

Lessons Learned from the Deadly Charleston Sofa Super Store Fire

**How the Construction, Occupancy, Protection, Exposures,
and Firefighting Tactics Affected the Outcome of This Incident**

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Introduction

Building owners, occupants and the fire service all play an important role in the outcome of any fire emergency. In this case one of the most tragic single event outcomes in history for firefighters was attributed to actions, inactions and conditions prior to and during the event itself. This article will review the existing investigative reports and highlight those items that were identified as critical to the overall outcome of this incident. Most of the available information was assembled into what are known as the Phase 1 and Phase 2 Reports by an independent team of respected fire service professionals from across the United States that was appointed by the City of Charleston, SC. Their mission was to conduct an exhaustive review of the incident and develop strategies for the City of Charleston to implement in improving their department, but also to benefit all fire departments across the county. The information developed also identifies crucial lessons for building owners and occupants that can be implemented to avoid becoming a contributing factor in a similar event.

The Incident

At 7:09 PM on the evening of June 18th, 2007 the first call reporting a fire behind the Sofa Super Store on Savannah Highway in Charleston, SC was received by the 9-1-1 dispatch center. The first due Battalion Chief and crew from the dispatched apparatus of Fire Station 11 observed visible smoke immediately upon leaving the driveway of the station and arrived on the scene less than three minutes later. The evening would end in tragedy as nine City of Charleston firefighters would perish in an incident that would later be determined to have been entirely preventable, from the fire itself to the loss of life.

Pre-existing conditions inside the building and inadequately managed fireground operations caused the conditions inside the structure to worsen rapidly. Many hose lines would be stretched into the building in an effort to combat the fast moving fire, taking firefighters at times as far as 200 feet inside the structure with zero visibility. By 7:40 PM, those nine firefighters had become

disoriented and could not find their way out of the building. Running out of breathing air, they would eventually succumb to carbon monoxide poisoning, smoke inhalation, thermal burns, or a combination in the untenable environment inside.

The most likely cause of the fire is believed to have been carelessly discarded smoking materials that ignited trash outside the loading dock, which in turn ignited furniture stored inside the loading dock, eventually spreading throughout the building. The fire spread through concealed spaces above the heads of firefighters without them being aware of how rapidly the conditions were deteriorating. The fire also communicated unchecked through unprotected doorways and directly penetrated walls that were not constructed of fire rated materials to reach more fuel. By 7:52 PM the roof of the west showroom began to sag due to heat exposure and at 7:56 PM the center showroom roof suffered a catastrophic collapse.(Phase 2 pp 53-80)

Several investigations conducted following the incident revealed there were many factors that contributed to the tragic outcome. The intent of these investigations, as well as this review, was not to place blame, but to aid others in learning how similar situations might be avoided. It will examine the common factors of construction, occupancy, protection, exposures and the operational strategies and tactics employed; as well as review the recommendations developed by the Charleston Post Incident Assessment and Review Team led by noted fire service expert J. Gordon Routely, P.E.

Investigations Conducted

It has now been over one year since the fire. Because of the high profile nature of an incident where nine firefighters died in the line of duty, the event has been examined by several different agencies to shed light on what happened and how it or future incidents could be prevented. The investigations by the South Carolina Department of Labor, Licensing & Regulation/OSHA and the Charleston Post Incident Assessment and Review Team investigations are complete. A draft of the NIOSH Firefighter Fatality and Injury Prevention Program investigation has been released to the public and for comment and review of the involved parties.

The OSHA investigation results were released on September 20, 2007. Both the Sofa Super Store and the City of Charleston Fire Departments were cited for both willful and serious violations of occupational safety standards. (SC OSHA)

The Sofa Super Store:

- Willful violation – exit doors locked while the building was occupied – initial penalty \$49,000, assessed penalty \$29,400. Cited under 1910.36 (d) (1).
- Serious violation – failure to properly maintain fire doors – initial penalty \$7,000, assessed penalty \$2,500. Cited under 1910.37 (a) (4).
- Serious violation – no Emergency Action Plan for employees – initial penalty \$7,000, assessed penalty \$875. Cited under 1910.38 (b).

Charleston Fire Department:

- Willful violation – the employer knew or should have known that the command system does not provide for the overall safety of personnel and their activities – initial and assessed penalty \$7,000. Cited under the General Duty Clause Sec. 5 (a) (1) of the Act.

- Serious violation – standard operating procedures were not developed to cover the special hazards associated with fighting and attacking a fire involving a metal truss roof – initial penalty \$1,000, assessed penalty \$900. Cited under 1910.156 (c) (4),
- Serious violation – body protection was not required to be worn by nine firefighters involved in interior structural firefighting – initial penalty \$1,000, assessed \$900. Cited under 1910.156 (e) (1) (i).
- Serious violation – SCBA not required to be worn by four firefighters while exposed to smoke and toxic substances – initial penalty \$1,000, assessed \$525. Cited under 1910.156 (f) (1) (ii).

The state of South Carolina administers its own OSHA enforcement program as do 25 other states and US Territories. This state provides for a reduced fine structure for governmental entities as compared to those in the private sector. The Charleston Fire Department would eventually reach what many would consider a controversial settlement with the Department of Labor and agree to pay only \$3,160 of the original \$9,325 in fines but admit to no wrongdoing. The agreement resulted in fines on only two of the violations originally cited.(SC OSHA)

It is clear based upon the work by the Post Incident Assessment and Review Team and NIOSH to date that many other potential violations were present during the incident and may not have been individually cited by OSHA. Specific violations of NFPA Firefighter Safety and Health standards (NFPA 1500) included: failure to designate one or more Incident Safety Officers on the scene, failure to have the required Rapid Intervention Teams assigned and standing by in the ready capacity, failing to keep crews together when operating inside an IDLH environment and to have an effective Personnel Accountability System to track the locations and assignments of firefighters involved in the incident. It is this reviewer's opinion that these individual items, while not separately cited, likely were contemplated in assessing the General Duty Clause citation noted above.

The NIOSH Firefighter Fatality and Injury Prevention Program conducted an investigation with the assistance of the National Institute of Standards and Technology (NIST). Although their preliminary report was released in May 2008, the final report with recommendations is not expected to be released until comments from several entities involved in the investigation can be reviewed and incorporated. That is expected to occur sometime later in 2008, but as of early November 2008 this had not yet occurred.(NIOSH)

Charleston Post Incident Assessment & Review Team has obviously done the most comprehensive work and to date has released two reports; the Phase 1 Report (38 pgs.) on October 16, 2007 and the Phase 2 Report (272 pgs.) on May 15, 2008. This report uncovered in great detail the time line of events, developing recommendations and lessons learned for others in the fire service. Those recommendations and lessons learned will be reviewed at the conclusion of this article.

Building Construction

The original building was constructed as a grocery store in the 1950's or 60's of hollow concrete block and a metal deck roof supported by open web steel bar joists. Later flanking additions of lightweight metal on pre-engineered steel beams were added to the original building in 1995 and 1996, bringing the total area to over 31,000 square feet. This comprised the showroom area that was separated into three fire areas by hollow concrete block walls with rolling steel fire doors to protect the openings between the sections. Because of the installation of the fire rated rolling steel

fire doors in the openings between these building sections, they were considered separate structures for building code purposes. Treating each section as a separate building kept them under the threshold that would have required automatic sprinklers under the building code enforced at the time.(Phase 2 pp 26-29)

In 1996 a 15,600 square foot pre-engineered warehouse was added to the rear of the structure and connected only by an enclosed hall protected with a rolling steel fire door to provide the necessary fire separation to classify the structure as two fire divisions. A variance was granted to not require a fire resistance rating on the north warehouse wall that exposed the showroom building due to the physical separation distance and 3-hour protective features on the corridor that attached the two. All of this construction was regulated under the city code enforcement process through proper permitting. As with the first two additions, this was also treated as a separate structure and was also under the threshold that would have required it to be protected with automatic sprinklers.(Phase 2 pp 26-29 & p G-2)

After 1996 several small wood frame additions covered with metal siding and roof decking were added to create what are termed “fill-in” additions. These typically take advantage of existing walls of one or more of the structures already built and effectively “fill-in” the space between them with a floor and roof. In this case, no Building Permits were obtained for these additions – nor is it likely they would have been approved. These additions caused two primary problems: the first being that they circumvented the fire separation created by the enclosed tunnel protected by an automatic fire door that was intended to separate the showroom from the warehouse; and secondly these additions enclosed required exits that were part of the original construction. This created dead end rooms that would later house high hazard operations and where an employee would be rescued by forcible entry directly through one of the exterior walls.(Phase 2 p 31)

The entire combined structure would now cover well over 46,000 square feet not counting the “fill-in” structures. Because of the unapproved construction, lack of proper fire walls, what would have been normally required opening protective devices, and other opening protective devices that did not function properly, all but 7200 square feet located at the east end of the building would be completely destroyed in the fire.

It was determined in the course of the investigation that not less than three of the seven fire doors in the facility were not in proper working order and failed to properly close. A U.S. Fire Administration bulletin issued in August 2007 indicated the doors had not been properly maintained as required under NFPA 80 – *Standard for Fire Doors and Other Opening Protectives*. Proper maintenance and periodic testing are required to ensure they will function as designed in event of a fire. (USFA HC2007-8-28)

The three doors noted in the OSHA citation were located in the wall between the main showroom in the center of the building and the décor showroom to the west. (SC OSHA) While the heat activated fusible links did activate, the doors failed to close. The west end and center sections of the showroom building collapsed during the fire. Two of the three fire doors separating the center showroom from the east showroom did function properly, while a third closed partially and prevented this portion from suffering nearly as much damage. While the failure of these protective devices installed in the openings between the center and west sections permitted the fire to spread, they would have certainly trapped firefighters due to the fire exits in the west décor

showroom being locked; and also potentially interrupted the water flow through hose lines extended into the west décor showroom.(Phase 2 p 92)

Concealed or “void” spaces above the showroom ceilings and a combustible roof coating of polyurethane foam caused heat and products of combustion to become trapped and spread laterally through the structure without being easily detected at the floor level where the firefighters were. This void space between the suspended ceiling and the roof created an uninterrupted plenum between 2 and 6 feet high depending on the slope of the roof at that location.(Phase 2 p 39) However, had a thermal imaging camera been taken into the building, these conditions could have been readily identified. A similar condition began to occur below the ceiling that was visible to the firefighters, but that was only part of the problem.

There was also a significant lack of “natural” vents on the roof of the building. Natural vents typically consist of openings already in place for equipment such as powered ventilation fans, HVAC units, air handlers, skylights, automatic smoke vents, etc. While not always the best means of vertical ventilation, they can give some relief inside by releasing products of combustion if “assisted” by manually opening them up to permit a chimney effect to occur. Convection currents caused the natural tendency of heated gases to rise helps to relieve the build up of heat inside. They also can help Incident Commanders better gauge what is going on with the fire spread by providing more opportunities to read the smoke conditions.(Phase 2 p 43)

Occupancy

The system of classifying the occupancy of a building is based on a recognized set of hazards common to a particular type of building occupant. Common classifications include: Business, Mercantile, Healthcare, Residential, Places of Assembly, Industrial, Storage, Educational, etc. Although there can be situations where the occupancy hazards can be greater than those commonly encountered, these can be separately rated. The goal is to identify the primary hazards and specify what protective features must be incorporated into the building design to ensure the safety of the occupants until they can escape a fire emergency.(Cote / FPH p 9-5)

The occupancy for the showroom portion of the building under the NFPA classification system would have been classified as Mercantile. The showroom was typical of a furniture sales operation with relatively narrow aisles separating large congested areas of furniture displays. This arrangement caused significant difficulty for firefighters attempting to stretch hose lines through the showroom areas as well as for those who became separated from their hose line and were attempting to find their way out.(Phase 2 p 36)

Although the showroom area would have been classified as mercantile, the warehouse would have needed to be separately classified since it was deemed to be a separate building by city officials when it was approved for construction. This portion of the building would have needed to be classified as a storage occupancy due to the high rack storage containing appreciable amounts of exposed Group A plastics in the form of upholstered furniture and bedding containing large amounts of expanded urethane foam.(Phase 2 p 36)

The warehouse building was 29 feet from the floor to the roof deck and contained single and double row racks at least four tiers high based on photos in the NIOSH report. The Phase 2 report indicates the storage to have been about 20 feet high. The racks were filled with exposed

upholstered foam filled furniture and bedding.(Phase 2 p 28) Narrow aisles between these racks allowed significant radiation feedback and natural flue spaces caused the fire to spread quickly through the building.

It would be discovered during the course of the post-fire investigations that a significant quantity of flammable and combustible liquids was being kept in the building in one-gallon cans and aerosols. The occupancy classification did not permit the storage of flammable liquids, hazardous materials, or spray finishing operations. At least 28 containers, including naphtha and lacquer thinner, were found in the post fire investigation. This exceeded the amount permitted under the fire code for incidental use.(Phase 2 pp 36-37)

Private Protection – Building Owner/Occupant

Private fire protection for the showroom and warehouse areas consisted only of portable fire extinguishers. Based on an account from an employee who went to the loading dock area to attempt to extinguish the fire reported by a passer-by, the fire was already too large to control with a single handheld unit. Upon locating and retrieving a second extinguisher from the showroom he could not even enter the loading dock and had to discharge that unit through a doorway from the adjacent holding room. He was ultimately unsuccessful in controlling the fire.(Phase 2 p 53)

There was no automatic heat or smoke detection; or automatic sprinkler system in place in any part of the building. Had building permits been applied for and obtained for the fill-in sections constructed, an automatic sprinkler system would have been required to be installed throughout the entire structure. Construction of these unauthorized additions compromised the fire separation features that were installed when the warehouse (the last section built within the city permit and approval process) was constructed.

These fill-in additions eliminated the separation distance between the showroom and warehouse buildings that was required under the variance that was granted by the city. In this case, the warehouse was constructed without a fire wall between it and showroom because it was separated by an adequate distance to prevent fire spread between the two structures and it was only connected by an enclosed tunnel that was protected by a properly rated fire door. The fill-in additions created or left unprotected openings that could allow fire to travel around the rated fire door that separated the showroom and warehouse.

Construction of these additions and failure to upgrade walls and opening protection effectively eliminated any fire separations between the building sections. Separating building sections by either physical distance, or by installing “fire walls” between them are the two most common methods of preventing fire from spreading through a large structure or between structures, thus lessening the risk of total loss due to fire. Fire walls are usually constructed of some type of heavy masonry materials and are designed to prevent fire from spreading from one side to the other. Ratings and design of these structures varies with the building size, occupancy, exposures and local code requirements. Any openings in these walls, such as doorways, must also have appropriately rated “fire doors” that close automatically in case of fire.

South Carolina enforces the International Fire Code and now requires mercantile occupancies over 12,000 square feet to be fully protected by automatic sprinklers With the

presence of Group A plastics, a sprinkler system for the showroom and loading dock area would have needed to be designed for at least Ordinary Hazard Group 2.(Phase 2 p G-16 & IFC 903.2.6)

Protecting exposed Group A plastics in high rack storage to a height of 20 feet in the warehouse would have been a much greater challenge. Rack storage of significant quantities of exposed Group A plastics falls outside the scope of Chapter 12, decision tree 12.3.3.1.1 of NFPA 13. Therefore a designer would need to refer to the FM Global (Factory Mutual) Data Sheets to find a protection scheme capable of controlling this extreme fire load. Schemes for situations similar to this require either the use of a combination of overhead and in-rack sprinklers. The overhead component would need to deliver water densities significantly higher than those require by NFPA Extra Hazard Group 1, but not as great as those required with an Early Suppression Fast Response (ESFR) overhead system due to the additional protection afforded by various configurations of in-rack sprinklers. NFPA Extra Hazard Group 1 would typically require a density of about .3 gpm over an operating area of 2500 square feet capable of flowing about 750 gpm through the system, but would require two rows of in-rack sprinklers at each level to supplement it and meet the FM Global requirements. The ESFR typically delivers 1.21 to 1.25 gpm over a minimum operating area of 960 square feet capable of flowing about 1200 gpm through the system and can often be used for Class 1 through 4 commodities, but not Group A plastics in this configuration. The FM Global recommended systems have an overhead delivery density of between .3 gpm over a 2000 square foot operating area (600 gpm flow) to .8 gpm over a 1500 square foot operating area (1200 gpm flow). The number and positioning of the in-rack sprinkler systems determined which overhead system can be employed.(NFPA 13 – 12.3.3.1.1 & FMDS 8-9 p 41)

The following is a comparison of protection schemes as described above. Based on protection of storage of 20 feet high in a building less than 30 feet high containing exposed expanded Group A plastics as are found in uncartoned upholstered furniture and bedding.(NFPA 13 & FMDS 8-9 p 41, table 2.3.7.3 (k))

Hazard Design	Approved	Additional In-rack sprinklers	Delivery Density	Operating Area	Total Water Flow
NFPA 13 Ex Haz. Grp 1	No	Without in-racks	.30 gpm	2500 sq. ft.	750 gpm
NFPA 13 ESFR	No	Without in-racks	1.2 gpm	1000 sq. ft.	1200 gpm
FM Global DS 8-9	Yes	With in-racks at every other level	.80 gpm	1500 sq. ft.	1200 gpm
FM Global DS 8-9	Yes	With in-racks at every level	.60 gpm	1500 sq. ft.	900 gpm
FM Global DS 8-9	Yes	With in-racks - 2 rows at every level	.30 gpm	2000 sq. ft.	600 gpm

Although delivering an adequate volume of water is crucial to absorption of the heat being released; how it is delivered is just as critical to successful control of such an extreme fire load.

One of the issues that compounded problems and diverted resources was the lack of an effective Emergency Action Plan to be able to account for not only employees, but patrons given that this was a retail establishment. An employee was trapped in one of the workshop areas that

were part of the fill-in construction with no exit except through the warehouse or showroom that were already well involved in fire. He called 9-1-1 with a cellular phone to report his situation. Management on site was not aware this worker was in the building until they recognized his vehicle in the parking lot. The worker had to be rescued by forcible entry, sawing an opening through the exterior wall of the building.(Phase 2 p 69)

A common practice in buildings frequented by the public is to implement a “Fire Warden” type program where certain employees are responsible for “sweeping” designated sections of the building to ensure everyone has been cleared from the structure. This is in addition to the manual head count conducted at predetermined muster sites outside to ensure all are accounted for.

Public Protection – Charleston Fire Department

The last city fire code inspection occurred on March 30, 1998 prior to the city suspending fire code inspections for mercantile occupancies in the year 2000. Although pre-plan visits had been made between 1998 and 2007, they were not complete and did not acknowledge the presence of the high rack storage in the warehouse or any other unusual hazards.(Phase 2 p 37)

Public protection capabilities are graded by the Insurance Services Organization (ISO). This complex system is based upon many factors. Ten percent of the scoring matrix is based on fire department resources and reliability. Fifty percent is based upon primarily availability of engine companies and water demand throughout the community. The remaining forty percent is based on how much of the required fire demand can be supplied over and above the daily community consumption. The resulting score is called the Public Protection Classification or PPC rating.(ISO Mitigation)

The City of Charleston was listed by ISO as a PPC – 1 department – representing what is ordinarily considered exemplary fire protection capability. There are currently fewer than 60 departments that have achieved this grading, representing less than 0.2 percent of all departments in the US. The system utilizes a matrix grading system to analyze the capabilities of a department based on equipment, training and response abilities. Ratings range from a PPC 10, which is considered almost non-existent fire protection; to a PPC 1, where based on the grading criteria the department is capable of providing extremely high quality fire protection service to the community.(ISO Mitigation) However, this event sheds light on the issue that some elements of the ISO PPC system may be outdated, such as minimum supply hose diameter and ensuring departments have adopted use of modern strategies and tactics applicable to today’s fire scenarios.

Current ISO requirements to be considered an adequately equipped engine company reflect outdated technology reflecting small diameter supply lines and marginal on board water tanks. The fire flow (water necessary) for combating today’s fires with large quantities of hydrocarbon based fire loading is higher than ever and continues to grow each year. Hence the trend away from 2 ½ and 3 inch diameter supply hose to large 5 and 6 inch diameter hose; and movement from the ISO minimum 300 gallon water tank capacities (ISO Mitigation) toward those of 1000 gallons and higher for even city fire departments.

Although it is not recommended to begin interior fire fighting operations until a secondary supply of water has been established, this extra on board water can make a difference in a quick fire knock down when municipal supplies are marginal. Flow rates through modern 1 ½ and 1 ¾

inch hose lines with adjustable nozzles can be as high as 125 and 175 gallons per minute respectively. With only 300 gallons of water on board, that equates to less than 2 ½ minutes of water flow with only one 1 ½ inch diameter hose operating. Even with a 1000 gallon tank and a single 1 ¾ inch hose line flowing up to 175 gallons per minute, the water supply would last less than 6 minutes. The minimum size attack hose lines for many departments fighting commercial building fires is 2 ½ inches in diameter because it is capable of flowing as much as 275 gallons per minute.(Hall p 526) Flow rates such as these, even with larger tanks, provide barely enough time to get supply lines connected and water flowing from a hydrant to the apparatus before the on board water supply is exhausted. As previously stated, beginning an aggressive offensive fire attack inside a building using only tank water is a very dangerous practice(Phase 2 p 126) and should be avoided unless there is a viable life inside the structure that needs to be rescued.

Water supply was one of the major challenges in this fire. Not only was there an immediate lack of available hydrants in close proximity to the building, but those that were available and used during the initial phases of the operations were not even on the same side of the 4 lane highway as the structure. The nearest hydrant to the building had been removed from service as it was continually being struck by truck traffic in and out of an adjacent property. The next nearest hydrants were over 500 feet away requiring relay pumping through a single 2 ½ inch diameter hose lays of 850 feet and a second single hose lay of 1750 feet of 2 ½ connected to 100 feet of 3 inch. Even with pressure from the city hydrants boosted by placing an engine at the hydrant and pumping toward the engines at the scene they could not overcome the friction loss in the hose to deliver the necessary water.(Phase 2 pp 124-128)

Friction loss in a hose or pipe is caused by disruption of the laminar flow of water within it due to the interior surface texture. The larger the diameter of hose the lower the ratio of disrupted flow to laminar flow with the result being more water flowing through the same combined cross sectional area. For example, a single 5 inch diameter supply line can flow 1250 gallons per minute through 600 feet of hose using the hydrant pressure of 65 psi and a residual pressure of 10 psi at the discharge end. It takes six 2 ½ inch diameter hoses at the same pressure and distance to flow 1260 gallons per minute.(STICO p SM 5-5)

The total water available from the two initial supply lines was less than 600 gallons per minute, even with boosting them to dangerously high pressures in an attempt to overcome the friction loss.(Phase 2 p 126-127) As many as nine hose lines had been extended from the two engines pumping at the scene with a calculated demand of nearly 968 gallons per minute. Therefore none of the hand lines being used during the initial attack were performing at their optimal flows. The hydrants in the area were capable of providing the necessary water flow for those attack lines used during the first 30 minutes of operations if proper supply lines would have been established.(Phase 2 p 128)

Later in the operations, master streams would be set up that caused the demand to exceed the water main and hydrant capacity in the area. (Phase 2 p 128) Master streams are large flow water application devices for 300 to 2000 gpm that can either be set up at ground level, or from elevated positions like aerial ladder trucks. They are designed for defensive fireground operations to apply large amounts of water to prevent fire spread from the building of origin by suppressing the fire or to adjacent structures by cooling their exterior surfaces due to radiant heat exposure.(Hall p 596)

Fire flow for purposes of common firefighting is calculated based on the total square footage involved divided by 3.(PICO p SM 5-4) The showroom being over 31,000 square feet and the warehouse of over 15,000 square feet would have demands of 10,300 gallons and 5,000 gallons per minute respectively if in fact they were separate fire divisions. Combined, due to lack of proper fire separation, total fire flow in excess of 15,000 gallons per minute could be needed to control the fire when fully involved in fire.

Exposures

Exposures on the fire scene can be external that must be protected from ignition or radiant heat damage; or can be those that create problems with normal fireground operations based on the building's own layout or construction.

There were some exterior exposures to the fire building created by nearby properties. Namely some residential properties and a garage building close to the warehouse. Once a determination was made that the fire in the warehouse was moving faster than could be overcome, the crews on that assignment went to a defensive strategy to protect the adjacent residential exposures.(Phase 2 p 93)

In this case the most critical factor was that the building created its own exposures. This was caused by lack of proper fire separations and opening protection that permitted the fire to extend from its area of origin by communicating through unprotected openings or directly through the metal siding into three adjacent areas.(Phase 2 p 85)

Other problems with the building construction that prevented traditional roof ventilation operations were the lack of "natural" openings in the roof and the design of the front parapet wall behind the entrance facade. The height of the front parapet wall prevented normal ladder operations from being conducted via the front side of the building where there was space to set up the aerial ladder. This 23 foot high parapet was part of the original construction and the two flanking additions to give the appearance of a much larger building above the existing 12 to 14 foot building roof line. It served no other purpose than cosmetic and would prove to be a significant impediment to roof operations.(Phase 2 p 41) Effective ladder company operations were also restricted along the sides of the building due to the narrow paved drives on each side that were within the standard collapse zone. Access to the rear of the showroom building was not possible due to trees and insufficient paved space. The rear of the warehouse area was accessible only on the side that abutted the public street, as the other sides were unpaved or had adjacent exposures.

The lack of conventional roof operations caused the conditions inside the building to deteriorate much faster than if normal vertical ventilation had been possible. Without being able to release the superheated products of combustion, they spread laterally at a much faster rate contributing to the risk of flashover inside.(Phase 2 pp 42-43)

Fireground Operational Issues – Strategies and Tactics

The fire department has been criticized in both the OSHA and Post Incident Assessment & Review Team investigations for errors in how the fire was fought. This is not to say that application of water in an effort to extinguish the fire was wrong, but they specifically address how the fire-

ground operations were managed. Problems were deemed to be the directly related to the fireground command, the department's culture, and equipment issues.

Incident Management is the ultimate responsibility of the Incident Commander (IC) who must conduct a risk assessment, develop an Incident Action Plan (IAP), assign resources and monitor the effectiveness of the operations aimed at accomplishing the goal(s) of the plan. As conditions continually change, the IC must be able to receive information, process the data, determine if actions are successful and change strategies and tactics as necessary to continue to have a positive impact on the situation. Other responsibilities for the IC include: maintaining effective communications, establishing an accountability system for personnel and requesting adequate resources far enough ahead of the current situation to control the fire.(NFPA 1500)

In this case, a single command was not established as evidenced by two separate operational commands attacking the fire with no coordination between them. One group of firefighters was able to escape through a nearby exit, but the other was too deep inside the building to find their way out before running out air. At one point three fire officers were directing independent operations on the same fire scene, violating the principle of a unified command. The fire chief did not exercise that single point of control over the fireground operations and became personally involved in operations near the loading dock (at the tactical level) making him unable to view or effectively command the overall incident (at the strategic level).(Phase 2 p 97)

Operations that took the firefighters as much as 200 feet into the building were risky because of the intense fire load and lack of readily locatable or even usable exits.(Phase 2 p 97) With the SCBA air management issues identified in the Phase 2 Report, safe working time inside the building, after finally reaching the fire area would have been extremely short and left no margin for safety in case they would become lost or entrapped. The goal of the air management policy required under NFPA 1404, Chapter 5.1.1 is to ensure each firefighter is aware of their air consumption patterns. With this in mind, interior firefighting work cycles in the IDLH environment must be kept short enough to ensure the firefighter can safely exit without the need to encroach on the "reserve" air supply. This reserve air supply is intended to provide the firefighter with a limited margin of safety that is only to be used in case they need to be rescued. No Rapid Intervention Team to rescue a firefighter in trouble was assigned even after undertaking the aggressive interior firefighting strategy. Each arriving crew was given the next tactical assignment instead of standing by for rescue operations. This clearly violated the OSHA 2 in / 2 out Rule found in the Respiratory Protection Standard, 29 CFR 1910.134 (g) 4. Command also did not appoint a functional Safety Officer(s) as required under NFPA 1500 – 6.1.4 and NFPA 1521 – 4.1.4.1 .

The Charleston Fire Department commonly staffed many of their apparatus with only three personnel, and only some were staffed with four. The first apparatus on the scene were only staffed with three firefighters each.(Phase 2 p 47) NFPA 1710 states that a minimum staffing of four persons on each fire apparatus is required to ensure the safety of the crew and provide the necessary manpower once on scene. The National Fire Academy recommends at least one firefighter for every 25 to 50 gallons per minute of fire flow demand.(MCTO-P IG 5-39) This incident could have easily used as many as 300 firefighters to provide for the normal search and rescue, suppression, ventilation, Rapid Intervention Crews, back-up crews, and support as the incident continued into a fully involved structure fire. They also initially responded with what

many fire service officers would consider a “light” response. Originally two Engine Companies and one Aerial Truck Company were dispatched along with a Battalion Chief (BC) were sent.

Upon the BC marking “smoke visible” while leaving the station driveway, a third Engine Company self dispatched according to established protocol. An additional 6 Engine Companies would be requested in the twenty minutes following the arrival of the first apparatus – one at a time. In commercial fires, resources are most commonly requested in groups, often referred to as “Additional Alarms” or “Box Alarms”. The intent of calling multiple pieces of apparatus is to get ahead of where you believe the fire will be once those resources arrive. Reflex time required to get from the request of resources until their arrival on scene becomes greater as the incident grows in size because those resources generally must come from farther away.(STICO p SM 3-4) Combining the lack of manpower and too few apparatus significantly hindered safe and effective operations

The Charleston Fire Department was very familiar with fighting residential fires, but had little training or experience with large, complex commercial fires. Aggressive offensive interior attacks were common practice for this department in residential fires. This would be a dangerous practice on a commercial fire when the required water supplies to support such activity had not yet been established. The water supplies that were eventually established were far too small to meet the basic fire flow required to control or extinguish the fire, as were the initial attack lines used in relation to the fire load involved. This left the crews inside dangerously exposed. However, this strategy may have worked if there had not been conditions that caused the fire to communicate from the loading dock into other areas of the building and a sufficient water supply would have been available. Because there was no information available to the IC to identify the potential problems, the offensive attack continued far longer than it should have. The final change from an aggressive offensive interior fire attack, withdrawal of the interior crews, and the move to a defensive strategy came too late. Readily observable conditions existed on the fireground that should have indicated they would not be able to control the fire.(Phase 2 pp 95-99)

No procedures had been developed and communicated to the firefighters to deal with operations involving the recognized safety hazards of metal truss roof structures, as noted in the OSHA citations. Truss roof construction is common to nearly every community, from small neighborhood retail stores to the “big box” stores and commercial warehouses. The major problem is the lack of protection for the structural members from heat making them highly susceptible to catastrophic collapse. A thermal imaging camera was available on the aerial truck that initially responded, but was not used to examine the building for fire extension into the ceiling voids.(Phase 2 p 86) Use of the camera would have provided early indications that fire was spreading undetected overhead in the concealed space between the ceiling and roof and allowed a timely retreat from the building.

The lack of conventional roof venting operations accelerated the fire’s lateral spread and would have been an early warning to change strategies. In this case collapse of the structure came after the firefighters are believed to have already died of carbon monoxide poisoning, smoke inhalation and / or thermal burns from being lost too deep inside the structure. However, the hazards of truss roof construction are well documented and outcome is almost always the same – sudden and catastrophic collapse as one or more parts of the system weaken and fail due to heat exposure. Knowing the reasonable limits of safe working time inside once heat levels become critical is essential to preventing loss of life. This requires an intimate knowledge of building

construction and how it is affected by fire. Unprotected structural steel members, as were used in this building, will begin to weaken to a point where they will no longer support even their own weight when heated above 1000 degrees F. (Hall p 70) Steel bar joists have been shown to collapse in as little as 9 minutes when directly exposed to fire. (PICO p SM 1-10)

Communication problems were encountered as the entire operation was being conducted on a single radio channel.(Phase 2 p 111) This caused many radio transmissions to be broken or unintelligible, and the initial distress calls by lost firefighters to go unheard and unanswered from the fireground. The first indication of firefighters in distress was communicated to the Chief by an Assistant Chief arriving later who informed him of what he was hearing on the radio away from the fire scene.(Phase 2 p 105) Also, without a functional Personnel Accountability System in place it was impossible to tell who was doing what and where they were, as crews had become separated and reassigned to other tasks away from their apparatus and normal duties.(Phase 2 p 122)

Key Factors Affecting the Outcome

Based upon the collective opinions of the members of the Charleston Post Incident Assessment and Review Team, they developed a list of key factors that had a direct impact on the outcome of this tragedy and could be used to prevent similar incidents in the future. Listed below is a summary from the panel opinions with additional commentary by the reviewer.

Building and Property – Owners/Occupants

- It is believed that this fire could have been easily prevented if proper care had been taken to prevent employee smoking near the storage of debris and other combustible materials immediately outside the loading dock.
- Installation of an automatic sprinkler system would have easily controlled the fire and prevented it from extending further into the building from the loading dock area – making this a fire of little consequence.
- The building owner would have been required to install a sprinkler system as part of the “fill-in” construction projects if proper building permits would have been obtained. This creeping construction compromised the integrity of the fire separation originally provided between the showroom and warehouse.
- The severity of the fire would have been reduced had improper storage of flammable liquids had not occurred in the loading dock area.
- Firefighters might have been able to escape the building before running out of air if proper exits had been maintained – some were even found to have been padlocked.
- Implementation of an Emergency Action Plan for the building occupant would have enabled them to ensure all employees and patrons were safely out of the building and accounted for. Accountability for the occupants reduces the resources that must be directed toward performing search and rescue operations by the initial responding fire personnel.
- An effective Fire Code Inspection and Engine Company Preplan Program would have discovered the deficiencies in the building and they would have been addressed through proper administrative procedures.(Phase 2 pp 133-134)

Fire Department Operations

- The fire suppression activities did not comply with South Carolina (Federal OSHA is adopted verbatim) health and safety regulations or NFPA consensus standards. These included those

items cited in the initial OSHA violations as well as aspects of many NFPA standards such as: NFPA 1500 – Fire Department Occupational Health and Safety Programs, NFPA 1404 – Fire Service Respiratory Protection Training, NFPA 1981 – Open Circuit SCBA for Emergency Services, etc.

- Lack of an effective Incident Command structure complicated a difficult situation. Changes in conditions that should have signaled an immediate change in strategy were not recognized and acted upon.
- The Charleston Fire Department was inadequately staffed, trained and equipped to handle a fire of such complexity and magnitude. In an effort to compensate for these problems, they engaged in dangerously aggressive tactics, including placing firefighters far too deep inside the structure in regard to their available air supplies.
- The department's normal, aggressive operational mode of using small hose lines with limited water volume was adequate for most of the fires encountered at the residential level, but was inappropriate for a large commercial occupancy with high fire load. They were not prepared for a fire where different or changing strategies would need to be employed based on the observed conditions.(Phase 2 pp 134-135)

Lessons Learned for the Fire Service

The intent of the Post Incident Assessment and Review Team Report was to provide a learning base so other departments can implement the changes necessary to prevent future tragedies. This has been one of the most detailed investigations ever conducted in an effort to not only improve the department involved, but allow others to learn as well. However as cited in the report, many of the recommendations are not new, but reinforce those that already should be known and widely implemented within the fire service.

Incident Management must be fully integrated at all levels of the department operations for all incidents, including:

- a single Incident Commander,
- establishment of a command post where an overview of the entire incident is possible,
- proper delegation of authority and responsibility for tactical and task level activities,
- use of an appropriate strategy based on size up of the incident,
- application of the principles of risk management,
- development of an Incident Action Plan to organize the strategic and tactical level activities,
- effective management of resources,
- situational awareness to be able to respond to changing conditions,
- assignment of Safety Officer(s) within the command structure,
- control over incident communications so operational and emergency traffic can be heard, understood and responded to,
- implementation of an effective Personnel Accountability System so the status of crews and individual firefighters can be determined at any time and on a regular basis as the incident progresses,
- standardized procedures for operations involving multi-jurisdictional responses to maintain a unified command structure.(Phase 2 pp 137-138)

Risk Management should be integrated into the process of scene size-up to perform a Risk/Benefit Analysis to determine the appropriate course of action for that particular set of circumstances.

Incident strategies should be appropriate for the situation based on the initial size-up of the event. The Incident Commander must consider all factors related to the situation including the resources available and the department capabilities to determine if an offensive strategy should initially be undertaken. If the resources and capabilities are not in place at the scene to effectively control the situation, such as an established water supply and capabilities for proper ventilation that can be coordinated for maximum effectiveness, the offensive strategy is dangerous and should not be undertaken. And most importantly, if conditions change, being trained to recognize those early warning indicators and changing the incident strategy from offensive to defensive is vital to the safety of the firefighters.(Phase 2 p 138)

Firefighter safety issues outlined in both the OSHA and NFPA standards as well as currently accepted operational procedures that should be implemented by all departments include:

- designating Incident Safety Officer(s) at all working incidents,
- maintaining the integrity of each Company or Crew so each company officer has direct supervision of the personnel in his charge as all members enter the building together, remain in contact with each other and leave the building together,
- assignment of Rapid Intervention Teams (or Crews) to provide an immediate response to a firefighter in trouble inside the IDLH environment,
- implement and utilize a firefighter Personnel Accountability System at all incidents that also includes those off-duty personnel who may have responded and to help discourage “freelancing” on the fire scene,
- training for all fire department members in the procedures for Maydays including self-rescue and rapid intervention,
- training of the firefighters in the concepts of Crew Resource Management where they will be able to recognize and challenge situations outside the “norm” that affect safety.(Phase 2 p 139)

Self-contained breathing apparatus (SCBA) issues centered around the lack of an Air Management Program as outlined in NFPA 1404. Better ongoing maintenance of the equipment, training in its use, and accountability for its state of readiness are necessary to ensure the safety of personnel.(Phase 2 p 140)

Radio communications were a challenge due, not due to problems with the functionality of the system, but lack of proper use to distribute tactical operations onto separate workgroups that are monitored, making appropriate situational and accountability reports.(Phase 2 pp 140-141)

Training of personnel in both basic skills and command level duties was lacking any type of performance evaluation to test the knowledge, skills and abilities of the members and how specifically to apply the principles of operational risk management.(Phase 2 p 141)

Fire department resources should be increased in the areas of on duty manpower, apparatus staffing and equipment dispatched on incidents. Additional resources should be summoned in a structured manner so adequate manpower and apparatus are available ahead of the actual need, cutting down on reflex time. Truck company operations were lacking within the department as a

dedicated function and should be emphasized in standard operations, as these are key to successful ventilation, forcible entry and searching for victims.(Phase 2 p 141-142)

Mutual Aid agreements should also include standardization of procedures, communication and equipment where possible to reduce the problems associated with interoperability between the departments.(Phase 2 p 142)

Advancing technology should be continually explored and exploited to improve safety, including more use of thermal imaging cameras, improving communication systems, firefighter accountability, pre-fire planning information management, and positive pressure ventilation, etc.(Phase 2 p 142)

Pre-fire planning of all business or high hazard occupancies to identify risks should be expanded as an informational gathering tool to ensure situations are not blindly entered where there is little chance of a successful outcome.(Phase 2 p 143)

Code Enforcement and Risk Mitigation must become part of the normal city activities through systematic inspections followed by corrective action. These must also be performed by qualified members who can communicate code enforcement issues to the appropriate bureau within the city for action. Proactive measures such as stricter requirements for installation of automatic sprinkler systems or other alternative protection systems should be supported at the local, county and state level.(Phase 2 p 143)

Coordination between affected agencies was identified as critical to successful outcomes. These included: the Police Department for traffic control and scene perimeters, the Water Department for hydrant placement, maintenance and water main adequacy, EMS and the Building Inspections Division.(Phase 2 p 144)

Epilogue

To date, the city of Charleston has set aside or spent more than \$7.4 million as result of the Sofa Super Store fire. Most of this money is allocated directly to improvements of the fire department. The money is being drawn from funds budgeted since the fire, emergency reserves and private donations of \$228,000 by local businessman Gene Reed to purchase compliant uniforms. It has caused the city's first tax increase since 1999.

Gordon Routely, leader of the Charleston Post Incident Assessment and Review Team, stated to reporters from the Charleston Post and Courier that this should send a message to other fire departments and elected leaders who oversee them.(Menchaca & Smith)

A Phase 3 Report is expected at some future date that will focus on strategic implementation of the recommendations. It is expected that complete implementation may take up to five years.(OH&S August 2008 p 65)

Recently, nationally noted Fire Chief Thomas Carr of the Montgomery County, MD Fire and Rescue Services was named by Mayor Joe Riley and confirmed by the Charleston City Council to take over the position as Fire Chief for the City of Charleston.

A detail of the expenditures released under a Freedom of Information Act request showed about \$3.6 million is to be spent on staffing, equipment and training for the fire department, about \$1.8 million on purchase of the Sofa Super Store property to erect a memorial, \$1.2 million to supplement state Workers Compensation benefits to the families and \$320,000 for the fees to the panel who investigated the incident. The legal fees and fines to settle the alleged safety violations cited by OSHA totaled about \$76,500 not including city legal staff expenses. Post-tragedy counseling services for the firefighters and the memorial service conducted came to nearly \$270,000 and \$62,000 respectively.(Menchaca & Smith)

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