for an assignment. Other cities assign this role to the second due ladder truck, chief's aide, or an ambulance (if it is part of the fire department).

Most of the SOPs reviewed remind personnel to minimize radio traffic at a highrise fire, but a few noted the importance of communicating the initial size-up through the chain of command – especially when a hazardous condition is found or when a company believes the incident commander is missing vital information that would alter operational tactics. Fairfax's SOPs, however, emphasize the need for continual size-ups by all companies through the duration of the incident. They state, "Companies must keep their superiors informed of the conditions in their area of responsibility so their superior can inform the next higher ranking officer of the conditions in that area...During multi-company operations, each unit must be aware of the identity of units adjacent to them and areas of responsibility must be understood. If one company's area develops problems, that company officer must inform the adjacent companies and their superiors."

Water Supply – One of the greatest problems with controlling the major highrise fires discussed earlier in this report was obtaining adequate pressure and flow to initiate an attack. Generally, the problems were due to the failure of pressure reducing valves or the building fire pump to operate properly. The best way for fire departments to address these problems is through inspection and testing of system components to ensure they are working to expected levels (this is discussed in detail later).

Highrise SOPs should instruct firefighters to use hoses and nozzles which can operate under low pressure conditions. As previously discussed, static pressures at standpipe outlets in highrises can be as low as 65 psi. SOPs should address this reality by establishing 2 1/2 inch hose as the choice hoseline for highrise fire attack. Smooth bore nozzles should be carried in highrise hosepacks since they require about one-half the operating pressure of most fog nozzles.

SOPs should also contain contingency procedures for situations where water supply is compromised by a problem with the fire protection system. SOPs should establish methods to

check building systems which do not appear to be operating properly, including the fire pump(s). Many of the SOPs reviewed assign this task to Lobby Control personnel, who can check fire pumps, generators, and other emergency equipment, and attempt to manually activate equipment if necessary.

Water supply SOPs should also establish which unit(s) is responsible for supplying the fire department connection(s). Special pumping procedures can also be included. Dallas' highrise SOPs specify that two pumpers supply the standpipe system in case one pumper fails or higher pressure is needed. They also disallow the use of large diameter hose between the engine and standpipe because this hose generally is not rated to the high pressures (over 200 psi) that may be required for supplying the fire department connection(s).

Elevators – Besides incident command, elevator usage is the most strictly regulated practice in the SOPs reviewed. Most of the SOPs define when and when not to use elevators. One set says, "Most procedures recognize that elevators are the most effective and efficient means to transport personnel and equipment in highrises, but improper use of elevators [at improper times] in fire situations can expose personnel to serious risks."

Elevator SOPs should specify certain steps firefighters must take before using them. First, elevators must be recalled and switched to manual or bypass mode if this feature is available. This feature overrides all elevator controls except those in the car and gives firefighters control over an elevator. The manual mode disables the door's electric eye (which could be blocked open by smoke) and prevents the elevator from being called accidentally to another floor. Fairfax County's SOPs prohibit use of elevators which cannot be operated manually until the officer on the first arriving engine determines which floor is affected by the fire.

Many SOPs also establish what equipment firefighters must carry when using an elevator. Firefighters are to be equipped with full protective clothing, SCBA turned on, an activated PASS device, and forcible entry tools. All of the SOPs prohibit firefighters from getting off on the floor where the alarm is activated, but at least one city, Dallas, allows firefighters to go to the floor of alarm if a guard or building engineer has personally confirmed there is no sign of smoke or fire. In general, the SOPs reviewed require firefighters to stop one to two floors below the floor in alarm.

SOPs should also establish who is responsible for establishing control over the elevators. This job is usually assigned to the first arriving engine or truck, and ultimately may be assigned to the Lobby Control Sector.

Milwaukee's SOPs note that firefighters should look up into the shaft through the elevator's trap door or through cracks between the floor and elevator to verify that there is no smoke in the shaft. If there is smoke, firefighters are cautioned against using the elevator. Los Angeles City specifically prohibits firefighters from using elevators in buildings under investigation for a fire emergency until it is determined by fire department personnel that the entire shaft is not threatened by fire.

Dallas, Philadelphia, and Chicago require that a firefighter with a portable radio be assigned to operate an elevator. Milwaukee's SOPs state that it is preferable to use a service elevator in a building serviced by split banks because the service elevator most likely serves the entire building, while Philadelphia's procedures recommend firefighters avoid using these elevators because they are typically slower and sometimes do not have firefighter bypass switches. Chicago and Dallas both require that firefighters manually stop an elevator every five floors to confirm that it is functioning properly. Dallas also prohibits firefighters from passing the fire floor in an elevator because of the significant hazard this creates. Dallas and Philadelphia restrict personnel from initially using an elevator if there is reasonable suspicion of a working fire below the eighth floor. Memphis's SOPs prohibit the use of elevators which serve the fire area when a working fire is declared.

Some departments do not allow firefighters to ascend a highrise unless they are carrying a highrise hosepack. This policy is designed to prevent a truck company from investigating a fire or even an activated alarm without having proper equipment to fight a fire. Los Angeles City's and Memphis' SOPs require that firefighters using elevators take at least one fire extinguisher with them and have it pointing at the elevator doors when they open. Some cities also require personnel using an elevator to carry forcible entry tools that could be used in an emergency to pry open elevator doors and, possibly, to break through the walls of the elevator shaft.

Dallas' elevator SOPs call for the dispatch of the department's high angle rescue team for cases when an elevator cannot be recalled and there is reasonable suspicion of a working fire. Los Angeles City requires personnel to be assigned to check elevators in banks serving the fire

floor to verify that all are empty. Fairfax County's SOPs note the importance of immediately searching elevator lobbies on floors affected by the fire. Many occupants still try to exit using elevators, despite warnings against it, and there is a higher probability that elevator lobby areas will contain victims than other areas of a floor.

Evacuation and Stairwells – Evacuation of a highrise can be one of the biggest challenges in controlling a highrise fire emergency. Firefighters depend on a prompt, organized evacuation by occupants so that they only have to concentrate on rescuing disabled persons, and on the fire attack. Unfortunately, building occupants do not always follow evacuation plans, and many persons may delay exiting and become trapped. This is why it is important for the fire department to establish procedures for managing occupant evacuation.

Occupant evacuation management requires that first arriving officers make an assessment of the risks posed to occupants who are still in the building. SOPs should emphasize the importance of making a decision in the early stages about whether firefighters should concentrate on suppressing the fire or helping occupants out of the building. Suppression and evacuation are usually the two biggest priorities at highrise fires. In some cases the best way to protect trapped occupants is to concentrate on extinguishing the fire before it reaches those above it. In other cases, the fire may be so large and uncontrollable that the best action is to protect stairwells from products of combustion and assist occupants out of the building. Once a decision is made, SOPs should instruct firefighters to communicate their plan with occupants in the building.

Los Angeles City's SOPs provide a lengthy discussion of evacuation procedures for large highrises. They note that in some cases thousands of people may try to leave the building. Evacuating a large number of people in a timely manner is impossible and would hamper firefighting operations. The SOPs call for the incident commander to assign an engine company to assist with evacuation. This crew can utilize the public address system in the stairwells and on floors, or use other means to communicate messages to occupants about who needs to evacuate and how to evacuate. In most cases, the department will evacuate three floors at a time to prevent stairwell overcrowding. Phoenix's SOPs state that occupants in the immediate fire area should be evacuated as quickly as possible, but that "further evacuation should be predicated on risk to the occupants since premature evacuation often hinders fire control efforts and adds to general confusion at the scene."

Some of the SOPs reviewed also established procedures to protect stairwells from the products of combustion. This is an important tactic for buildings which do not have built-in fans to create a pressurized environment. Los Angeles City's SOPs require firefighters to place positive pressure fans at the base of stairwells to establish a positive pressure environment, or to augment built-in pressurization fans. In buildings over 25 stories, the fans are to be placed every 25 floors. Although many departments prohibit the use of gasoline powered, carbon monoxide producing positive pressure fans in stairwells, some departments allow their usage if there is sufficient air flow to remove the carbon monoxide fumes.

Very few of the SOPs reviewed noted the importance of checking early in the incident to verify that stairwell roof hatches are open. Fire protection systems that activate fans to pressurize stairwells usually open hatches automatically. Closed hatches prevent smoke from escaping and create a stack effect.

Many SOPs urge firefighters to establish separate stairwells for evacuation and as a base for fire attack. In reality this may impossible unless the stairwells or building are equipped with a public address system that allows firefighters to communicate the evacuation plan to occupants. The Milwaukee Fire Department SOPs require that civilians be evacuated from the stairwell(s) before firefighters begin suppression operations.

Fairfax County's SOPs prioritize search areas in a highrise. The fire floor and floor above are to be searched first, followed by the top floor before searching the floors in between. For large or very populated highrises, the SOPs recommend relocation of occupants on the fire floor and two floors above and below the fire. The remaining occupants probably will be safer staying where they are in the building, particularly if the building is sprinklered.

Fire Attack – Some of the highrise SOPs reviewed for this report provide basic guidelines about the size and type of team which should be assembled to initiate fire attack in a highrise. The size of attack teams varies from department to department, but most of the SOPs reviewed required the attack comprise the first engine and first truck, at a minimum, if there is indication of a working fire. Memphis' SOPs, which were revised following a highrise fire that killed two firefighters, stipulate that all operations be conducted by task forces comprised of two engines and one truck. Task forces are assigned particular missions, i.e. fire attack, rescue, ventilation, etc.

Memphis believes this unique arrangement of personnel "improves accountability and provides sufficient personnel and equipment for meeting the complex demands of a highrise fire."

Chicago's SOPs specify that a crew with an attack line should be put in place on the floor above the fire as quickly as possible to prevent any lapping or vertical extension. This is particularly important if windows begin to fail on the fire floor. Los Angeles City's SOPs state the firefighters should try to initiate an attack from the stairwell containing a roof hatch if possible so that there is no ventilation problem or stack effect in the stairwell. Some SOPs say that in cases where the fire can be controlled quickly, fire attack may be given priority over evacuation of occupants.

Fairfax County's SOPs warn officers about conducting simultaneous fire attacks from different stairwells because of the possibility of a situation where two attacks oppose one another. Operations from different stairwells may be necessary if there is a large volume of fire, but this attack must be well coordinated. The SOPs also warn about negative effects of compartmentation and partitions which are routinely found in highrises. These internal structural divisions are designed to contain the fire, but they may allow firefighters to unknowingly go past the fire and become entrapped.

Because of the unusual designs and layouts of highrise buildings, Fairfax County's SOPs require the first arriving engine company to provide a verbal size-up of the fire floor to the incident commander. The size-up should include information about the floor layout and their exact location relative to the fire's location. The SOPs state, "The first arriving engine company officer should remember that the Battalion Chief will normally build his strategy around the engine company's first tactics. All facts that are found in the fire area must be communicated to the incident commander."

Safety – Safety is given very little attention in many of the SOPs reviewed. Due to the potential size and complexities of fighting a highrise fire, highrise SOPs should emphasize safety by designating an individual to function as the Safety Officer. This individual should be given the responsibility of monitoring hazards specific to highrises including falling glass. Complex highrise fires may require a lead safety officer at the command post and several other safety

officers assigned to specific sectors (e.g. interior safety, exterior safety). Interior safety officers should have another firefighter accompanying them so they are not alone in a hazardous environment.

One set of SOPs reviewed for this report requires firefighters to establish a safe access corridor between the street and the building, and that ventilation efforts be prohibited above the corridor. Philadelphia's SOPs include a position for an interior safety officer who is responsible for ensuring that personnel are moved, controlled, and supported in a safe manner. Memphis requires that at least one task force (two engines, one truck) be kept in the exterior staging area at all times during a working fire. In addition, a safety team labeled the "Rapid Intervention Team" is dispatched to working highrise fires. Its personnel ascend to the interior staging area for the purpose of providing rapid intervention in the event that firefighters become trapped, lost, or need emergency assistance.

Communications Equipment – Several of the fires previously discussed demonstrate the communications difficulties which can arise while operating within highrise buildings. Highrise building construction may shield radio waves and hamper communications between exterior and interior personnel. Highrise SOPs should develop communications contingency plans. For example, some of the SOPs reviewed suggest using simplex (non-repeated) channels when personnel are unable to transmit over primary channels. Newer highrise buildings may be equipped with internal communications systems. Pre-fire plans for highrise buildings should document these features, with instructions on how to use them.

Los Angeles City urges the first arriving companies to note the number of the phone in the lobby area before investigating the fire in case a radio fails and a firefighter needs to telephone the incident commander.

Ventilation – Many of the SOPs reviewed require Command to establish a ventilation sector early in a highrise incident. This sector's responsibilities generally include:

- shutting down the building's HVAC system unless it is capable of providing smoke removal without spreading smoke to the rest of the building
- setting up positive pressure fans at the base of stairwells and ensuring that stairwell pressurization fans are working

- opening roof hatches as necessary
- providing horizontal ventilation by breaking out windows only after consulting with the IC and notifying ground companies.

One set of SOPs specified that firefighters are to break a small hole in a window and then reach out through the hole and push the glass inward, if possible. The SOP also requires ventilation companies to tape windows prior to ventilation to prevent untempered glass from shattering.

Accountability – Accountability is integral to effective management of a highrise fire. Several of the firefighter fatalities in highrise structures listed earlier in this report were caused by firefighters who became lost or disoriented. The mazes of hallways, rooms, and partitions found in highrises (particularly in office highrises) and limited evacuation routes increases the likelihood that a firefighter could become lost. This is why it is particularly important to have a system to account for personnel fighting a highrise fire.

Highrise SOPs should build upon the fire department's standard accountability system. Two major types of highrise personnel accountability systems are discussed in the SOPs reviewed. The most prevalent type is to have one firefighter from the first alarm units establish Lobby Control and record the names of firefighters entering the building. Another approach is to have units post a velcro passport containing the names of firefighters on the respective units on a command board on the first arriving vehicle or in the lobby.

Helicopter Operations – Dallas' and Los Angeles City's highrise SOPs incorporate procedures for the use of helicopters in highrise fire emergencies. The teams have been incorporated primarily to evacuate occupants who flee to the roof, but also to provide a means of delivering firefighters to the roof to open ventilation hatches or descend into the building. Los Angeles City established a helicopter operations sector at least one-half mile away from the scene and notes that helicopter operators must be stay at least 500 feet away from the sides of the affected building to avoid blowing smoke and fanning the flames. Some buildings there are required by code to have helipads on their roofs.

HIGHRISE PRE-FIRE PLANNING AND SYSTEM INSPECTION

The major fires previously discussed demonstrate the fire department's dependence on built-in fire protection systems to successfully control a fire in a highrise building. Most fire departments across the country are accustomed to regularly testing fire hydrants and conducting pre-fire plans of water supply systems in their communities, however, many fire departments do not give this high level of attention to fire protection system testing and pre-fire planning of highrises.

Fire departments also should conduct pre-fire plans of individual highrises so that they have a written plan for handling a fire before it happens. A recent article on major highrise fires noted, "System failures - power, elevator, and stairway pressurization - are common to most [recent major fires]. While the [recent major fires] are not a representative sample of incidents, they suggest that these systems are more vulnerable than we may think. Failure of critical systems should be incorporated into pre-fire plans for highrise office buildings."[7] At a minimum, pre-fire plans should address the types and capabilities of fire protection systems, the layout of the building, locations of stairwells and elevators, and how evacuation will be handled.

The Vancouver, British Columbia Fire Department has devised a unique and comprehensive method for developing and updating pre-fire plans for highrises. The fire department authorized several firms in the city to write comprehensive pre-fire plans for highrise buildings. Each firm produces plans in a standard format established by the fire department. Highrise building owners are required to select one of these firms to write a plan for their building. Once the plan is written, a copy is kept in the fire control room and one is filed with the fire marshal’s office. Building owners must have one of the firms revise the plan every five years. A sample of a Vancouver Fire Department pre-fire plan is included in Appendix B.

Since successful tactical operations depend heavily on the functionality of a highrise building's fire protection system, fire departments must ensure through testing and inspections that the systems are maintained and work properly. Fire protection systems should be inspected upon installation and regularly thereafter. Inspections should ensure that standpipe outlet pressures and flows are sufficient; that primary systems are working up to the level of

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[7] Jennings, Charles. "Highrise Building Evacuation Planning." *Journal of Applied Fire Science*, Vol. 4 No. 4, 1994, pg. 294.

expectation; that backup systems will work if primary systems fail; and that the proper valves and connections are open and functional. Regular testing of systems can be performed or observed by fire department personnel, but most cities require building management to have systems inspected by a private contractor who is certified by the city to perform inspections. Inspections should include testing of all outlets with pressure reducing devices to ensure adequate flow and pressure under flowing and non-flowing conditions.

TRAINING IN FIRE PROTECTION SYSTEMS

This report has emphasized the fire department's reliance upon built-in fire protection systems to control a highrise fire emergency. Firefighters should be trained on the capabilities and limitations of these systems, and they should know how to intervene if a system component fails.

Fire departments which protect highrise structures should have personnel with special knowledge of fire protection systems. An individual or select group of individuals could be given special training on fire protection systems, or the department may hire or establish a relationship with a knowledgeable fire protection engineer. These individuals would have the knowledge and ability to provide technical advice if a system component failed or to answer general questions about systems.

Many large city departments have a staff position for a fire protection engineer. Some departments also have specially trained highrise units. The Phoenix Fire Department is in the process of forming a special highrise response team which will be given advanced training and equipment for handling a highrise fire. The goal of the team is to "make the building behave in a way the ensures the safest operation possible for firefighters and occupants." In Phoenix, a fire protection engineer responds to working fires to confer with the building owners and managers.

OCCUPANT EVACUATION TRAINING

Fire departments generally do not have the manpower to rescue hundreds of trapped occupants in a highrise fire. They will usually be able to manage the evacuation and directly assist those near the fire floor. If the fire cannot be controlled rapidly or occupants removed quickly, a disaster may result. Automatic sprinkler systems are the most effective way to control

a highrise fire quickly so that occupants are not threatened. If sprinklers do not immediately suppress the fire, they generally delay its growth and allow time for occupants to escape. It is much more likely for there to be evacuation problems in unsprinklered buildings. Fire departments must be prepared to manage the evacuation of occupants from these buildings. Given the problems which can be anticipated with evacuation from unsprinklered buildings, fire departments should ensure that occupants of these buildings routinely practice evacuation procedures and understand the importance of a prompt and orderly response.

Experience clearly shows that it is easier for firefighters to manage evacuation if the occupants have been trained in evacuation procedures. During a highrise fire at the Peachtree building in Atlanta, government employees on the floor above the fire who were regularly required to participate in evacuation drills successfully evacuated; however, five employees of private firms which did not regularly participate in regular drills died.[8] Some jurisdictions across the country have also dedicated fire prevention staff to work with building managers to practice occupant evacuation. Some fire departments across the country require that highrise building managers design an occupant evacuation plan to train occupants how to respond to an emergency. Most highrise occupant evacuation plans are based on the premise that occupants exit the building through protected stairwells in a prompt and orderly manner.

Building public address systems is an important tool for evacuation management. Many newer highrise buildings have incorporated public address systems into their design. These systems allow the fire department to communicate evacuation instructions to occupants. They are particularly important to have when occupants become trapped above the fire and firefighters cannot reach them. Firefighters should be trained about how to evacuate a building using public address systems. In the absence of these systems, fire department personnel will have a difficult time managing the evacuation of a highrise building.

[8] Ibid.

RECOMMENDATIONS

The following recommendations about highrise firefighting are taken from lessons learned at recent major highrise fires across the country. Departments that protect highrise structures should consider the following to maximize their ability to handle the inherent complexities and hazards of a highrise fire emergency.

1. All fire departments which have highrise buildings in their response areas should have highrise SOPs to address incident command, water supply, and occupant evacuation. The recent major highrise fires illustrate the need for these due to the inherent challenges and hazards presented by a highrise structure.

2. Pre-fire planning of highrise building fire protection systems is essential for conducting a safe and orderly fire attack and occupant evacuation.

3. Local jurisdictions must work closely with highrise building management to ensure that highrise fire protection systems are tested on a regular basis and that individual components are functioning to the fire departments' expectations. Departments should give particular attention to pressure reducing devices to ensure that they provide adequate water volume and pressure at all levels throughout the structure.

4. Fire departments should be prepared for the failure of key fire protection system components in a highrise building, and should have contingency plans in place in case a component fails to work properly.

5. Highrise hose and nozzle packs must be designed to operate under potential low pressure water supply scenarios.

6. Properly designed, installed, and maintained sprinkler systems have proven to be the best method to successfully control and extinguish highrise fires and protect occupants.

7. Special highrise training drills should be conducted regularly to allow firefighters and command officers the opportunity to become familiar with the highrise firefighting operations. Drills should cover three important areas: incident command, firefighting and tactics, and evacuation and management of occupants.

8. Regular occupant evacuation training in commercial and residential highrises is essential to an organized occupant response in a real emergency.

Appendix A

Sample Highrise Standard Operating Procedures

This plan is intended to adapt normal Standard Operating Procedures and systems to a high-rise mode of operations.

High-rise fires present some particular problems in fire fighting operations. Most of these are related to the difficulties of access, the complexities of construction, and the number of occupants in these structures. By virtue of these considerations, any situation in a high-rise structure is more complicated than the same situation occurring in a low-rise environment.

The Life Safety aspects of a fire in a high-rise structure are always a primary concern for Command.

The strategic plan must include an evaluation of the conditions in each area of the structure and the tenability of same for evacuation. Large numbers of occupants may be involved in these decisions.

Command must direct the decision to remove occupants, when necessary, and the plan for evacuating or relocating occupants must be coordinated with the fire control strategy.

An aggressive coordinated attack has proven to be the most effective tactical option in the majority of high-rise fire situations.

Immediate Priorities

The construction of most high-rise buildings effectively shields the interior from the outside. Even with "nothing showing," an assumption of a concealed fire should be made by Command.

The initial arriving units should be concerned with:

1. Identifying the fire floor.
2. Providing an attack on the fire floor with at least three (3) companies.
3. Providing for the life safety of persons in immediate danger.
4. Providing water supply for the initial attack.
5. Establishing lobby control.
6. Making a size-up of conditions on the fire floor and the floor above and ventilation needs.

ESTABLISH COMMAND

In most high-rise situations the need for establishing Command "in the street" is secondary to the urgency of getting an officer and crew up to the fire area. A single company, arriving alone, should prepare to go up into the building with basic equipment. The first arriving company should give an arrival report, announce the its actions and PASS COMMAND to the next arriving officer.

When several units arrive simultaneously, the officer of the first arriving company has the option of assuming or passing Command. At least one officer must go up to lead the attack and an exterior command post shall be established.

INITIAL ATTACK

The Initial Attack should consist of at least three (3) companies (preferably 2 engines and 1 ladder). The officer leading the attack will be responsible for selecting the method of ascent to the reported fire area (elevator, stairs) depending on conditions. The communication panel must be checked for additional information prior to ascending to fire floors.

As soon as the fire floor is reached and identified, the officer will give Command a report of conditions on the fire floor, immediate needs, and a confirmation of the actual fire floor number. Command should then establish the fire floor as a Sector (Floor 16 = Sector 16).

When a building has multiple standpipes, the Fire Floor Sector Officer must advise Command where he needs water and Command will confirm the availability of pumped water to that particular riser.

At least one member shall remain in the lobby area to establish Lobby Sector and to gain control of all elevators using Emergency Recall or Manual Override. Lobby Sector must maintain accountability for attack companies and their method of ascent.

The Initial Attack Companies will go upstairs with only SCBA, hose packs, and basic forcible entry tools. If access is via an elevator, an extinguisher should also be taken. Other equipment will be pooled in the lobby until a Rehabilitation Sector is established.

COMMAND PRIORITIES

Once the initial attack companies have started up to the fire floor, Command must be concerned with the following.

1. Provide an early water supply for the attack. Assign engineers and pumpers or additional engine companies to provide water to standpipes. When there are multiple systems, pump all standpipe inlets to insure a water supply to all standpipes in the building.

2. Assign a company to check the floor above the fire floor. Command must get a report on conditions above the fire as quickly as possible, indicating fire extension possibility, smoke conditions, need for evacuation and resource requirements.

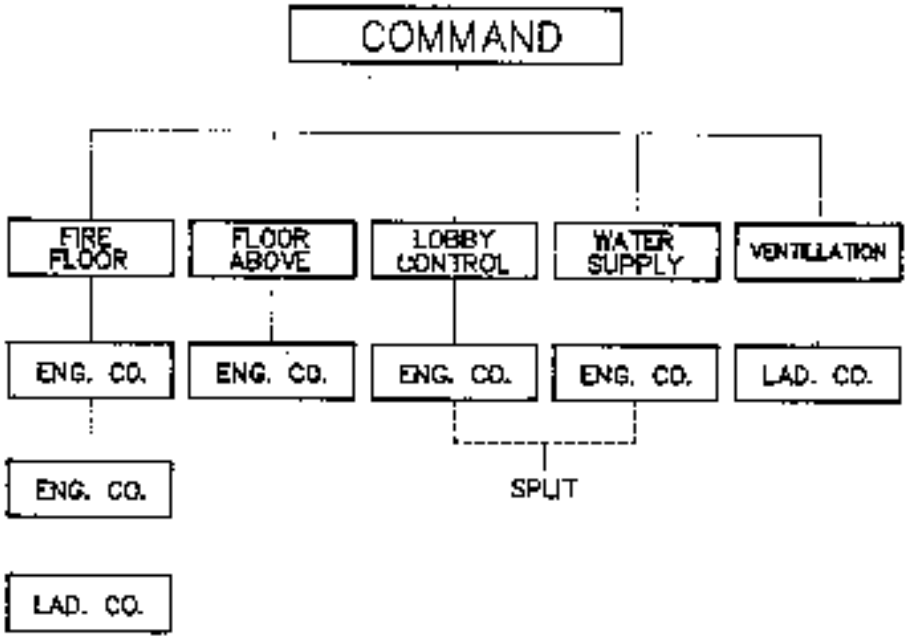
3. Establish Lobby Control. A full company is needed for Lobby Control to take control of elevators and alert systems and each stairway. Additional personnel may be required to assist as fire permits (See LOBBY CONTROL).

4. Call for additional resources. Any type of working situation will quickly utilize an initial first alarm assignment. Call for additional alarms as soon as the need is identified. A second alarm will be required on any incidence of a fire in the building. A third alarm has proven to be the base minimum needed for a working fire. Use level II staging.

5. Begin to establish supporting systems. A fire which is not controlled by the Initial Attack Companies will require a larger attack force and a supporting structure including Staging, Resources Sector, increased Lobby Control and the necessary additional elements. Begin to build this structure as soon as possible.

6. Establish ventilation sector. Assign a ladder crew early to establish a ventilation sector. Early positive pressure ventilation of the attack stairwell is an absolute must. Additional stairwells may also require positive pressure ventilation.

INITIAL ATTACK



A working fire in a high-rise may not be controlled by the Initial Attack Companies. In such a case, the operation becomes prolonged and escalates into a major operation.

WORKING FIRE

A strong organization is required to support a fire fighting force above ground. The principal objective of this supporting organization is to provide the fire fighting sectors with manpower and equipment to operate effectively and to assist in solving some of the major problems involved in high-rise structures.

Command must exist to identify and build this organization as quickly as possible after assigning units needed for Initial Attack. These elements can be expanded upon as the availability of personnel increases.

The major elements which need to be considered in most working high-rise situations are:

- Fire Floor Sector
- Lobby Control
- Floor Above (Extension)
- Ventilation
- Evacuation Sector
- Level II Staging
- Floor Below (Property Conservation)
- Ventilation, (Stairwells a Priority)
- Evacuation

In addition to these elements, many (or all) of the sector functions associated with standard operations may be required.

STAGING

Standard Level I Staging will be used by all first alarm companies. Level II Staging should be established by Command when requesting multiple alarms. Any apparatus parked in close proximity to the building, by companies assigned to the interior, should be moved to a Level II area as time permits. No apparatus should be parked within 200 feet of the building.

All apparatus should remain in this Staging Area unless needed for a specific purpose. Enclosed vehicles may be employed to move personnel and equipment from the Staging Area to the building.

LOBBY CONTROL

The Lobby Control Sector is responsible for the control of elevators and stairway access, for the operation of alarm panels, communications systems and building system controls located at ground level, and for the stockpiling and dispatching of equipment from the lobby to the Resources Sector. This sector maintains a log of all personnel going up to the fire area.

This sector must be established early to control elevators and access. Lobby must locate the building engineer and have the engineer report to lobby or other fire officers as determined by command. The additional responsibilities can be added incrementally. (See M.P. 209.01C, LOBBY CONTROL SECTOR.)

RESOURCE SECTOR

The Resource Sector should be established in a convenient location providing good access to the fire operations area. One floors below the fire floor (or other safe environment) is usually a good location. All spare SCBA bottles hose, nozzles, and other equipment and will be stockpiled at this sector.

This sector acts as a forward staging area and provides a supply of manpower and equipment to provide direct support to fire fighting operations. As crews arrive in level II staging, they will be dispatched to the Resource Sector to await an appropriate assignment.

If not already in operation, this sector should be established by the first company relieved from initial attack. (See M.P. 209.01D, RESOURCES SECTOR.) This sector should be established while the initial attack crews are making their first entry to the fire area.

FIRE FLOOR - Companies assigned to the fire floor are primarily concerned with search and rescue, fire attack and ventilation.

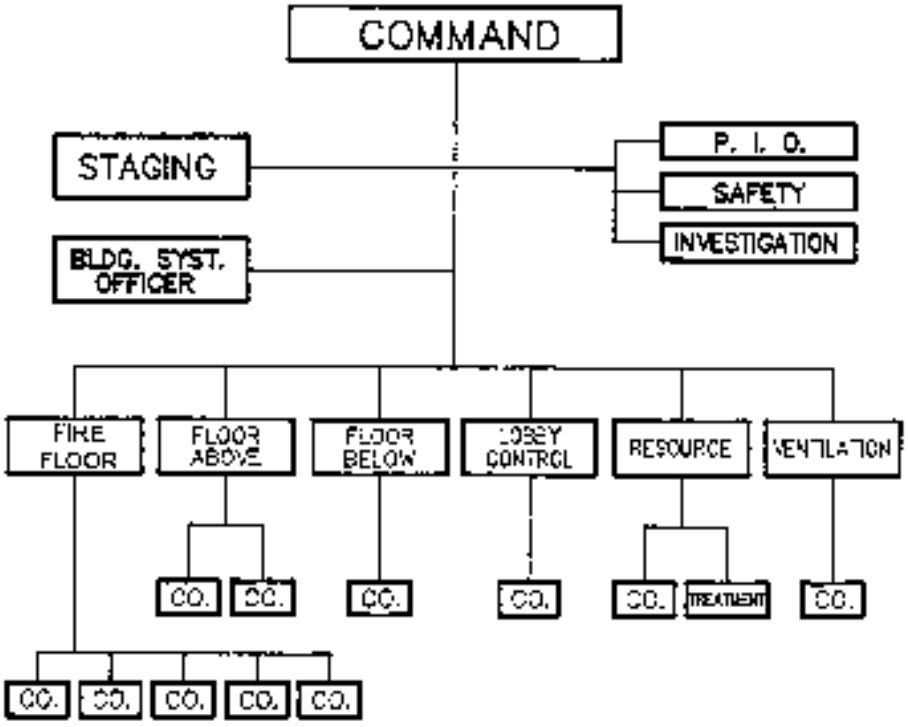
FLOOR ABOVE - Units on the floor above will determine the fire safety of occupants and evacuate if necessary. They will check for fire extension in the upward direction.

FLOOR BELOW - The floor below must be checked for any possibility of fire extension and for property conservation needs. Salvage is usually the most significant activity.

VENTILATION - The initial attack stairwell must receive positive pressure ventilation as soon as possible. Additional stairwell may also require positive pressure ventilation. A ventilation sector shall be established. The ventilation sector will be responsible for coordinating all ventilation activities at the fire.

EVACUATION - Building occupants may require evacuation. Occupants should first be taken to three floors below the fire and then removed from the building as time and resources permit.

WORKING FIRE



Campaign situations are those incidents which require large forces of manpower and equipment to control and continue for long periods of time. A campaign situation in a high-rise fire would be a fire involving an entire floor or more. The commitment of manpower and personnel to fire fighting may require several sectors for tactical organization and a full array of supporting sectors and functions would be activated.

Command should establish the "OPERATIONS" level of command in these circumstances. This would place all interior fire fighting sectors under the supervision of a "FIRE OPERATIONS OFFICER" who would normally be located within the building.

When significant numbers of occupants or injured victims are involved, the MEDICAL OPERATIONS level may be implemented to handle standard functions, including evacuation and Welfare Sector.

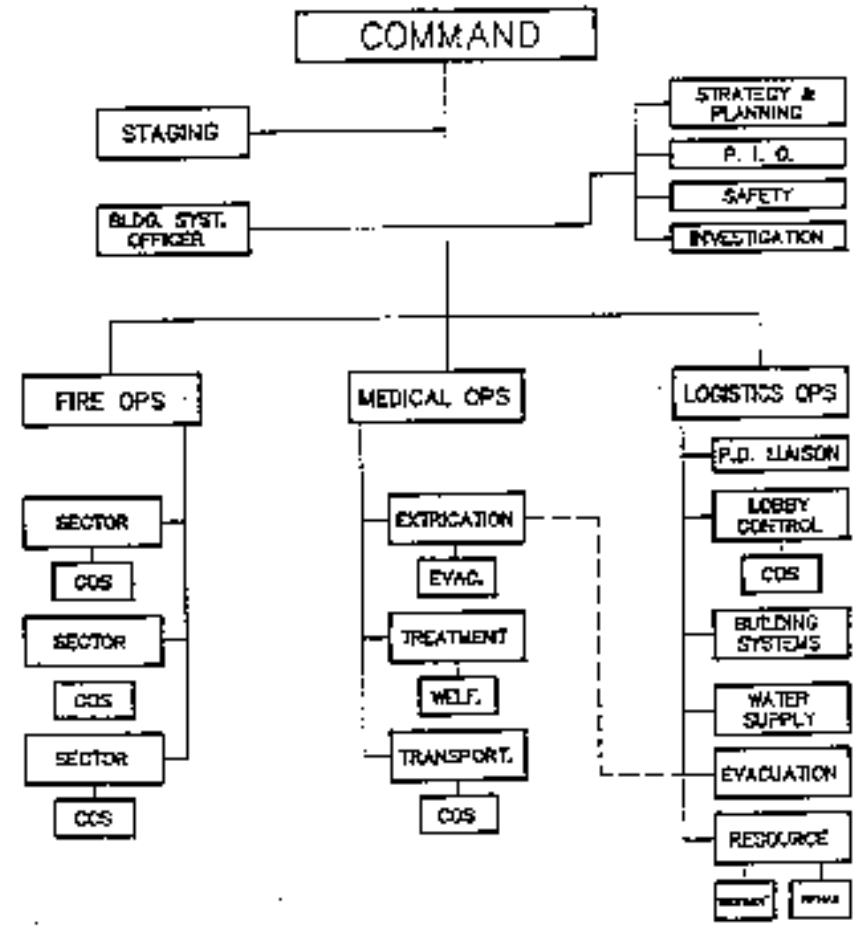
The Staging, Lobby Control and Resources Sector are primarily concerned with the flow of manpower and equipment into the building and up to the fire area. These should be grouped under a "LOGISTICS OPERATIONS OFFICER."

For effective communications, the elements of each Operations area should use a separate radio channel.

In addition to these elements, a standard array of staff function sectors would be established and report to Command. Most of these (P.I.O., Safety, Investigation) are established automatically by arriving staff personnel. Senior Command Staff would provide support at the Command Post as necessary.

CONTINUED FIRE - SEE NEXT PAGE

CAMPAIGN


COMMAND
STAGING
BLDG. SYST. OFFICER
STRATEGY & PLANNING
P. I. O.
SAFETY
INVESTIGATION
FIRE OPS
MEDICAL OPS
LOGISTICS OPS
SECTOR
COS
SECTOR
COS
SECTOR
COS
EXTRICATION
EVAC.
TREATMENT
WELF.
TRANSPORT.
COS
P.D. LIAISON
LOBBY CONTROL
COS
BUILDING SYSTEMS
WATER SUPPLY
EVACUATION
RESOURCE

BUILDING SYSTEMS OFFICER

In buildings where complex systems (elevators, air handling, fixed fire protection, internal communications) are a factor in operations, Command should appoint a Building Systems Officer (and Assistance as necessary) to provide advice and liaison with building maintenance personnel on the operation of these systems. Many buildings are required by Code to provide a Building Control Station in the Lobby with plans, controls and monitors for all of these functions. The assigned officer should be familiar with systems and with the particular building if possible.

The Building Systems Officer reports directly to Command and would relieve Lobby Control of this responsibility.

EVACUATION OFFICER

In some situations a significant number of occupants may need to be evacuated or otherwise directed. It may be advantageous to separate this area of responsibility from fire fighting and assign companies under an Evacuation Officer to accomplish this function and reduce Command's span of control.

EVACUATION POLICY

The evacuation routes available to occupants of a high-rise building are normally limited to two stairways. The stairways are also the prime access route for fire fighting forces to make an attack.

Occupants in the immediate fire area should first be evacuated as quickly as possible to three floors below the fire floor or other safe environment. Further evacuation should be predicated on risk to the occupants, since premature evacuation often hinders fire control efforts and adds to general confusion at the scene. The determination of risk and the decision to evacuate should be made by personnel on the floor.

Subsequent evacuations should be managed to avoid interference with operations as much as possible. (See EVACUATION SECTOR). If sufficient Police personnel are available at the scene, they may be used to good advantage in assisting with evacuation. Police assistance may be most valuable in controlling evacuees in the lobby and preventing re-entry.

COMMAND OFFICERS

The first Command Officer shall establish an effective exterior Command Post. The second arriving command officer should be assigned to the fire floor sector to command the attack.

Command officers should be assigned to relieve company officers as early as possible in each sector. The officers field incident technician shall accompany the chief and take VHF radios and flipcharts with tactical worksheets.

STAIRWAYS

In structural fire fighting operations, at each one stairway should be kept clear to provide access to or escape from floors above the fire. This will require communicating which stair is being used for fire fighting access and/or ventilation and which is being kept clear for human travel.

Stairways may or may not have vent hatches at roof access at the top to allow venting for trapped smoke. Early positive pressure ventilation alone usually traps smoke in the stair or keep smoke from entering. Avoid intentionally venting the fire floor's stairway.

AIR HANDLING SYSTEMS

Unless the system is designed for smoke removal and fresh air supply it should be shut down until the fire is stabilized and the method of smoke removal is decided.

Lobby Control (or the Building Systems Officer if one assigned) is responsible for establishing contact with building engineering personnel to assist with these systems. The controls may be at a Building Control System in the lobby or in an equipment area.

ALARM AND COMMUNICATIONS SYSTEMS

Fire Alarm and/or one or two-way voice communications systems are required for all high-rise buildings. These provide a method of sounding alarms or making announcements on individual floors selectively or to the whole building. Lobby Control will have the responsibility for operating these systems at the main panel.

The construction of most high-rise buildings will tend to shield radio transmissions, particularly between Alarm Headquarters and portables inside the structure. A unit in the street usually will be able to communicate with units inside and may have to relay messages to Alarm.

All senior officers should use UHF radios when available. Internal communications systems in many buildings may be used in addition to normal radio communications; Command will need to establish communications with the system control panel.

A direct communications link between the Building Control Station and the Command Post is needed.

Appendix B

Excerpt from Vancouver Fire Department Highrise Pre-fire Plan

FIRE DEPARTMENT OPERATIONS BOOK

for

CITYVIEW

1046 HARO STREET

VANCOUVER, B.C.

DESIGNED AND DEVELOPED BY:

PACIFIC FIRE DESIGN
#505A-185 WEST HASTINGS ST
VANCOUVER, B.C.
V6B 1H9
Office (604) 681-2799
Fax (604) 681-2779

FIRE DEPARTMENT APPROVAL DATE: OCTOBER 1994

REVISION/UPGRADE DATE: OCTOBER 1997

GENERAL DESCRIPTION OF THE BUILDING AND ITS SAFETY FEATURES

Description and Construction:

This 8 storey, 185 suite residential complex over 10 years old known as Cityview is located at 1045 Haro Street, Vancouver, B.C. Its main construction materials consist of poured reinforced concrete. The external construction consists of stucco on top of steel frames housing aluminum framed windows. The internal construction consists of gypsum on top of steel studs. Various wall coverings and wood trim finishes have been applied. This building is finished with a flat top roof construction. There is one level of underground parking which is accessed via a concrete ramp off the rear lane off Thurlow Street. A security gate has been provided for limited access. This parkade is fully connected with the parkade at 842 Thurlow Street on the west side.

Safety Features:

- Supervised Fire Alarm System
- Water Mains
- Fire Hydrant Locations
- Fire Department Connection
- Sprinkler System
- Fire Hose Cabinets
- Standpipe Riser
- Emergency Power
- Fire Department Key Box
- Exit Systems
- Elevator
- Smoke Control
- Heating
- Utilities
- Mechanical Room

Fire Alarm System:

This complex is protected by a single stage Notifier 640 fire alarm system. The main fire alarm panel is located inside the electrical room on parking level. An annunciator panel is located inside the entry lobby on Haro Street. The fire alarm system of this building is linked with the fire alarm system at 842 Thurlow Street.

Normal Standby Operation:

1. The green AC POWER indicator must be lit.
2. All alarm (red lights) and trouble indicators (yellow lights) should be off.

Alarm Condition:

Activation of a compatible detector or any normally open fire alarm initiating device will result in the following action by the System 600 control panel:

1. Activate alarm indicating, control and signalling outputs as programmed.
2. Light the Red SYSTEM ALARM LED and the associated initiating circuit alarm LED(s), and
3. A steady audible tone will sound until the alarm is acknowledged or silenced.

The controlled outputs will remain activated and the associated alarm LEDs will flash until the alarm has been silenced or acknowledged, or the system has been reset.

Acknowledge / Silence Tone:

Depressing the ACKNOWLEDGE switch will turn the audible tone off and switch operation of associated LED(s) from flashing to steady. New alarms and/or troubles will resound the audible tone and flash their associated LED(s).

Alarm Silencing Procedure:

Alarm Indicating Appliance Circuits, control relays and signaling circuits that have been programmed as silenceable may be silenced by depressing the SIGNAL SILENCE switch on the CPU control panel (top left module). Subsequent alarms will reactivate alarm outputs.

SIGNAL SILENCE should not be pressed until it is determined that an evacuation of the building is not required.

Alarm Reset:

After locating and correcting the alarm condition, reset the control panel by depressing the SYSTEM RESET switch on the CPU control panel (top left module).

Disable/Enable:

Refer to the System 500 Installation Manual. WARNING: Disabling a circuit will reduce or eliminate fire protection.

Trouble Condition:

Activation of a trouble signal under normal operation indicates a condition that requires immediate correction. Carefully note which indicators (LEDs) are illuminated and contact your local service representative. The audible tone may be silenced by depressing the ACK/SILENCE switch. Subsequent trouble(s) will reactivate the audible tone. Trouble LEDs will continue to display the trouble condition(s) until the trouble(s) is corrected.

Water Mains:

A city water main runs into the sprinkler room on parking level with the shut off located inside this sprinkler room.

Fire Hydrant Locations:

There are two fire hydrants located within the vicinity of this building.

#1 - Located at the northeast corner of Hare Street and Burrard Street.

#2 - Located at the southeast corner of Hare Street and Thurlow Street.

Fire Department Connection:

A siamese fire department connection has been provided for the sprinkler system and is located outside the main entry on Hare Street.

Sprinkler System:

A fully automatic "dry" sprinkler system has been provided for this building. The system provides coverage for the parkade. The main control valves are located inside the sprinkler room located at the elevator lobby on parking level. The sprinkler system is monitored by the fire alarm system.

Fire Hose Cabinets:

Fire hose cabinets are provided and are located on main to 6th floor. Each cabinet houses a 75' x 1½" hose with a fog combination nozzle. Also located within each cabinet is a 5 lb. "ABC" type extinguisher. See floor plans for locations. See following pages for instructions.

Standpipe System:

Located inside the west, centre and east stairwell is a standpipe riser. Coming off the riser at each floor level and open mail is a 2½" fire department connection. These connections are to be used by Fire Department personnel only.

Emergency Power:

In the event of an A.C. power failure, a gas fired Simpson Maxwell 3 phase 27.5 KVA generator has been provided and located in the courtyard on restrictive. This unit provides power to emergency lighting, exit signage, elevator, the fire alarm panel and all related emergency equipment.

Fire Department Key Box:

A fire department key box is provided and located outside the main entry on Hare Street. Located within the key box are keys for main entry, service rooms, mechanical rooms, and the fire alarm panel.

Exit Systems:

There are three dogleg style configuration stairwells located within this building:

#1 - Located on the west side, accessing main to 8th floor open roof. Exits onto rear lane off Thurlow Street.

#2 - Located at the centre of the building, accessing parking level to elevator machine room level, exits onto Hare Street via the entry lobby.

#3 - Located on the east side, accessing main to 8th floor open roof, exits onto footpath off Hare Street.

Additional Exit from Main Floor:

An exit being provided at the centre of the building exits onto rear lane via open air courtyard.

Additional Exit from Parkade:

An exit being located on the east side exits onto Hare Street.

Elevators:

There are two elevators provided and located at the centre of the building providing access to all levels, parkade to 8th floor. These units are serviced by NORTH WEST ELEVATORS - 581-8877. There is no firefighters elevator provided for this building.

Smoke Control:

The common corridor on each floor is provided with 3 air duct openings, except the 8th floor is provided with one for pressurization purposes. Activation of any smoke or heat detector of the fire alarm system will automatically open the pressurization fans on roof.

Heating:

Electric baseboard heaters provide heating for all the residential suites and common corridors.

Utilities:

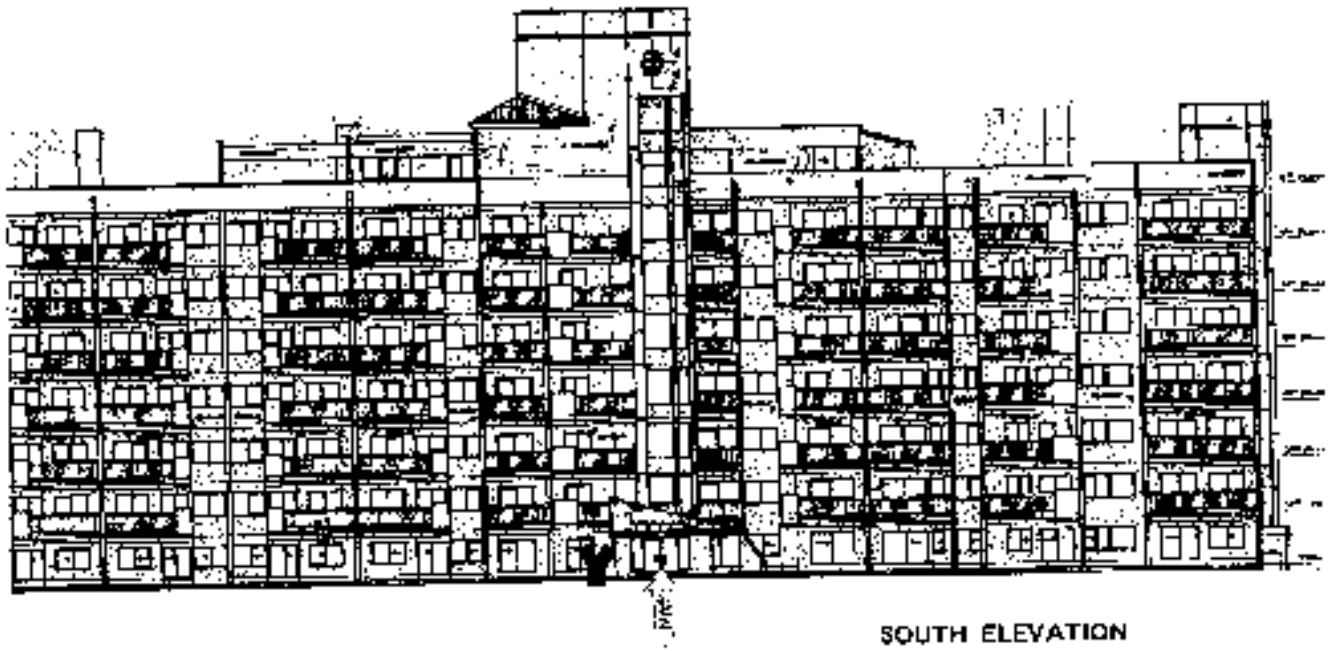
Gas: The main gas meter is located adjacent to the drive ramp on the northeast corner.

Water: The main water shut off located inside the sprinkler room on parking level (See parking level plan for details).

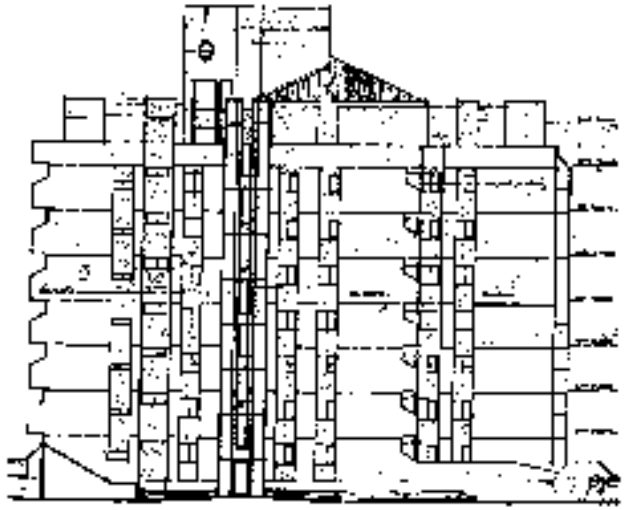
Electrical: The main electrical room is located on parking level (See parking level plan for details).

Mechanical Rooms:

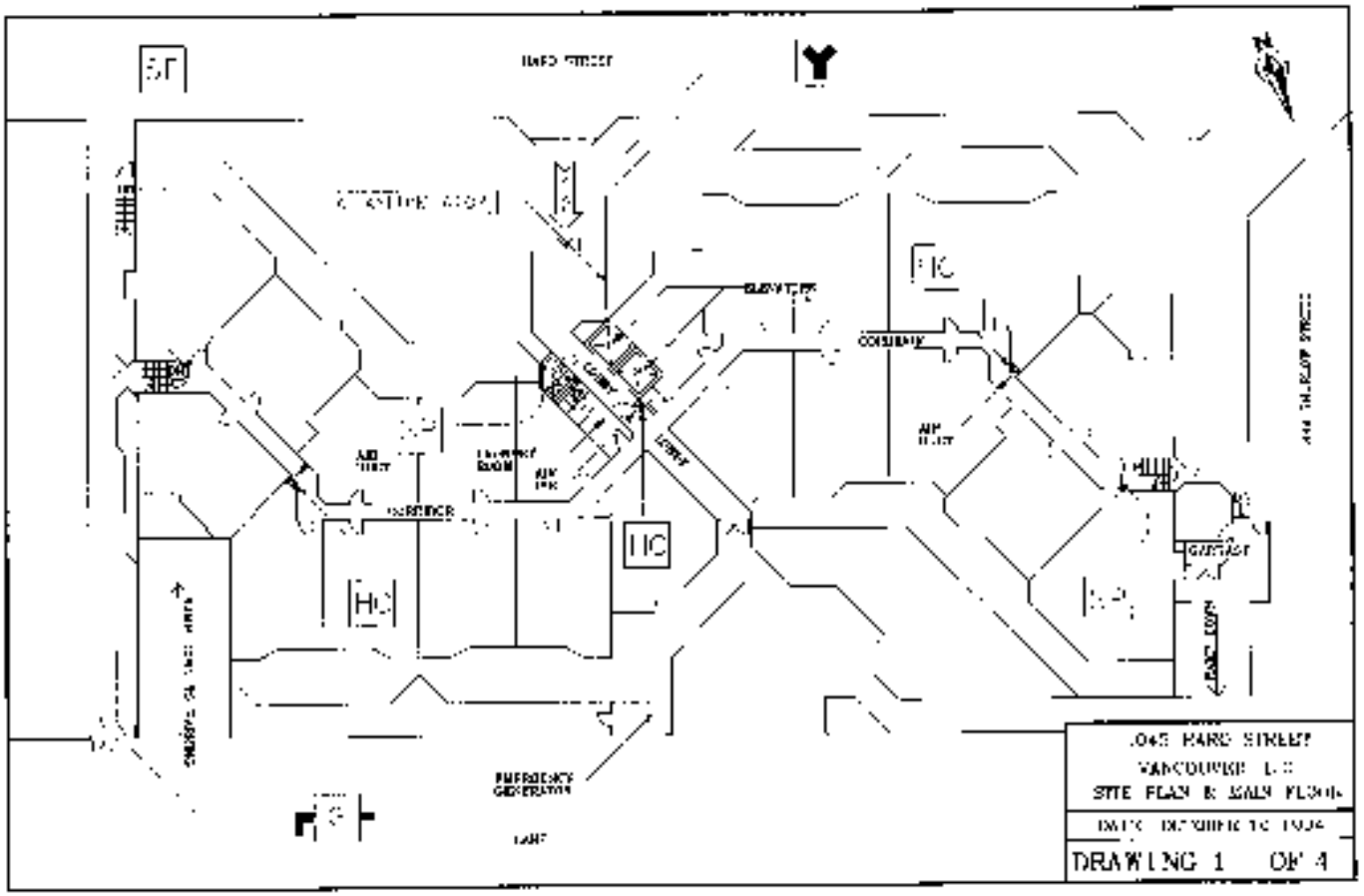
The mechanical room is located on the 8th floor.

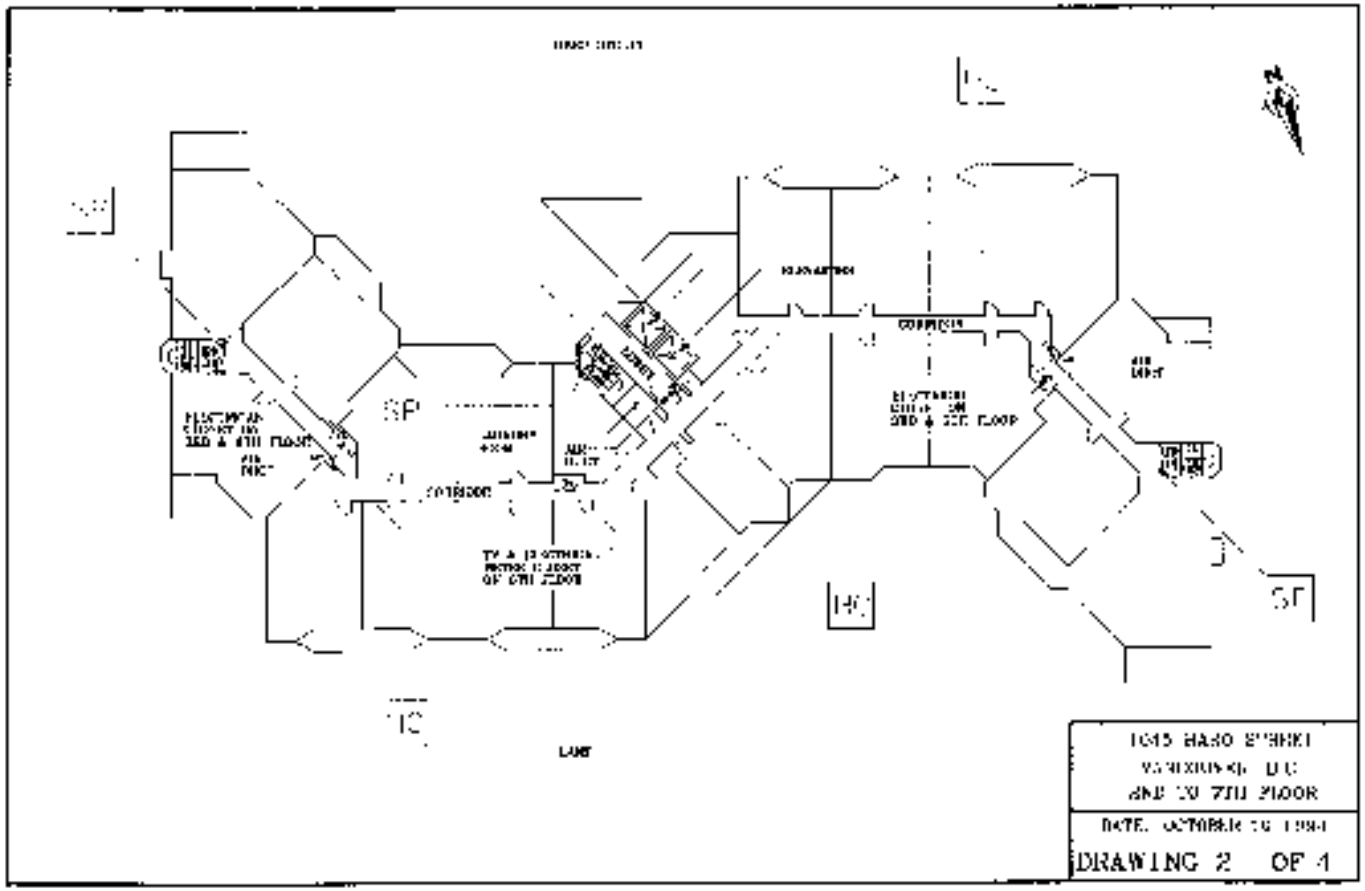


SOUTH ELEVATION



EAST ELEVATION


SITE PLAN & MAIN FLOOR
DRAWING 1 OF 4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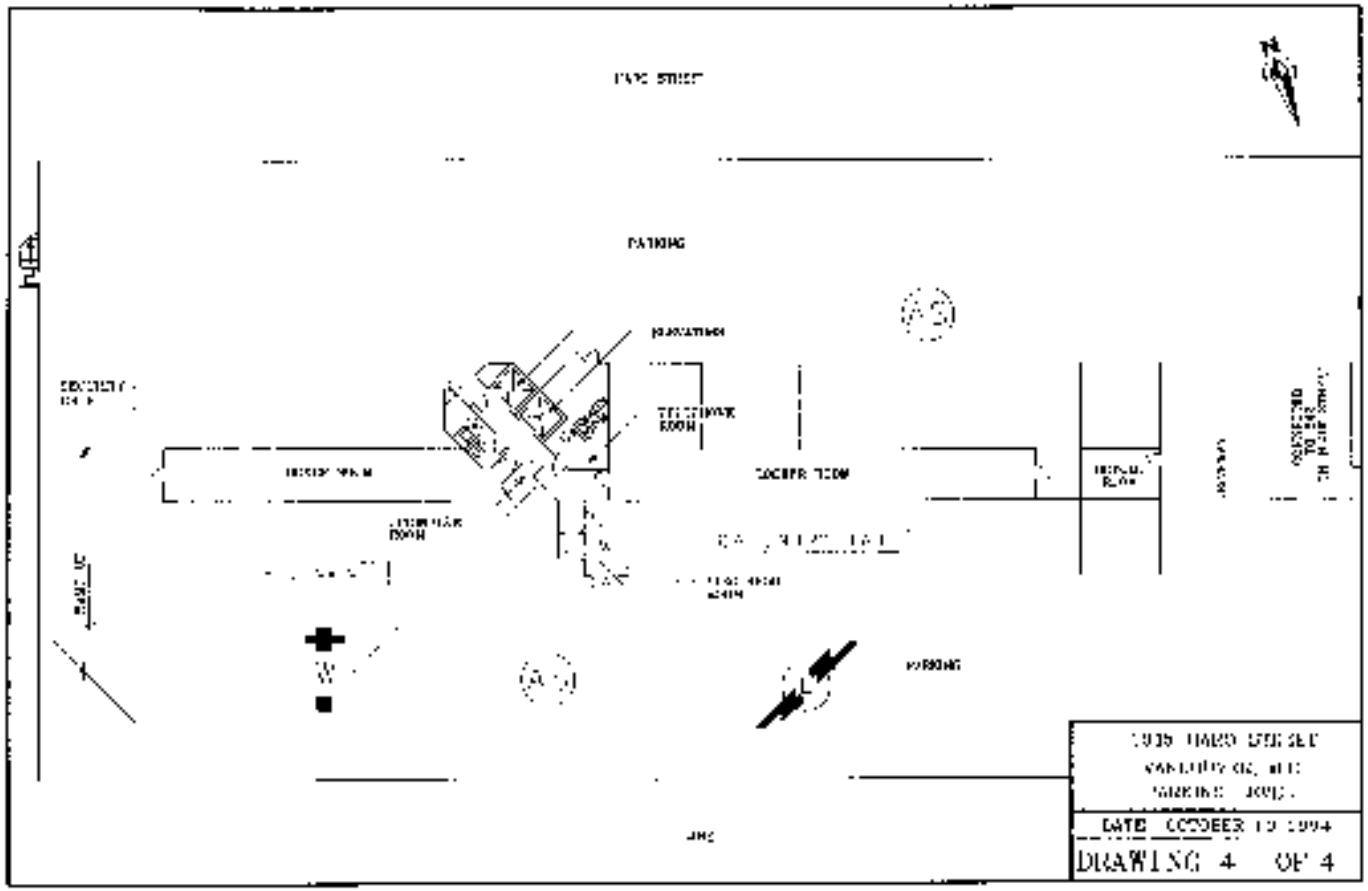
2ND TO 7TH FLOOR
DRAWING 2 OF 4


PARKING
LOCKER ROOM
DATE OCTOBER 10 1994
DRAWING 4 OF 4