Fire Department High Pressure Pumping Operations at High-Rise Fires

Gary M. Savelle

New Orleans Fire Department, New Orleans, Louisiana

Abstract

The New Orleans Fire Department (NOFD) currently does not have a standard policy or procedure for high pressure pumping operations at high-rise fires. The purpose of this research was to assist the NOFD develop a formal policy. Descriptive research was used for this project, which included literary review, interviews, surveys and experimentation. This research identified what procedures other departments have in place, the limitations of standpipe systems in New Orleans and other cities, and the limits of NOFD equipment. Interviews with subject matter experts and field test were conducted, resulting in unexpected findings. These findings are reflected in the recommendation of upgrades with NOFD equipment and stricter building codes for standpipes in the City of New Orleans.

Table of Contents

Appendices

Fire Department Standpipe Water Supply Operations at High-Rise Building Fires

Introduction

Rarely are municipal fire departments the sole supply of water at high-rise building fires, especially at fires that occur above the 40th floor. Buildings lower than 20 stories do not present the same water supply challenges of the very tall buildings (buildings 40 stories or higher). Usually the stationary/relay fire pumps in the building will supply the water needed while the fire department supplements the system. Because of this lack of familiarity, small details can get lost in a very complicated operation.

Fire departments across the United States are not very consistent in policies or procedures that address water supply in high-rise building fires. High-Rise buildings are defined as "buildings where the floor of an occupiable story is greater than 75 ft above the lowest level of fire department vehicle access" (National Fire Protection Association [NFPA] 14, 2007, sec 3.3.5). Some fire departments go into great detail explaining high-rise water supply while other fire departments barely address the issue. Having an effective high-rise water supply procedure is essential in achieving success in the event of a high-rise fire on the upper floors of one of these buildings.

The New Orleans Fire Department (NOFD) currently has no standard policy or procedure on standpipe water supply operations at high-rise fires. In the event of stationary/relay pump failure, this variable could cause unpredictable water supply to the upper floors of a high-rise building fire jeopardizing firefighting operations and/or life safety.

The purpose of this research is to develop a comprehensive procedure for supporting standpipe systems in high-rise buildings in a manner that all members of the NOFD will be able to understand, practice, and successfully execute.

The research method utilized will be descriptive. The research approach will include interviews, surveys, and field test to answer the following questions:

1. What are the design and support requirements for standpipes in other cities?
2. What are the design and support requirements for standpipes in the City of New Orleans?
3. What methods are used by fire departments to identify and correctly support standpipe system water supplies?
4. What and how can equipment in the NOFD be used to correctly support standpipe systems?

Background and Significance

The City of New Orleans was established in 1718 but it was not until 1891 that the NOFD was formed as a fully paid professional fire department. Although the City of New Orleans is relatively old, it contains approximately 100 high-rise buildings. Most of these buildings are concentrated in the Central Business District, where 25 buildings are over 20 stories high and 5 buildings are over 40 stories high (NOFD, 2001).

The tallest building currently in the City of New Orleans is One Shell Square located at 701 Poydras standing at 697 ft (NOFD, 2001). The building was constructed in 1972 and was retroactively fitted with a sprinkler system after the passing of a state statute in 1975. This statute was passed after the November 23, 1972 fire on the 15th floor of the Rault Center, located in the Central Business District, where six civilian fatalities occurred (firemuseumnetwork. 2007).

The newest very tall high-rise building in the City of New Orleans is the First NBC Center located at 201 Saint Charles Ave in the Central Business District. This building was constructed in 1984 and stands 645 ft tall (NOFD, 2001) and is fitted with a combination sprinkler/standpipe system. Located at 1001 Howard Ave is the 531 ft Crescent City Towers. This building has been vacant since 2002 due to toxic mold and asbestos problems. It currently is sealed off and unused (Wikipedia. 2007). Currently being proposed, with a completion date of 2009, is the Trump International Hotel & Tower. This building will stand 716 ft and will be the tallest building in the City of New Orleans upon completion.

All though New Orleans has not had a significant high-rise fire since the Rault Center fire in 1972, the potential for a major high-rise fire is obvious. If a fire was to occur on the upper floors of a very tall high-rise building, and the stationary pumps failed to operate or experienced mechanical failure, it would then be the sole responsibility of the NOFD to supply water to the top of the building under the proper pressure. This could mean pumping pressures in excess of 400 psi in a building 700 ft tall (NOFD, 2003). Working with those kinds of pressures can be very dangerous and could cause great bodily harm or death if not done properly. Also, if the NOFD was unable to properly supply water to the upper floors of a high rise building fire and that building suffered enough structural damage that it had to be condemned, the economic impact to the City of New Orleans would be tremendous, not to mention the possible loss of life.

Although the One Meridian Plaza fire in Philadelphia that occurred on February 23, 1991 can be blamed on inadequate water pressure on the upper floors caused in part by improperly set reducing valves on standpipe outlets, this fire claimed the lives of three firefighters and is estimated to have caused $100 million in direct property loss and even more in business interruption. Litigation from the One Meridian Plaza fire is estimated to cost $4 billion in civil damage claims (iklimnet, n.d.). This is why it is essential to have an established high-pressure pumping operation procedure in place so the NOFD can supply water to the upper floors of very tall high-rise building in the event of stationary pump failure.

This helps fulfill the United States Fire Administration (USFA) Operational Objective to reduce the loss of life from fire of firefighters (Homeland Security, 2005 p 3). Without adequate water supply in a high-rise building fire, firefighter's lives can be place in jeopardy. The Executive Development course at the National Fire Academy (NFA) teaches Executive Fire Officer Candidates to "use research to solve real-world problems" (Homeland Security, 2006 SM p 12-4). The knowledge gained in that course was used to conduct the research to answer the above questions.

Literature Review

After reviewing NOFD Standard Operating Procedures (SOP's) and training manuals it was determined that very little was written on high-pressure pumping operations at high-rise fires. In fact, only one document produced by the NOFD (Hand Hydraulics Manual, NOFD) mentions high pressure pumping operations. It is only one page and only addresses friction loss and head pressure. The example given is of a fire on the ninth floor that would dictate an engine pressure of 207 psi to allow for 100 psi nozzle pressure (NOFD, n.d.). This would be a simple enough operation. But if the same calculations are used for a fire on the 58th floor, the pressure increases to 479 psi, crating a far more complex operation. Although the Chicago Fire Department (CFD) and the Fire Department of New York City (FDNY) recommended pump pressures fall below this figure (CFD, 2006) (FDNY, 1997), it must be remembered that these calculations are estimates only. It should also be pointed out that the NOFD calculations are based on an average of 12 ft per story (NOFD, 2003). This calculation does not take into account large shopping areas at the base of some buildings or large atriums and lobby areas. For example, the One Shell Square building in New Orleans is 697 ft tall but only has 51 stories. If the 12ft per story average is used, simple math states that the building should have 58 stories. Those missing seven stories will account for 45 psi of fire department pumping pressure.

A request was made of 16 fire departments from around the United States that have very tall high-rise buildings within their jurisdiction for their High-Rise Policies and Procedures. Of that number, 12 responded (Appendix B). After reviewing the responses, it appears about half of the departments address high-pressure pumping operations in some fashion. Some departments, such as Chicago and New York, go into great detail explaining this operation. They not only include tables for recommended pressures but also address the issue of high pressure supply hose. Although these two departments have comprehensive procedures, they do vary somewhat. This may be due to local knowledge or customs. The Atlanta Fire Department policy acknowledges that pressures of up to 500 to 600 psi may be required in very tall buildings, yet it sets a limit that no City of Atlanta Engine exceed 300 psi (Atlanta, 2005). Some departments on the other hand only have very limited information in their high-rise policy. The NOFD high-rise policy (2-02-S-04-91) for instance, instructs the first apparatus to connect to the fire department connection on the building and follow the NOFD Standpipe Standard Operating Procedure (SOP). After further searching it was determined that the NOFD has no Standpipe SOP. May it also be noted that the NOFD High-Rise Policy was issued in 1991.

NFPA 13E was developed as a recommended practice for fire department operations in properties protected by sprinkler and standpipe systems. It must be remembered that this document is only to assist fire departments in developing a basic operation and should not restrict a fire department from exceeding its minimum suggestions (NFPA 13E, 1.2.1). It should be noted that for fire department connection to automatic sprinkler systems, this document does not recommend that fire departments supply more than 150psi to the fire department connection (NFPA 13E, 4.3.4). This could cause a potential conflict with Chapter 6 when standpipe systems are addressed. This chapter refers to supplying the system with the “required pressure to give the desired working pressure on the standpipe outlet being used” (NFPA 13E, 6.3.3). According to the Chicago and New York Recommend Pressure tables, and using the One Shell Square building as an example, this could mean pressures in excess of 475 psi in the event of stationary pump failure (CFD, 2006) (FDNY, 1997). Most modern sprinkler/standpipe systems are now combination systems. This design has the Fire Department Connection (FDC), the siamese on the outside of the building, supplying both the sprinkler and standpipe. If the situation dictated that a fire department supply a combination system in excess of 475 psi this could over pressurize the sprinkler system possibly causing failure (Meara, 2007).

According to John Moore, Standpipe Plans Review Specialist/Architect, of the Louisiana State Fire Marshall’s Office, The State of Louisiana has adopted NFPA 14 Standard for the Installation of Standpipe, Private Hydrant, and Hose Systems as code for the State of Louisiana. Section 5-2 of this code set a maximum pressure limitation in standpipe systems that “at any time shall not exceed 350 psi” (NFPA 14). In an interview with the designer of the standpipe/sprinkler combination system installed in the First NBC Center, Mark Taylor, Architect for American Sprinkler Company, Inc., feels that, in general, most standpipes can only handle 300 psi. This is partly due to the fact that the couplings used to connect the piping are only rated to 300 psi. As seen earlier, fire departments may subject standpipes to much higher pressures than the maximum allowed by NFPA 14, possible causing failure of the system. Assistant Chief Howard J. Hill (retired) of the FDNY supports this when he wrote that the “FDNY’s experience that when pressures at the siamese reach 250 psi or greater, breaks in the piping often occur” (Hill, 2007). A closer look at the FDC reveals that Elkhart Brass, a manufacture of FDCs, only rates the connection bodies for 175 psi (Elkhart Brass, n.d.). NFPA 14 does state that nothing should restrict any jurisdiction from exceeding these minimum standards and the purpose of the standard is to “provide a reasonable degree of protection”. So, it becomes obvious that NFPA does not take into account local characteristics and that the local jurisdiction must address these issues through local building codes.

One June 27, 2003 the City of New Orleans adopted the 2003 International Building Code as the official Building Code for the City of New Orleans. Section 905 of this code refers to Standpipe Systems. A review of this section reveals that the City of New Orleans made no changes to this code and adopted it as is. This code does not address the pressures a fire department may place on a standpipe system in the event of stationary pump failure. It only states that standpipes shall be installed in accordance with its own standards and NFPA 14 (International Building Code, 2003). New Orleans is not the only city to adopt the International Building Code. The City of Philadelphia and the City of Milwaukee have also adopted this code, with only very minor changes, while not addressing the pressures the fire department may place on the standpipe systems. This may be a common practice for cities to adopt the International Building Code to use as a supplement to NFPA 14. The two cities in the United States with the most high-rise buildings, New York and Chicago, have gone much further with their building codes. Both cities address the high pressures that fire departments may subject the standpipe to and dictate what type of material must be used to construct the standpipe, valves, and fittings but not the FDCs.

Some cities building codes go into great depth to address the pressures the local fire department may place on the standpipe system. And it appears those same cities fire departments have detailed high-pressure pumping polices. It appears that in the City of New Orleans, there is a disconnect between the local building codes, as they pertain to standpipes, and the mission of the fire department in the event of a fire in one of the very tall building with stationary pump failure.

Procedures

This Applied Research Project utilized the Descriptive Method to assist the NOFD in developing a high pressure pumping operation for fires in very tall high-rise buildings in the event of stationary pump failure. The research included literature review of municipal fire departments high-rise policies that have very tall high-rise buildings within their jurisdiction. NFPA Standards that apply to standpipes, NFPA recommend practices for the use of sprinklers and standpipes, local Building Codes, and articles relating to high pressure pumping operations from WNYF publication. For technical information on apparatus capabilities interviews were conducted with technical specialists at American LaFrance, LLC and Waterous Company. For in depth information on standpipes construction, an interview was conducted with an architect/designer of sprinkler/standpipe systems. Interviews were also conducted with the State of Louisiana Fire Marshall's Office along with the NOFD Chief of Fire Prevention for code information. Also interviewed was the Chief Building Engineer of the One Shell Square building. Field tests were also conducted with NOFD apparatus to test different pumping techniques.

High-Rise SOPs and High Pressure Pumping SOPs were requested from 16 different fire departments from around the United States. All of the surveyed departments have in their jurisdictions very tall high-rise buildings. To keep influence from the state level to a minimum, only one city from a given state was surveyed. A complete cross section of the United States is represented, including the Honolulu Fire Department. Of the 16 fire departments contacted, 12 replied and forwarded the appropriate SOPs (Appendix B). These SOPs were reviewed to learn how other fire departments around the country accomplish high-pressure pumping operations and to use the best practices to help develop a standard for the NOFD.

Before apparatus field trials could begin to test some of the techniques learned from other fire departments high-rise SOPs, a technical specialist was contacted to ensure that the field test were within the capabilities on NOFD's apparatus and that the test would be conducted in a safe manner. The NOFD currently is under a lease program with American LaFrance to supply the apparatus in the NOFD fleet. The NOFD mostly utilizes 1250 gpm pumps of both the single and duel stage type. Waterous is the manufacture of NOFD's apparatus pumps. Todd Rogers, a Service and Training Specialist with Waterous was contacted by telephone on August 16, 2007. When Mr. Rogers was asked about how much pressure NOFD apparatus pumps can generate, he stated that a single stage pump can generate up to 400 psi and a duel stage pump is capable of 600 psi. He also stated that all Waterous pumps are hydrostatic tested to 800 psi. When questioned about the gallons per minute delivery at these pressures, Mr. Rogers replied that a duel stage pump, connected to a properly maintained municipal water system, should deliver approximately 600 gpm. Mr. Rogers forwarded a centrifugal pump performance curve chart to support his claims (Appendix C). It appears that a duel stage pumping apparatus should be able to deliver 500 psi, the current maximum pressure required for NOFD, but the single stage pumping apparatus will have to be used in series to achieve these same pressures. In the most extreme cases, to spread the work equally between the pumping apparatus in series, the second pump will be receiving approximately 250 psi into the intake manifold. Knowing that the intake relief valves on NOFD pumping apparatus are set to open at approximately 120 – 140 psi and are set from the factory, Mr. Rogers was asked about the dangers of capping off the dump pipe for intake relief valve so that the device can be overridden. Mr. Rogers stated that in a one-time extreme event, such as a high-rise fire, this maneuver will not harm the pumps, but under no circumstances should the intake relief valve dump pipe remain capped off. He reinforced that the device is there for the safety of members on hand lines. Mr. Rogers requested and was given the serial number of one of the apparatus pumps. After some research, Mr. Rogers stated that Waterous did not install the intake relief valve on the pump in question, that the apparatus manufacture, American LaFrance, installed the device and that Waterous had no knowledge of the relief valve specifications.

The NOFD has a working relationship with American LaFrance due to a lease agreement that is currently in place. The training specialist at American LaFrance that has worked with the NOFD in the past, Scott Detweiler, was contacted by telephone on August 20, 2007 for information on the relief valves that American LaFrance has installed on NOFD apparatus. Mr. Detweiler confirmed that the intake relief valves that the NOFD currently has installed on its American LaFrance pumping apparatus are set for approximately 120 psi and are set from the factory. When asked if there was a quick procedure to adjust or disable the intake relief valve, Mr. Detweiler replied that there was no quick method. He stated the only way to adjust the device was with a wrench, and from under the apparatus.

A field experiment was conducted on August 25, 2007 to test the capabilities of the NOFD's apparatus. The first experiment was to determine the amount of pressure that a duel stage pump can develop on its own. A 1997 Pierce with a 1250 gpm centrifugal pump, Waterous pump model CM, serial # 40453W with an engine governor set at 2500 rpm was used in this experiment. The apparatus was connected to a city hydrant that supplied 50 psi of pressure.

A 2 ½ inch discharge on the opposite side of the operator's panel was partially opened to keep a constant flow of water. The volume of water flowing was unknown. This was done to ensure that the pumps did not over heat. All personnel were kept clear of the area. The engine speed was slowly increased in stages to the following engine rpm: 1000, 1300, 1600, 1700, and 2000 with the pressure at each stage recorded. This test was not conducted on a single stage pump since NOFD's single stage pumps are not rated for the target pressure.

The next experiment was to test the intake relief valve settings on four different apparatus. The apparatus used in this experiment were a 2007 American LaFrance with a 1250 gpm, pump model PSM 1250, serial # 88296; a 1997 Pierce with a 1250 gpm, pump model CM, serial # 40453W; a 1997 Pierce with a 1250 gpm, pump model CM, serial # 40680W; and a 2006 American LaFrance with a 1500 gpm, pump model CSUYCX-1500, serial # 123773. This was accomplished by having a supply pump connected to the intake of the test pump with a 50 ft length of 3 inch supply hose. The test pump did not have its pumps engaged and the motor was off. The supply pump slowly increased pressure to the test pump until the intake relief valve functioned on the test pump and discharged water through the dump pipe. The pressures were recorded for each apparatus.

The last experiment at this time was an attempt to achieve 500 psi while utilizing two apparatus pumping in series. Using great caution, the intake relief valve dump pipe was capped for this experiment. The supply pump (A) was connected to a city hydrant that supplied 50 psi of pressure. Pump A was then connect to the intake of the test pump (B) with a 50 ft length of 3 inch supply hose. Pump B had a partially opened 2 ½ inch discharge on the opposite side of the operator's panel to keep a constant flow of water. This was done to ensure that the pumps did not over heat. All personnel were kept clear of the area. Pump A slowly increased pressure to pump

B until 250 psi of pressure was achieved on pump B’s intake. Once this was accomplished, pump B was to increase its discharge pressure to 500 psi. All four apparatus used in the previous experiment were also utilized in this experiment in different configurations with the results recorded.

To determine if a field test could be conducted on the standpipe system at the One Shell Square building, an interview was conducted on August 31, 2007 with Mr. Louis Norman, the Chief Engineer of the building. Mr. Norman stated that the building was 697 ft tall with 52 stories and was fitted with a sprinkler/standpipe system. He also stated that the sprinkler/standpipe system was configured into three zones. Zone one supplied water to the system from grade level to the 16th floor. Zone two received its water from zone one, and had a relay pump on the 16th floor to supply water from the 16th floor to the 37th floor. Zone three received its water from zone two, and had a relay pump on the 37th floor to supply water from the 37th floor to the roof. Mr. Norman also stated that an emergency power system is in place in the event of power failure. This is in the form of a natural gas/diesel generator that can supply power to the stationary pump and the relay pumps. When Mr. Norman was asked about the pressure limits of the system he stated that he did not know what the rated limit of the system was. Knowing the limits of the system is very important. If the fire department pressurizes the system above it rated limits, it could cause catastrophic failure of the system. To gather this information a sprinkler/standpipe architect was consulted.

An interview was conducted on October 11, 2007 with Mr. Mark Taylor at the office of American Sprinkler Company, Inc. Mr. Taylor is an architect and sprinkler/standpipe designer. He was the architect for the sprinkler/standpipe in the First NBC Center, which stands 645 ft tall. When asked about the pressure limits of standpipe systems, Mr. Taylor replied that NFPA 14 sets a limit of 350 psi for standpipes and that in his experience, in general, most standpipes are designed to handle a maximum of 300 psi. To support this claim, Mr. Taylor produced a material specification sheet from Anvil International for their standpipe coupling. The specification sheet showed that this coupling has a maximum working pressure of 300 psi (Anvil International, n. d.). Mr. Taylor stated that this coupling was an industry standard and is used in most local standpipes. He went on to explain that in very tall buildings, like the First NBC Center, the systems are zoned and use relay pumps. This zoning of the system ensures adequate water supply the upper floors without exceeding the pressure limitations. When Mr. Taylor was informed of the pressures the fire department may subject the system to in the event of stationary/relay pump failure and asked why the systems were not designed to handle these higher pressures, he replied that as designers, they never viewed the system from that aspect. They assumed that the fire department would only supplement the system through the FDC, not be the sole supply of water to the upper floors. The designers were mostly concerned that the system complied with NFPA 14, which is the code for the State of Louisiana. When asked if there was a backup water supply in the event one of the stationary/relay pumps failed, Mr. Taylor said that NFPA 14 permits as a sole source of water a public waterworks system with adequate pressure and flow, like the New Orleans water system.

Mr. Taylor then began to explain a problem that may occur on the sprinkler side of a combination system if the fire department was to charge the system with more than 400 psi. The sprinkler system is connected to the standpipe risers for water supply, but sprinklers need only approximately 15 psi to operate. Pressures in excess of 70 psi can cause a sprinkler head to discharge. To stop this from happing, pressure reducing valves (PRV) are used to regulate the pressure entering the sprinkler system. Mr. Taylor stated that the maximum inlet pressure for sprinkler system PRVs is 400 psi. If this pressure was exceeded, it could cause the PRV to default to the open position allowing the full pressure into the sprinkler system causing sprinkler heads to discharge. This would be more probable on lower floors where the pressure would be the highest. When Mr. Taylor was informed that the fire department wanted to conduct a test on the standpipe system at the One Shell Square building, to see if the fire department could supply water to the roof of the building, he said that he would advise against the idea. He felt that the fire department could over pressurize the system causing it to fail.

Once a sprinkler/standpipe system is designed, the plans are sent to the State of Louisiana Fire Marshall's office for review of compliance. On October 16, 2007, Mr. John Moore was interviewed at the State Fire Marshall's office in Baton Rouge, Louisiana. Mr. Moore is the Standpipe Review Specialist for the State Fire Marshall and is also an architect. When Mr. Moore was asked what the State Fire Marshall looks for in plans review, Mr. Moore stated that they only look for compliance to NFPA 14. The reason for this is the Louisiana Legislature has adopted NFPA 14 as a standard for the State of Louisiana. When informed of the pressures that a fire department may subject a sprinkler/standpipe system to, Mr. Moore was surprised. He stated that he had no idea that a fire department could generate so much pressure with their apparatus and, that as a plan reviewer, he never thought about that issue.

Mr. Moore went on to say that section 1.4 of NFPA 14 states that the standard is not intended to prevent a superior system from being designed. Mr. Moore also stated that local jurisdictions have the authority to enact stricter standards than NFPA 14.

The final review for sprinkler/standpipe plans is conducted by the local jurisdiction. Chief Elbert Thomas, Director of Fire Prevention for the NOFD was interviewed on October 24, 2007 for information on City of New Orleans codes. Chief Thomas stated that the City of New

Orleans has adopted the *International Building Code 2003* as the city standard. When asked what Fire Prevention is looking for when doing a plans review, Chief Thomas replied that the State Fire Marshall ensures that the plans are in compliance with NFPA 14 and that his department looks for local issues, such as fire hydrants are within the required distance of the FDC, that there are no obstructions to the FDC, thread size on the system is compatible with NOFD hose. Chief Thomas also stated that the City of New Orleans has not modified the *International Building Code* as it relates to standpipes.

The limitations of this research involve the small number of fire departments surveyed for high-rise SOPs. Although a complete cross section of the United States is reflected in the survey, only 12 fire departments are represented. Also, out of the 12 fire departments surveyed, only four of those cities building codes were readily available for review. The field tests were limited to four pumping apparatus. Two of which were late model American LaFrance and two that were older model Pierce. Also, the apparatus did not deliver the pressures in the field test to a standpipe system. Finally, only one sprinkler/standpipe architect/designer was interviewed for this project due to time constraints.

Definition of Terms

Duel stage pump: Centrifugal fire pump with two impellers. This type of pump can arrange the impellers in series for maximum pressure or in parallel for maximum volume.

Intake relief valve: Relief valve on the intake manifold of a pump that only allows a set amount of pressure into the pump. Excess pressure is dumped through a discharge pipe usually located under the apparatus. Relief valves will activate at a pre-set pressure set at the factory or may be an adjustable type and can be quickly set in the field.

Pumping in series: One apparatus connects to a hydrant and pumps directly into another apparatus to achieve higher pressures than obtainable with one apparatus pumping alone.

Relay pump: Fire pump in a high-rise building that receives water from a lower pump and supplies water to an upper sprinkler/standpipe zone.

Stationary pump: Fire pump in a high-rise building, usually located on grade level that supplies water to the upper floors of the building and or a higher sprinkler/standpipe zone.

Single stage pump: Centrifugal fire pump with one impeller. This type of pump is associated with maximum volume but lower pressure.

Very tall high-rise building: A building over 40 stories high

Results

The information gathered through interviews, field test, building codes and fire departments SOPs was used to answer the questions that guided this research.

After reviewing the building codes of Chicago, New York and Philadelphia as they pertain to standpipe systems, it was determined that wide variances exist between the respective codes. Although Chicago and New York building codes do differ slightly, both go into detail about what materials are to be used in the construction of the piping and valve bodies of standpipes systems depending on the pressures that may be place upon them by the local fire department. On the other hand, it appears that Philadelphia utilizes the *International Building Code* as it relates to standpipes. Philadelphia does not addresses the issue of the pressures the local fire department may place on a standpipe system, nor does the city require the piping or valve bodies be constructed of certain materials.

The City of New Orleans is more in line with the practices of Philadelphia than Chicago or New York. The City of New Orleans has adopted the *International Building Code* as its standard for standpipe systems. The City of New Orleans has not changed or modified the *International Building Code* in any significant way as it relates to standpipes. This means the code does not address the issue of the pressures the local fire department may place on a standpipe system, nor does the city require the piping or valve bodies be constructed of certain materials.

Of the 12 fire departments surveyed for high-rise SOPs, only five go to any length detailing high pressure pumping operations. With some variations, both New York and Chicago give step-by-step, detailed instructions to accomplish this operation with an emphasis on safety. Interestingly, these were the only two departments that made any reference to the use of high-pressure supply hose at incidents where higher than normal pressures may be encountered. The NOFD currently uses Snap-tite brand fire hose. This hose is service pressure tested to 300 psi which dictates a maximum working pressure of 270 psi (Snap-tite, n.d.). Most of the departments just have a casual reference to water supply operations, with a line or two in the policy that basically instructs the first due engine to connect to the FDC and supply the system with the appropriate pressure. The NOFD falls into the latter category with just a few sentences dedicated to water supply in its High-Rise Policy (NOFD, 2001 p. 20).

The field test that determined the amount of pressure that a NOFD dual stage pump, in the pressure position, could develop on its own produce the following data:

Engine rpm:	1000	1300	1600	1700	2000
Pressure:	200 psi	300 psi	400 psi	500 psi	600 psi

As can be seen, the dual stage pump was able to achieve more than the desired pressure while remaining 500 rpm under its governed engine speed.

The second field test was to determine at what pressure the intake relief valves on NOFD apparatus are set from the factory. On both American LaFrance apparatus the intake relief valve activated at 140 psi. On both of the Pierce apparatus the intake relief valve activated 120 psi.

The last field test was an attempt to achieve 500 psi final discharge pressure utilizing two apparatus pumping in series. When a dual stage pump was used in this experiment it was left in the volume position. In the first round the older Pierce apparatus were used providing the following data:

Pump A: 1997 Pierce	Engine rpm: 1200	Discharge pressure: 250 psi
Pump B: 1997 Pierce	Engine rpm: 2000	Discharge pressure: 500 psi

As can be seen, the two pumps, both in the volume position, were able to achieve the target pressure while remaining well under the governed engine speed. The volume of water flowing was unknown. A much different result occurred when the American LaFrance apparatus were used in the same experiment.

Pump A: 2007 American LaFrance	Engine rpm: 1200	Discharge pressure: 250 psi
Pump B: 2006 American LaFrance	Engine rpm: idle	Discharge pressure: 250 psi

During this test Pump A, connected to the hydrant and supplying 250 psi to the intake of Pump B, performed as expected. What was discovered was that when the intake pressure on Pump B exceeded the point where the intake relief should activate, the throttle on Pump B became disabled and the engine remained at an idle. This would not allow Pump B to increase the pressure it received from Pump A. After changing the apparatus into different positions in the experiment, it was learned that the older apparatus could override the intake relief valve, but the newer American LaFrance apparatus could not. Scott Detweiler at American LaFrance was contacted on September 10, 2007 regarding the above situation and was asked if there was anyway to override the intake relief valve or a way to quickly adjust the valves in the field in the event that high pressure pumping operations need to be conducted. Mr. Detweiler replied that a safety device was installed on the apparatus the keep the intake relief valve from being overridden and that he knew of no way to override or quickly adjust the device.

Discussion

The genesis of this research was to help the NOFD develop a high pressure pumping procedure in very tall high-rise buildings in the event of stationary pump failure. Enough information on high pressure pumping operations was gathered from other fire departments to put together a best practices policy. But limitations with NOFD equipment and local building codes prevented any type of practical standpipe test from being conducted.

The NOFD is beginning to purchase new pumping apparatus that are of the single stage design. This type of pump can only generate 400 psi (Rogers) and is not capable of achieving the pressures required to reach the top of the tallest building in the City of New Orleans. This situation should be easily overcome by placing two apparatus in series, using both pumps together, to generate the desired pressure. A problem arises with the intake relief valve on the newer American LaFrance pumping apparatus. This devise is not readily adjustable and will not allow more than 140 psi into the pump (Detweiler). This situation would dictate that the second pump in the operation would have to generate approximately 350 psi to achieve the target pressure. This means the second pump will be running at almost maximum capacity. If an operation extended for a long period of time, this could be very stressful on the second apparatus. Attempts to override the intake relief valve caused the throttle on the apparatus to become disabled, not allowing the increase of engine speed. Obviously, this type of safety device that was installed on the newer American LaFrance apparatus to keep firefighters from trying to override the intake relief valve, also limits the effectiveness of the apparatus when being used in series for high pressure pumping operations. Although the older pumping apparatus in the NOFD fleet do not have this safety device and can be used in a series type operation, this equipment is currently being replaced. It must also be said that although the duel stage pumping apparatus were able to achieve the target pressures in field test, the pumps did not actually test supplying a standpipe system.

The supply hose currently used on the NOFD is manufactured by Snap-tite Hose-USA. This hose is industry standard with a service pressure test of 300 psi (Snap-tite, n.d.). The manufacture recommends a maximum working pressure of 90% of the service test pressure, in this instance 270 psi. As seen earlier, the pressure required to reach the top of the One Shell Square building is over 475 psi. This would create a dangerous situation if this hose was subjected to this kind of pressure. The need for high pressure hose is reflected in the Chicago and New York SOPs where recommended pressure charts show pressures in excess of 500 psi. This was one reason why an actual standpipe test was not conducted.

At a high-rise fire, the fire department connects to the building sprinkler/standpipe system via the FDC. In the majority of cases the fire department will be supplementing the system with a recommended pressure of 150 psi (NFPA 13E). In the event of stationary pump failure these pressure may be much higher. A major manufacture of these connections is Elkhart Brass. A review of the specifications of these connection bodies reveals that the industry standard for pressures ratings is only 175 psi (Elkhart Brass, n.d.). The two cities that were found to have standpipe building codes that exceeded NFPA 14 (Chicago, New York) did not address the pressure ratings for FDCs. Although attempts to find an instance where one of these bodies failed while being used under high pressure were unsuccessful, this low pressure rating could make these bodies subject to failure.

The State of Louisiana has adopted NFPA 14 as a minimum standard for standpipes. This standard sets a pressure limit of 350 psi on standpipe systems (NFPA 14, p14-15). Even in very tall buildings this is possible by dividing the building into zones and using relay pumps to supply the upper zones. It is the experience of Mark Taylor at American Sprinkler Company, that in the New Orleans area most, if not all, standpipe systems are only rated to 300 psi. This is due to the couplings that are used in the construction of standpipes being only rated to 300 psi (Anvil International, n. d.). If the stationary and/or relay pumps fail, this would force the fire department to attempt to supply the building from grade level through the FDC. If the fire was above the 40th floor, this would create a situation where the fire department would be pressurizing the system above its rated capacity, possibly causing the piping system to fail. In the experience of Assistant Chief Hill (retired) of the FDNY, standpipes often break when the pressures at the FDC reach 250 psi or greater (WNYF, 3rd/2007, p 6). This situation can be very dangerous. Firefighting crews on the upper floors may suddenly lose water if the system fails possible causing them to become trapped. Also, a person could be gravely injured if he/she was in close proximity of a standpipe riser when it blew apart.

Charging a combination sprinkler/standpipe system with higher than the rated pressures can cause other problems. In a combination system, the sprinklers are supplied with water from the standpipe risers. PRVs are used to keep the higher pressure in the standpipe system from entering the sprinkler system. According to Mark Taylor, if more than 400 psi is sent through the system the PRVs could default to the open position allowing the full pressure to enter the sprinkler system. This kind of pressure could cause sprinkler heads to discharge or piping to fail on the lower floors where the pressure is greatest, not only causing water damage but also diverting water from suppression operations on the upper floors. Battalion Chief Meara of the FDNY states that sprinkler system components are only rated for pressures to 175 psi and should the PRV fail to operate, the high pressure in the system could burst the sprinkler piping.

As can be seen, over pressurizing a sprinkler/standpipe system can cause all kinds of problems. It is also evident that NFPA 14 does not address the pressures that a fire department will place on a sprinkler/standpipe system through the FDC in the event of a fire above the 40th floor with stationary and/or relay pump failure. Some cities, like Chicago and New York, have enacted much stricter standpipe building codes than are reflected in NFPA 14. These codes take into account the higher pressures a fire department may place on the system while trying to supply the upper floors through the FDC (Chicago, 2006) (New York, 2004). Other cities, like New Orleans and Philadelphia, have adopted the *International Building Code* that does not take into account the higher pressures a fire department may place on the system (New Orleans, 2003) (Philadelphia, 2003).

Recommendations

The following recommendations for the NOFD are a product of the research conducted for this project. Other cities that have very tall high rise building may also benefit from these recommendations.

It is recommended that when the NOFD purchases new pumping apparatus, whether the single stage or duel stage type, the pumps have adjustable intake relief valves. These intake relief valves should be adjustable up to 300 psi. This will allow the apparatus, when put in a series configuration, to pump more effectively to achieve the pressures required to reach the top of the tallest buildings in the City of New Orleans.

It is also recommended that the NOFD purchase 3 inch special high pressure supply hose that is working pressure rated to 500 psi, the pressure that may be required at a high-rise fire. This special high pressure supply hose could be carried on the heavy rescue squads to ensure it arrives at any high rise fire for deployment and is not intended for everyday use. Following NOFD procedures (NOFD, 2001) for apparatus placement at high-rise fires, 1200 feet of this special hose will be required.

Finally, it is recommended that the City of New Orleans enact building codes, as they apply to standpipes, to reflect the pressures the fire department may place on the system in the event of stationary/relay pump failure. These codes should address the pressure ratings for FDCs, sprinkler PRVs, all valve bodies, piping, and couplings. This upgrade in codes becomes even more imperative with the construction of the 716 ft Trump International Hotel & Tower about to begin in 2008. Due to political and cost considerations, it is unknown if requiring buildings to retro fit existing standpipes system to withstand the pressures the fire department may place on them is a viable option.

References

Anvil International. (n.d.). Figure 7400 Lightweight Coupling, Data Sheet 38. Retrieved October 15, 2007, from, http://www.anvilstar.com/db/datasheets/DS_038.pdf

Atlanta Fire Department. (2005). Sprinklers. *FAO Manual* (2005 4th Edition). Author

Chicago Fire Department. (2006, November). Three (3) Stage High-Pressure Pumper. *Operations Order 06-018*. Author

City of Chicago. (2006, December 13). Municipal Code of Chicago, Illinois. Cincinnati: American Legal Publishing Corporation. Author

City of New Orleans. (2003). Fire Code - International Building Code, 2003 Edition. Author.

City of Philadelphia. (2003). Fire Code (Philadelphia Amendments to the 2003 International Fire Code). Author

City of New York. (2004, October 1). Building Code of the City of New York. Author

Department of Homeland Security. (2nd Printing-October 2006). 3rd Edition. Executive Development – Student Manual. Author.

Elkhart Brass Mfg. Co., Inc. (n.d.). Building Connections. Retrieved November 21, 2007 from http://www.elkhartbrass.com/catalog/files/catalog-11-08.pdf

Fire Department of New York City. (1997, January). Firefighting Procedures, High-Rise Office Buildings. *DCN: 3.02.01*. Author

The Fire Museum Network. (n.d.). William James McCrossen – July 11, 2004. Retrieved November 14, 2007, from http://www.firemuseumnetwork.org/misc/memorial.html

Hill, H. (2007) High-Pressure Trilogy-The Drill at 7 World Trade Center. *WNYF*, 3rd/2007, 5-6

Iklimnet. (n.d.). High-rise Office Building Fire One Meridian Plaza Philadelphia, Pennsylvania. Retrieved November 20, 2007, from http://www.iklimnet.com/hotelfires/meridienplaza.html

International Code Council, (2003). International Building Code, 2003 Edition. Author.

Meara, T. (2007) Water Supply in Super High-Rises. *WNYF*, 3rd/2007, 7-8

National Fire Protection Association. (2007). *Standard for the Installation of Standpipe and Hose Systems* (NFPA 14). Author.

National Fire Protection Association. (2005). *Recommended Practice for Fire Department Operations in Properties Protected by Sprinkler and Standpipe Systems* (NFPA 13E). Author.

New Orleans Fire Department. (2001). High Rises Orleans Parish. New Orleans, LA: Author.

New Orleans Fire Department. (2003). Fire Scene Hydraulics. New Orleans, LA: Author.

Snap-Tite Fire Hose. (n.d.). Hose Sizing and Specifications. Retrieved October 25, 2007, from http://www.snap-titehose.com/products/industrial/6d/index.html

Wikipedia. (2007, October 12). Crescent City Towers. Retrieved November 15, 2007, from http://en.wikipedia.org/wiki/Crescent_City_Towers

Wikipedia. (2007, October 19). List of tallest buildings in New Orleans. Retrieved November 15, 2007, from http://en.wikipedia.org/wiki/List_of_tallest_buildings_in_New_Orleans

Appendix A

New Orleans Fire Department Hydraulics

Standpipe Calculations: Standard friction loss for standpipes systems is 25psi. This 25psi includes the standpipe, friction loss in the standpipe and friction loss in the elbows. It does not include back pressure. When figuring back pressure, remember: That 12 ft is allowed for each floor and the RULE OF THUMB is 5psi back pressure for each floor. Do not count the fire floor when figuring back pressure.

Example: Fire on the 9th floor

Nozzle Pressure	100psi (Fog)
Friction Loss on attack line: 100’ of 2 ½ “ line with 300 GPM flow	
3.0 X 7 = 21psi per 100’	21psi
Standpipe Friction Loss: Siamese, Connection and Piping	25psi
Friction Loss on supply line: 2 350’ of 2 ½ “ line into FDC	
300 GMP ÷ 2 (number of lines)	
= 150 GPM each line	
= 1.5 X 4 = 6psi per 100’	
= 6psi X 3.5 (hundreds of feet)	21psi
Back Pressure	
9th floor – 1 = 8 X 5psi (friction loss per floor)	40psi
Total Engine Pressure	207psi

Back Pressure	
58th floor – 1 = 57 X 5psi (friction loss per floor)	285psi
Total Engine Pressure	479psi

Appendix B

List of Fire Departments Responding to Request for SOP's

Atlanta

Chicago

Columbus

Honolulu

Kansas City

Las Vegas

Los Angeles

Milwaukee

New York

Oklahoma City

Philadelphia

Seattle

Appendix C

Centrifugal Pump Performance Curve