HIGH-RISE FIREFIGHTING
AN ANALYSIS OF PROCEDURES FOR OPERATIONAL EFFECTIVENESS

EXECUTIVE ANALYSIS OF FIRE SERVICE OPERATIONS
IN
EMERGENCY MANAGEMENT

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ABSTRACT

The problem, despite the vast improvement with fire prevention efforts, is that catastrophic fires continue to occur in high-rise occupancies resulting in large loss of life and property; therefore the Oakland Fire Department needs to be prepared. The purpose of this research is to analyze procedures for effective high-rise firefighting operations to serve as a model for the Oakland Fire Department. The goal is to reduce fatalities and property loss through effective operations. This was an evaluative research project. The research questions were:

1. What are the effective tactics and strategy for combating a high-rise fire?
2. How should the Incident Command System be employed?
3. What considerations should be made for the building components?
4. What current Oakland Fire Department high-rise procedures need to be amended?

The procedures primarily involved considerable literature review as well as feedback from other large municipal jurisdictions.

The results clearly indicated a need to change the Oakland Fire Department’s current high-rise procedures in order to be better prepared to respond effectively, efficiently, and safely to incidents of this nature. Training was identified as a key component to the success of the implementation of new high-rise procedures. Recommendations, based on this study, were for the drafting and implementation of new high-rise procedures, creating a high-rise training manual and establishing procedure for standpipe and sprinkler operations. Additionally, equipment needs were identified and recommended to facilitate the new Oakland Fire Department high-rise procedures.
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INTRODUCTION

The problem, despite the vast improvement with fire prevention efforts, is that catastrophic fires continue to occur in high-rise occupancies resulting in large loss of life and property; therefore, the Oakland Fire Department needs to be prepared. The purpose of this study is to analyze procedures for effective high-rise firefighting operations to serve as a model for the Oakland Fire Department. The goal is to reduce fatalities and property loss through effective operations. This is an evaluative research project. The research questions are:

1. What are effective tactics and strategy for combating a high-rise fire?
2. How should the Incident Command System be employed?
3. What considerations should be made for the building components?
4. What current Oakland Fire Department high-rise procedures need to be amended?

BACKGROUND AND SIGNIFICANCE

One of the most difficult and challenging incidents that can be experienced by a municipal fire department is a fire in a high-rise building. These incidents can easily overwhelm a fire department and cause significant death and destruction. “The best-kept secret in America’s fire service is that firefighters cannot extinguish a fire in a 20 or 30-thousand-square-foot open floor area in a high-rise building” (Dunn, 1995, p. 22) Historically, there have been many tragic high-rise incidents resulting in large loss of life and or property that have had a tremendous impact on communities and the fire service. Internationally, there are two specific fires that stand out. Coincidentally, both fires occurred in Sao Paulo, Brazil.

The first occurred on February 24, 1972 in a 31 story office building.
Fire spread from the fourth floor and burned completely to the roof.

Miraculously only sixteen people were killed. The second high-rise fire occurred on February 4, 1974. This fire started on the twelfth floor and rapidly extended to the roof on the twenty-fifth floor, resulting in 179 fatalities (Kramer & Bahme, 1992, pg 203).

An incredible photo of the first fire shows nearly every floor of the structure fully burning, clearly indicating that the local fire department was confronted with overwhelming challenges.

There have been numerous catastrophic high-rise fires on a national level. “Eighty-seven people died as a result of the MGM Grand Hotel Fire that occurred November 21, 1980 in Las Vegas. This was the second largest life-loss hotel fire in United States History” (1981, p.1).

The sheer number of personnel needed to successfully respond to incidents of this nature and the potential enormity of a major high-rise fire can have a tremendous impact on firefighter safety. “On June 24, 1980 a fire in a 42-story Manhattan, New York, skyscraper raged out of control for more than two hours, injuring 127 firefighters…” (Kramer & Bahme, 1992, p. 204). “On May 4, 1988 a fire occurred at the 22 story First Interstate Building in Los Angeles. This fire burned from the twelfth through the sixteenth floor and was stopped by the heroic dedication and tactical decision making of the Los Angeles Fire Department. This fire required over 400 firefighters to control.”(Kramer & Bahme, p. 201) “Fourteen firefighters were injured in the fire which caused an estimated 450 million dollars in damage” (Bush & Routley, 1996, p. 7). High-rise fires can result in firefighter fatalities. On February 23, 1991, the One Meridian Plaza building in Philadelphia burned nine floors resulting in three firefighter fatalities and twenty four injuries (Eisner & Manning, 1991, p. 51). On April 11, 1994 two firefighters died while fighting a high-rise fire in Memphis Tennessee……(Schaitberger, 2001) Three New York firefighters
were killed in December 1998 while battling a fire on the tenth floor of a ten story residential high-rise. The World Trade Center terrorist attack and subsequent fires on September 11, 2001 was likely the single most disastrous event to face this country. Thousands of people died including over 300 firefighters. Countless more were injured. The magnitude of this catastrophic incident has tremendously impacted our society.

Despite the best intentions of fire prevention programs, high-rise fires will continue to occur. Many high-rise buildings were constructed prior to more stringent codes; therefore, many high-rises are not protected by automatic sprinklers. “Six people died due to a fire in a 35 story building in Chicago on October 17, 2003. This building had an alarm system but not sprinklers” (AP [AP], 2003). “The First Interstate Bank building in Los Angeles was being retrofitted for sprinklers prior to the fire in 1988. A sprinkler system was being installed throughout the rest of the building and was 90 percent complete at the time of the fire but not in service” (Eisner, 1988).

The One Meridian Plaza Fire provided the fire community and the world with another dramatic testimony to the value of automatic sprinklers. Without sprinklers, nine floors were completely destroyed. With sprinklers on the 30th floor, a free burning, out-of-control fire was extinguished – with nine sprinkler heads. (Eisner & Manning, 1991, p.66)

High-rise fires are a specific concern for the Oakland Fire Department. The City of Oakland, Ca is an older municipality with over 100 high-rises. There has never been a major disaster in a high-rise building within the city of Oakland; however, there is tremendous potential
since there are many that do not have automatic sprinklers. Additionally, there is a twin tower high-rise federal building and a new state high-rise office building in downtown Oakland, which could be the target of a terrorist attack. There have been high-rise fires in Oakland; however, they have been relatively small or compartmentalized and have been extinguished by automatic sprinklers or aggressive firefighting tactics. In 2000, a fire occurred on the tenth floor of a high-rise building under renovation. Fire crews were required to extend supply lines to the tenth floor since the standpipe system was disabled, which severely delayed extinguishment. In 2001, there was a fire on the seventh floor of a ten story senior citizens residential facility resulting in the death of an occupant. This building, although “fireproof” did not have sprinklers. Historical high-rise fires elsewhere should have an impact on the fire service, including the Oakland Fire Department. Fire departments should capitalize on lessons learned from previous incidents. “Critiquing our own operations as well as those of other departments and jurisdictions will help us to be better prepared to meet the ever-increasing challenges” (Tracy, 1998, p. 108). The current high-rise procedures drafted in March of 1998 addresses basic position functions in accordance with the Incident Command System (ICS); however, there is minimal information on basic tactics and strategy, building components, or the use of standpipe systems. To avoid the calamity of a major disaster and provide the highest level service possible, it is imperative that the Oakland Fire Department evaluates options to the current high-rise procedures.

The City of Oakland Fire Department normally employees approximately 500 uniformed personnel that provide fire protection and emergency services to a population of approximately 380,000 residents. 131 personnel staff each of the twenty-four fire stations during a twenty-four hour shift. Budgetary woes have resulted in a temporary reduction of personnel each shift, which can detrimentally affect operations. A high-rise fire of any significance will rapidly deplete
available Oakland resources requiring the need of mutual aid assistance from neighboring jurisdictions. Lastly, approximately 300 personnel have less than ten years experience, most of which have never experienced a high-rise fire or have had any formal high-rise training. This reinforces how important it is for the Oakland Fire Department to review and amend the current high-rise procedures and ensure that personnel are appropriately trained.

This research is influenced by lessons learned in all facets of the National Fire Academy’s “Executive Analysis of Fire Service Operations in Emergency Management” course, but most significantly in the “Emergency Operations” section. The ultimate goal is to provide the community with the highest quality service possible. This research is directly related to the United States Fire Administration’s mission and goals to reduce firefighter deaths. Additionally, a proactive approach may ultimately result in reduced civilian casualties and significantly reduced property loss.

**LITERATURE REVIEW**

The purpose of this literature review is to analyze procedures for effective high-rise firefighting operations to serve as a model for the Oakland Fire Department. There are four questions that need to be addressed. First, what are effective tactics and strategy for combating a high-rise fire? Second, how should the Incident Command System be employed? Third, what considerations should be made for the building components? Finally, what current Oakland Fire Department high-rise procedures need to be amended?

**Tactics and Strategy.**

“Strategic and tactical considerations for fighting high-rise office building fires must be proactive” (Federal Emergency Management Agency [FEMA], 2000, SM 4-3). “The strategy used to control a high-rise fire depends to a large extent on the building and the effects that its
features have on the travel of smoke and fire” (Norman, 1998, p. 361). According to Vincent Dunn, the only strategy for a high-rise fire beyond the reach of an aerial ladder is an interior attack….If this method fails, there is no alternate plan. An outside attack is not an option (Dunn, 1995, p. 22).

When confronted with a high-rise structure, we find the building itself is an antagonist to our operations. Much of the building is above the reach of ladders, which eliminates their use for rescue, ventilation, and outside water streams should a fire be of the magnitude to warrant their use….construction features in a high-rise limit our strategy and tactics (Tracy, 1998, p. 65).

Clearly, the most effective method to combat a fire in a high-rise is through an aggressive interior attack, especially if the fire is above the 100 foot reach of an aerial ladder. Tactics and strategy at an incident begin at the first arrival of emergency units. Emergency apparatus placement is critical to effective operations. “Pumpers should be located at a positive water source in close proximity to the hotel’s fire department connection……Ladders should be in a position to ladder the building when possible and when needed” (Tracy, 1998, p. 70). “Ladder companies often were placed in a position to rescue victims from windows, only to be thwarted by inadequate reach” (Cannell, Reall & Bernzweig, 2001, p.60). “Fallen glass is a major threat to safety at a high-rise incident. Safety zones must be established, maintained, and readjusted as necessary” (Eisner & Manning, 1991, p. 70) The next concern is gaining access to the building. For access below grade, according to Tracy, “elevators are not an option…..use the stairs for safety reasons…the stairs used should be closest to the alarm site and that contain a water supply, a standpipe outlet” (Tracy, 1998, p 72-73)
For access above grade, Tracy states “should the fire be on a lower floor….within the first seven floors, consider using the stairs……If the fire is above the seventh floor recall the elevators to the lobby and use the firemen service (FS) feature if it is available. Choose the bank of elevators that will provide the greatest safety, not speed. Do not use an elevator in a bank that services the fire floor if a lower bank of elevators reaches within five floors of the fire floor. When it is necessary to use an elevator in a bank that services the fire floor….use a car with the FS [fireman’s service]feature….select a floor at least two floors below the fire. (Tracy, 1998, p. 73)

Reflex time should be considered. “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 (Bush & Routley, 1996, p. 6)

Strategy and tactics at a high-rise fire will be dictated by the results of the size-up. “On arrival, your size-up is as important as it is any other response. Determine the following: Where is the fire located? What is burning? What is exposed? What is the immediate life hazard? Are fire service members in danger?” (Tracy, 1997, p. 49)

Information is the key to successful firefighting…..An officer in command must get the following information as quickly as possible to effectively command and control the fire: What floor is the fire on? What is the size of the fire? Is an attack hose line discharging water on the fire? What stairway is being
used for attack? What is the status of the building systems? Are the key fire ground sectors in operation? Are there open stairways?

(Dunn, 2003, pgs 1-7)

Occupant safety in a high-rise is paramount; therefore, consideration should be given to search, rescue, and evacuation. “If at all possible, at high-rise incidents an evacuation stairway should be designated and its integrity maintained. This stairway should provide egress for firefighters trapped on upper floors and access for search, rescue, and logistical operations” (Eisner & Manning, 1991, p. 70). The type of evacuation is a factor that should be considered. “The most common theories on egress have held that high-rise situations call for two basic types of evacuation: self evacuation of the building and controlled evacuation. Self-evacuation, which takes on a life of it’s on, is essentially a haphazard process” (Blossom, 2002, p. 78). Defending in place is another option.

Firefighters cannot order everyone within a high-rise to leave during a fire. It isn’t possible for thousands of people to leave such a structure quickly. Thus, the strategy used is one of defending in place – extinguishing the fire while most of the occupants remain inside. Such a strategy depends on two factors: that the building has the ability to confine the fire to a particular area, and that the occupants will obey the chief’s instructions to stay in place (Dunn, 1999, p. 150).

Searching for trapped occupants is another critical tactical concern. Vincent Dunn (1996) identifies the following key factors for searching a high-rise building:
1. There are two methods of searching for life at a high-rise fire: One is carried out when the fire is small and confined to a room and the floor is clear of fire and heat, just a light smoke condition exists – in other words the floor is accessible. The other method of searching for life in a high-rise fire is used when the floor is inaccessible – when heat and smoke have spread throughout the entire floor and meet firefighters at the stair doorway leading to the burning floor.

2. At a high-rise fire, firefighters search every office cubicle and space on the floor and all floors above are checked for smoke. Additional firefighters will be required. The fire extinguishment may take only 20 minutes and the search an hour or two, depending on how much smoke was generated and how many people were in the building.

3. When firefighters are searching for the fire’s location, they are also conducting the primary search (the first search of a fire area) for trapped victims. The primary search is a quick, systematic search of areas in which there is the highest chance of finding a victim.

4. After the fire has been extinguished, the secondary search of the entire fire building and surrounding area for victims – can begin.

5. A secondary search in a high-rise must be organized and controlled. The most important part of organizing a secondary search is obtaining information from building employees (Dunn, 1996, pp. 22-24).

Once a fire has been located it is imperative that the appropriate hose and nozzles are used to facilitate extinguishment. Hose streams are a significant tactical consideration for high-rise firefighting applications. “NFPA 14 was written reflecting the use of 2 ½ inch hose and solid bore nozzles. When departments decide to use 1 ½, 1 ¾, or 2 inch hose they violate the design of the standpipe system”(Norman, 1998, p. 134) A standpipe outlet with reduced pressure can
detrimentally affect fire flow: therefore larger diameter hose and low pressure nozzles should be used.

It is very important that fire departments choose an appropriate nozzle type for their standpipe firefighting operations….. the 2 ½ inch smooth bore nozzle with a 1 18 inch tip produces a usable stream (250 gpm) at 50 psi inlet pressure requiring 50 psi at the valve outlet with 100 feet of 2 ½ inch hose or 73 psi at the outlet with 150 feet of hose(NFPA 14, 2000, A5-7).

When the correct hose and nozzle configuration has been provided the next facet is the actual fire attack.

There are five attack strategies that can be used at a high-rise fire: a frontal attack, a flanking attack, a defensive attack, a non attack, and an outside attack. A direct, head-on frontal attack is the most common and most successful strategy used at a high-rise fire. Firefighters drag a hose line straight into the path of the flames. They come face to face with the fire and extinguish it. Ninety-five percent of fires are extinguished with this strategy(Dunn, 1999, p. 159).

When operating in the stairwell of a high-rise building, there are many factors to consider. Peeples (2001) provides the following tactical tips which can improve operations and provide for firefighter safety:

1. Enclosed stairwells are frequently locked to prevent reentry onto the floor. It is imperative that the ladder team arrive quickly to ensure that the engine can gain
access to the fire floor. Once entry has been gained, use a door strap, if necessary, to prevent relocking.

2. Designate stairways as “attack,” “evacuation,” or “ventilation” early in the firefight.

3. Don’t descend an unenclosed stairwell into a basement without a charged hose line if there is any indication of a fire. If the fire takes off, it will head for the stairs, cutting off your exit.

4. Just because the standpipe is located in a particular stairwell does not necessarily mean that that stairwell should be designated as the attack stair. It may be much easier to connect to the standpipe, stretch the line to another stairwell, and use this stair to attack the fire, depending on the fire’s location and wind conditions.

5. Never attempt to stretch more than two lines up the same stairwell. Failure to adhere to this rule will result in a knot of hose that will not allow anyone to advance the line. Use a rope stretch, a fire escape, or another stairway instead.

(Peeples, 2001, p. 86)

Ventilation is a critical tactical objective that can aid search, rescue, and extinguishing operations.

Ventilation is an important and difficult task that must be established at a high-rise incident. It is critical that this operation is coordinated with attack, search, and evacuation activities. Communication to the Incident Commander is key. The three basic ventilation tactics include horizontal through the windows, vertical through the stairwells, and utilization
of the buildings [heating, ventilating, and air conditioning] HVAC system. Horizontal ventilation in a commercial high-rise while the fire is active should not be used. (p. 7)

When fighting high-rise fires it is critical to search for extension of the fire. Dunn (1996) recommends the following safety precautions:

1. Size-up the fire you are going above. Are fire forces capable of extinguishment?
2. Use a stair clear of smoke and fire that is not being used by the attack line.
3. Assign a firefighter to warn of a fire increase that may cut off your escape route.
4. Notify the incident commander when you go above the fire and when you safely return.
5. You may need forcible entry tools to gain access.
6. Use a search rope – for quick exit if smoke suddenly increases and visibility is reduced or to quickly stretch a hose line to an area where flame is spreading.

Use lights, masks, and portable radios (Dunn, 1996, p. 28).

Lastly, the use of helicopters should be a tactical consideration.

Incident commanders at high-rise incidents should consider early on in the incident how helicopters could be used to advantage, if necessary, and should contact appropriate agencies in advance to place available helicopter units on standby. Preplans should indicate which buildings in the jurisdiction are suitable for helicopter roof operations. (Eisner & Manning, 1991, p. 70)

Incident Command System (ICS)

The use of ICS significantly impacts how effectively an incident can be managed; therefore, it
should be implemented by first arriving officers.

It will be the responsibility of the IC [Incident Commander] to develop an organizational structure using SOG’s [standard operating guidelines]. This structure should be developed as soon as possible after arrival and implementation of initial tactical control measures. The size and complexity of the organizational structure obviously will be determined by the scope of the emergency and availability of the resources. (FEMA, 2000, p. 11)

The IC must be involved with directing available resources to accomplish incident goals through operational and command responsibilities. To ensure proper incident management by coordination of overall operations of command, tactical operations, and support functions, a responsive organization must be developed (FEMA, 1989, SM 1-4).

The California Office of Emergency Services (OES) 1999 report on ICS for high-rise fires details the following:

1. The five major functional areas of the ICS; Command, Operations, Planning, Logistics, and Finance do not change in the high rise incident. All positions in the ICS organization applicable to a structure fire apply to the high rise fire incident.

2. Two ICS incident facilities (Base and Staging) have modified functions and locations in the high rise incident that reflect a fire location many floors above the ground and the complexity of the incident. Staging is generally located two or
three floors below the lowest fire floor as long as the atmosphere can stay clear. The Staging Area Manager reports to the Operations Chief. Base should be located away from buildings to provide personnel safety from falling glass and debris.

3. In recognition of the extreme hazards of this type of fire control operation and the difficulties in assuring firefighter accountability in interior operations, as well as the egress and ingress of building occupants, the Lobby Control Unit is established.

4. In recognition of the basic and specialized systems incorporated into all high rise buildings, from electrical supply systems to smoke removal systems, the Systems Control Unit is established to operate, supervise, and coordinate the vital operation of the building systems.

5. The ground support leader is responsible for providing transportation for personnel, equipment, and supplies, providing refilling of SCBA air cylinders and maintenance of SCBA; providing fueling, service and maintenance of vehicles and portable power equipment and tools.

6. The Medical Unit Leader is primarily responsible for the development of the Medical Emergency Plan, for providing medical aid and transportation for injured and ill incident personnel, for providing for rehabilitation services for incident personnel, and for preparation of reports and records.

7. The Incident Safety Officer is a member of the Command Staff and reports directly to the Incident Commander. The Safety Officer is responsible for
monitoring and assessing hazardous and unsafe situations and developing measures for assuring personnel safety. (OES-FIRESCOPE-OCC, 1999, pp. 1-17)

“The incident scene should be subdivided in a manner that makes sense. This should be accomplished by assigning divisions to geographic locations (e.g., Roof Division, Division “A”) and assigning functional responsibilities to groups (e.g., Ventilation Group, Salvage Group) (FEMA, 2000, p. 21).

Also, “When the numbers of divisions and groups exceed the recommended span of control for the Operations Sections Chief, the IC or Operations Section Chief should designate a multi-branch structure, and allocate the divisions and groups within those branches” (FEMA, 2000, p. 24).

Lastly, the IC should ensure personnel accountability and the establishment of the Rapid Intervention Team (RIT). “An incident commander should have a RIT standing by during any fire to rescue a trapped, injured, or missing firefighter” (Dunn, 1999, p 257)

Building Components

“Electrical Systems in high-rise buildings can be extremely complex and hazardous under fire conditions….Have a utility company or the building engineer do the shutdown in electrical vaults” (FEMA, 2000, p. SM 3-3).

The use of elevators is a highly critical function that could compromise firefighter safety and affect operations.

Firefighters battling a fire in a high-rise building depend on the building systems for success in extinguishment. The elevator must take them, tools, and equipment up to the fire…..In New York City, an eight year study of 179 major fires revealed
elevators failed at 59 fires- at one third of the major fires. Fire, heat, or water caused electrical malfunctions in elevators. At some fires, elevators took firefighters up to the fire floor instead of the floor two or more levels below the fire. At other fires, the elevators stalled, trapping firefighters inside stuck cars (Dunn, , p. 3)

For elevator use Norman recommends, “Where smoke is reported on several floors, get off two floors below the lowest reported floor. Ensure that each team that enters an elevator has the car number, unit, and destination recorded by a firefighter at the lobby. Ensure that each team is properly equipped”(Norman, 1998, p. 370)

Heating, ventilating, and air conditioning systems can pose a significant problem for occupant safety and firefighting operations. “Any system that has not been shut down automatically, should be manually shut down. This should include both supply and return fans”(FEMA, 2000, SM 5-11)

“Alarm Panels and surveillance cameras must be operational if they are to provide vital information. The public address system must work properly if occupants are to be issued instructions. If any of these systems fail or aren’t present, firefighting operations will be thwarted, perhaps abrogated altogether” (Dunn, 1999, p 147)

Communications within a structure is another extremely critical function for effective fire ground operations. “It is a known fact that portable fire department communications equipment can be ineffective or even completely unusable in a high-rise. A built-in emergency communications system can be used as a primary communications channel if portable equipment is not functioning properly”(FEMA, 2000, SM 3-17)
Oakland Fire Department Procedures

According to the Oakland Fire Department High-Rise procedures, “They are designed to provide a systematic and organized process to mitigate fires and other emergencies, increase personnel and accountability, and establish common standards with outside agencies at high-rise incidents” (Oakland Fire Department, 1998, p. 1)

Furthermore, “These procedures give the order of assignment in an outline form. The outline is followed by Position Description Sheets, which describe the duties, location, and radio designation of each position. Also included is an ICS flow chart” (Oakland Fire Department, 1998, p. 3)

In summary, the literature review was central to this research. It provided comprehensive information regarding all aspects of high-rise firefighting including tactics and strategy, use of the incident command system, building components, and allowed for the comparison with the current Oakland Fire Department high-rise procedures.

PROCEDURES

The research procedure used primarily to prepare this paper was a thorough literature review, which included a search of multiple trade journals, the internet, textbooks, and the Oakland Fire Department Operations Manual. The research process was completed by the author between September and December 2003. This paper explored what the most effective tactics and strategy are for mitigating a high-rise fire, how the Incident Command System should be employed, what considerations should be made for the building components in a high-rise, and how this relates to the current Oakland Fire Department procedures. Most importantly, the research focused on what Oakland Fire Department procedures need to be amended and evolved
into determining what changes need to be made within the Oakland Fire Department to improve high-rise firefighting operations.

Feedback Form.

A feedback form (Appendix A) was developed to determine what the industry standard is for high-rise firefighting hose lines, specifically those used by large active municipal fire departments. This was primarily to determine which hose and nozzle configuration will provide the best fire flow. This is a huge factor which impacts tactics and strategy at a high-rise structure fire. Additional feedback was requested regarding their standard attack hose as that may be used, especially in the lower levels of a high-rise occupancy.

Population

Ten large municipal fire departments responded to the feedback study indicating their hose and nozzle configurations. The specific departments were chosen based on a variety of factors including: geographical (these are large municipalities diffused throughout different areas of the United States), the number of high-rises, extensive response activity level, and previous experience fighting significant fires in high-rise occupancies.

Limitations and Assumptions

First, there is a tremendous amount of information regarding the various aspects of high-rise firefighting; therefore, some details were omitted. For example, a person could write a book regarding HVAC or standpipe systems, but that is unnecessary since the research addresses the four questions adequately to indicate that there are a number of changes that the Oakland Fire Department must make to be prepared for a high-rise fire. Secondly, it is assumed that the responses to the feedback forms were accurate. Lastly, the potential limitation of the results of this research is resistance to the recommended changes in a fairly traditional fire department.
This evaluative research suggests that changes need to be made to current operational procedures and training practices, which may not be well received by line personnel.

**Definition of Terms**

- **Branch** – An organizational level between Divisions/Groups and the IC or Operations.
- **Divisions** – An organizational level responsible for operations is a specific geographical area.
- **Groups** – An organizational level responsible for a specific function. For instance, fire attack, search, rescue, or ventilation group.
- **High-rise** – A structure that has a height of 75 feet or more above the ground.
- **Incident Commander (IC)** – Has the responsibility for overall management of an incident.
- **Flow** – The amount of water measured in gallons per minute (gpm) delivered through a hose or nozzle.
- **PSI** – Pounds per square inch. This is the force of water. For firefighting applications it typically refers to pump pressure or nozzle pressure.
- **Reflex time** – The amount of time it takes to react and take action.
- **Size-Up** – A mental evaluation of a situation. This is also known as a report on conditions.
- **Strategy** – The plan of action i.e. confining fire to the floor of origin.
- **Tactics** – Actual hands on operations that must be performed i.e. search, rescue, evacuation, protecting exposures, fire attack, ventilation, salvage, and overhaul.

**RESULTS**

The results of the literature review and the feedback form provided the following answers:
Research Question 1:

There are a number of factors associated with effective tactics and strategy for combating a high-rise fire. First, poor vehicle placement can detrimentally affect fire operations and compromise firefighter safety; therefore, apparatus should ideally be parked in a safe effective position. First arriving units must make a good size-up and initiate the appropriate tactics. The Incident Commander should consider the appropriate strategy to mitigate the incident and then direct units to perform the necessary tactics. “….The IC determines the broad strategic goals for the incident and then transforms these goals into obtainable, practical objectives” (FEMA, 1989, p. SM 2-4) Safely accessing a building should be considered. The elevators should only be used if deemed safe and beyond practical reach by walking the stairs.

Feedback from ten large, busy municipal fire departments indicated that a majority use 2 ½ inch hose with 1 1/8 inch smooth bore nozzles. Some also use 1 ¾ inch hose with 7/8 inch smooth bore nozzles. (Appendix B) This configuration appears to be the industry standard. The type of attack for a high-rise structure fire should be considered. Most frequently that would be a direct attack. “The attack strategy used at almost every fire in high-rise structures is the direct frontal assault” (Tracy, 1998, p. 104) An attack stairwell should be designated. Evacuation may be required; therefore an evacuation stairwell should be designated. Fire crews should facilitate this process. Search and rescue may be required at a high-rise incident. This should be a well coordinated effort using search rope, proper ventilation techniques, and floor plans if available. “Floor plans are very important. You may have to consult them from the onset of an operation if a maze-like area is involved” (Tracy, p. 98) Ventilation must be performed to aid in search and rescue, and fire extinguishment. This comprises of pressurizing stairwells, opening up roof access doors, possibly opening or breaking windows, and using the ventilation system when the
fire is confirmed to be extinguished. “Once the fire is extinguished, the IC decides whether to ventilate smoke from the fire area of operations” (Tracy, p. 104) Throughout the incident a Rapid Intervention Crew should be in place prepared to assist personnel in distress. Lastly, all possible voids, utility closets, pipe chases and any other means of communicating fire should be systematically checked to determine whether there has been any fire extension.

There are specific areas to which fire has spread upward at previous high-rise fires. Fire officers must know these locations and quickly examine them for fire spread. If firefighters discover fire spread, they must quickly notify the officer in command so a hose line can be stretched to extinguish the fire. (Dunn, 1996, p. 26)

Research Question 2

The Incident Command system should be established at the initial stages of the incident. The IC should determine the need for additional resources based on the size-up and then assign the command positions predicated on the needs of the incident. Position description sheets provide basic guidelines for personnel. All personnel should be aware of what role they assume in the system. Since a high-rise fire will likely involve other agencies, a unified command post should be established. “Under the unified command concept, all involved agencies contribute to the command process. Overall goals, planning, tactical objectives, conducting integrated tactical operations, and maximizing the use of all available resources are decided jointly” (FEMA, 1989, p. SM 1-7). The IC has overall responsibility for developing an incident action plan and managing tactics and strategy, and ensuring personnel accountability.

Research Question 3

Building components such as the elevators, HVAC, electrical system, fire control rooms,
communications systems, windows, sprinklers, and standpipe systems should be utilized to facilitate mitigation of a high-rise incident. Failure of these building components or systems could significantly impact an incident and detrimentally affect firefighter safety. “The failure of one component often leads to the failure of other components, generally because failure allows the fire to grow so large that it impinges on other components, or overpowers the ability of other components to function properly” (Bush & Routley, 1996, p. 19)

Elevators must be recalled to the lobby utilizing the fireman’s service control key. “This feature overrides all elevator controls except those in the car and give the firefighter control over an elevator” (Bush & Routley, 1996, p. 28). Care should be taken to ensure that the elevators are safe. “Elevator failures have hampered operations in many high-rise fires” (Bush & Routley, 1996, p. 19). Smoke in the elevator shaft warrants a trip up the stairwell. Consider the potential for occupants trapped within elevators. Personnel should use the stairs if the fire is below seven floors.

HVAC systems must be shut down in the event of a high-rise fire. Preferably this can be accomplished with assistance from the building engineer. When extinguishment has been completed the HVAC system can be used to vent smoke from the building. Failure to shut the system down could result in actual fire propagation to other levels and an untenable smoke condition, which could compromise the safety of the building occupants and fire personnel.

The electrical system could also cease to function as a result of the fire. “Electrical system failure can be catastrophic since many components of a high-rise fire protection system are powered by electricity” (Bush & Routley, 1996, p.19). If back-up power does not work then other systems such as the elevators and the fire pumps could fail. Failure of the fire pumps could result in drastically reduced pressures in standpipes, especially on upper floors.
Fire alarm systems should be monitored by fire personnel to determine the location and type of alarms that are indicated. These systems are often in fire control rooms that also have control panels for elevators, HVAC, and communications systems.

It is not uncommon for portable radios to provide sub par performance while operating in a high-rise. “High-rise building construction may shield radio waves and hamper communications between exterior and interior personnel. High-rise SOP’s should develop communications contingency plans” (Bush & Routley, 1996, p. 33) Internal building communications should be utilized by fire crews, especially in the event of portable radio failure.

Windows should not be opened on the fire floor until hose lines are in place. “If windows were to fail or be broken, the area around the firefighters may ignite” (Tracy, 1998, p. 102) There is enormous concern for the effects of wind, which has been directly attributed to firefighter fatalities. “If a window in the fire apartment fails, the increase of air flow will be more than five times the normal air infiltration for the entire floor” (White, 2000, p. 90) When forcing windows permission should be obtained from below to ensure that no one is struck by fallen glass.

Sprinklers extinguish a majority of all fires that occur in buildings with automatic sprinklers. “Based on a review of statistical data, this Digest shows the reliability of such systems in place to be in excess of 96 %”(Richardson, 1985, p. 1). It is imperative that fire crews augment a sprinkler system in the event of a high-rise fire. This is completed by connecting and pumping a minimum of two hose lines into the sprinkler inlets typically positioned on the exterior of the building. “Supply the system early, before residual pressures in the mains start to drop; supply the system with multiple lines of the largest size hose possible , using two lines of 2½ inch hose as a minimum” (Norman, 1998, p. 117)
Lastly, a high-rise building's standpipe system absolutely must be augmented by fire apparatus, especially if a building has fire pumps and they fail to operate. “The standpipe system must be provided with some means to overcome head pressure in order to deliver water at an effective firefighting pressure to the upper floors” (Fornell, 1991, p. 71). This should be completed using the same method for augmenting a sprinkler system. In fact, sometimes sprinkler and standpipe systems are cross-connected, which allows for only pumping into one system. Potential problems should be anticipated with these systems. Vandalism can render a system inoperable or at least compromise firefighting operations. Pressure relief valves can malfunction or may be set to inadequate discharge pressures. Sediment in a line can severely clog standpipes and render them significantly less efficient. “Debris, rust, scale, and sediment within the standpipe system are just more facts of life for those departments with high-rise and standpipe equipped buildings” (McGrail & Tracy, 2000, p. 106). For fire on upper floors of a high-rise the use of the standpipe system is key to an aggressive interior attack. It is essentially the only way to put a fire that is out of reach of the aerial ladders.

**Research Question 4**

After very carefully analyzing the Oakland Fire Department procedures contained within the Operations Manual, it indicates what role each responder is to perform, but not specifically how to do it. For instance, there is nothing written in the procedures regarding when fire crews should or should not take the elevator. There is nothing in the current procedures suggesting what floor to connect the hose lines to or what size hose or nozzles are required. “For high-rise standpipe operations, we recommend that fire departments hook up to a hose outlet on the floor below the fire floor” (McGrail & Tracy, 2000, p. 104). Although, the Oakland Fire Department dispatches an engine company to serve as the RIT, there is nothing in the high-rise procedures
that indicate the need for a RIT or how and where they are to function. There is very little
information in the current procedures regarding all facets of tactics and strategy. There is very
limited information regarding building components. Due to the potential for loss of life and the
logistics required to successfully combat a high-rise fire, a third alarm should be requested at a
confirmed fire. “Departments should consider the benefits of upgrading to a third alarm on
arrival for working structure fires. Even with the best conditions and the smallest fire, the time
factor and the logistical and operational demands are great” (Eisner & Manning, 1991, p. 70) The
current procedures leave this to the discretion of the IC.

DISCUSSION

The findings of the research indicate that there is a tremendous quantity of information
that personnel must know to successfully mitigate a fire in a high-rise structure. Effective tactics
and strategy are paramount to a successful operation. “Strategic and tactical considerations for
high-rise office building fires must be proactive” (FEMA, 2000, p SM 4-3). There are so many
factors to consider regarding tactics and strategy including vehicle positioning, accessing a
building, search and rescue, evacuation, elevators use, the size hose and type of nozzles used, the
type of fire attack, ventilation, salvage, and overhaul. All these tactics and strategy must be
employed with careful consideration for the building components. “To deal with this problem,
fire officers must implement new strategies based on the buildings construction and
facilities”(Norman, 1998, p. 359). Very little of this information is included in the current high-rise procedures. Failure to be aware of this critical information can detrimentally affect fire
operations and compromise occupant and firefighter safety.

The findings of the research show that the Oakland Fire Department procedures
adequately address the Incident Command System primarily through the use of the Position
Description Sheets. Most every position is considered; thereby, providing a model framework for the ICS. “The five major functional areas of the ICS; Command, Operations, Planning, Logistics, and finance do not change in the high-rise incident” (OES-FIRESCOPE-OCC, 1999, p. 8) The exception is that there is no mention of a Branch Director in the procedures. A large scale incident can easily require the use of branch directors to assist with the management of an incident. “At large scale or complex incidents the number of Divisions and/or groups may create a significant span of control problem. When this occurs, consideration should be given to the implementation of Branches” (FEMA, 1989, p SM 2-14).

The findings of this research regarding building components are that there is a variety of systems that have an enormous impact on a high-rise fire. Knowledge of the idiosyncrasies of these systems is critical for successful operations. “Firefighters battling the flames in a high-rise depend on building systems to serve them in achieving a successful outcome” (Dunn, 1999, p. 147) The Position Description Sheets in the Oakland Fire Department High-Rise Procedures states what a person must do. For Instance,

The purpose of the Systems Officer is to monitor, control, and maintain all of the building operating and control systems. These include, but are not limited to, the detection and alarm, the HVAC, the fire suppression water pump and distribution, electric power, natural gas, and the building communications system. (Oakland Fire Department, 1998, p. 14)

Without the assistance of a building engineer or similar representative, personnel with insufficient knowledge of the building characteristics could have problems when attempting to shut a system down. “Summon engineering personnel early. If a fire involves equipment for
which they are responsible, their technical assistance can mean the difference between a minor fire or emergency and a multiple alarm with many fatalities” (Tracy, 1998, p. 98) There is no direction in the procedures on how to manage the components within a high-rise structure. The implications are that the Oakland Fire Department will have to include information regarding building components in the new procedures.

The findings of this research clearly indicate that the Oakland Fire Department procedures must be amended. The position descriptions contained in the current procedures adequately address each specific role and incorporate the ICS, but they generally do not tell how to perform tactical or strategic tasks or the impact of building components in a high-rise fire. The position descriptions would be more appropriate as a check-list in the Emergency Procedures Manual. This is a manual that is maintained on every apparatus, which provides a check-list of responsibilities at a variety of potential incidents based on the hazards associated with the city of Oakland.

The organizational implication of the study is that the Oakland Fire Department must amend the current high-rise procedures. Furthermore, due to the extensiveness and complexity of high-rise fires, a comprehensive training manual must be created. Research revealed that the Oakland Fire Department does not have procedures for standpipe operations. Additionally, personnel will have to be trained in accordance with the new manuals. “All firefighters responding to a serious high-rise fire should also be trained in the unique problems and operations that they may be likely to face…..may be the most crucial factor when preparing for a high-rise fire” (Norman, 1998, p. 377) These factors are primarily limited by time constraints, minimal staffing to perform the work, and the logistics necessary to train 500 personnel.
RECOMMENDATIONS

Based on this research, the Oakland Fire Department should make changes to the current high-rise procedures included in the Operations Manual. This may be timely as it was learned that the Operations Manual is to be replaced by a new set of standard operating guidelines (SOG’s). Due to the extent of the information associated with high-rise firefighting, a comprehensive SOG is warranted. An updated version of the Position Description Sheets should be provided to reflect the changes in the procedures. These should be included in the Oakland Fire Department’s Emergency Procedures Manual. A new high-rise training manual should be developed and used for training all uniformed personnel. The focus should be on tactics and strategy and building considerations. Additionally, the Incident Command System should be included in the training manual and integrated into the new high-rise SOG. Actual hands-on high-rise training drills for Oakland Fire Department personnel are imperative for practical application of the material contained within the new manuals. New high-rise hose packs consisting of 2 ½ inch hose and 1 1/8 inch smooth bore nozzles for commercial high-rise standpipe applications and 1 3/4 inch hose with 7/8 inch smooth bore tips for select residential high-rise standpipe applications should be implemented in the Oakland Fire Department.

Lastly, procedures for standpipe and sprinkler operations must be created. These new procedures must be incorporated into the new high-rise SOG’s and training manual, but it must also be a separate document since not all buildings that have standpipes or sprinklers are high-rises. All these factors can optimize operational efficiency, effectiveness, and firefighter safety. This will greatly facilitate making the Oakland Fire Department much better prepared for combating a fire in a high-rise occupancy.
Future readers who have an interest in high-rise firefighting and or are concerned with their jurisdictions procedures are encouraged to conduct a similar literature review. The outcome is educational and may result in positive changes within an organization. Ultimately, it may help to save life and property.
References


APPENDIX A

HOSE AND NOZZLE

FEEDBACK FORM

I am conducting a survey on behalf of the Oakland, Ca Fire Department to determine the ideal hose and nozzle configuration to optimize fire flow for structural firefighting. Please fax your responses to Battalion Chief James Edwards at 510-238-5225 or you can contact me t 510-238-4042. Your assistance in this matter would be greatly appreciated.

1. What size hose does your department use for standpipe operations? ________________
2. What type and size nozzle do you use for standpipe operations? ________________
3. What size fire attack lines does your department use? _______________________
4. What type and size nozzles do you use for fire attack lines? ____________________
5. Does your department have a minimum standard fire flow? ________________
6. If yes to #5, what is the standard flow? ________________
7. Comments ________________________

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Respectfully,

BC James Edwards
## APPENDIX B

### NATIONWIDE

### HOSE AND NOZZLE SURVEY

<table>
<thead>
<tr>
<th>Department</th>
<th>High Rise Hose</th>
<th>High Rise Nozzles</th>
<th>Pre-connect Hose</th>
<th>Pre-connect Nozzles</th>
<th>Standard GPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>New York Fire</td>
<td>2 1/2</td>
<td>1 1/8</td>
<td>1 3/4</td>
<td>Low pressure fog</td>
<td>180</td>
</tr>
<tr>
<td>Los Angeles City</td>
<td>2</td>
<td>1 1/4</td>
<td>1 3/4</td>
<td>100 PSI fog</td>
<td>Not specified</td>
</tr>
<tr>
<td>Chicago Fire</td>
<td>2 1/2</td>
<td>1 1/4</td>
<td>1 3/4</td>
<td>Low pressure fog</td>
<td>Not specified</td>
</tr>
<tr>
<td>Denver Fire</td>
<td>2 1/2</td>
<td>1 1/8</td>
<td>1 3/4</td>
<td>7/8 low pressure fog</td>
<td>150</td>
</tr>
<tr>
<td>Boston Fire</td>
<td>2 1/2</td>
<td>1 1/8</td>
<td>1 3/4</td>
<td>Low pressure fog</td>
<td>Not Specified</td>
</tr>
<tr>
<td>San Jose Fire</td>
<td>2 1/2</td>
<td>1 1/8</td>
<td>1 3/4</td>
<td>Low pressure fog</td>
<td>Not Specified</td>
</tr>
<tr>
<td>Philadelphia Fire</td>
<td>2 1/2</td>
<td>1 1/8</td>
<td>1 3/4</td>
<td>Low pressure fog</td>
<td>Not Specified</td>
</tr>
<tr>
<td>Miami Fire</td>
<td>2 1/2</td>
<td>1 1/8</td>
<td>1 3/4</td>
<td>100 PSI fog</td>
<td>Not Specified</td>
</tr>
<tr>
<td>Sacramento Fire</td>
<td>2 1/2</td>
<td>1 1/4</td>
<td>1 3/4</td>
<td>7/8 low pressure fog</td>
<td>Not specified</td>
</tr>
<tr>
<td>San Francisco Fire</td>
<td>1 3/4</td>
<td>7/8</td>
<td>1 3/4</td>
<td>7/8</td>
<td>Not Specified</td>
</tr>
</tbody>
</table>

**NOTE:** THE 7/8″, 1 1/8″, AND 1 ¼″ ARE SMOOTH BORE NOZZLES