DEPARTMENT OF HEALTH & HUMAN SERVICES

Public Health Service

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July 2008

Dear Fire Fighting Professional:

The National Institute for Occupational Safety and Health (NIOSH) Fire Fighter Fatality Investigation and Prevention Program was established in October 1997. NIOSH conducts independent investigations of fire fighter line-of-duty deaths and develops a written investigation report which includes a summary of findings and recommendations for injury prevention. One of the primary goals of the program is the distribution of information to fire departments and fire fighters across the country for use in injury prevention efforts.

Enclosed are copies of five fire fighter investigative reports and a Safety Advisory for your use and distribution to others in the fire fighting community. One report contains information on a fire fighter who was killed after the front awning and façade collapsed at a commercial structure. Another report covers the death of a fire fighter who became trapped at a residential fire while operating above the fire without a hose line. Two reports contain information about fire fighters who suffered heart attacks, one during a structure fire and one during physical fitness training. The last report contains information about a junior fire fighter who was killed when the tanker truck she was riding in failed to negotiate a sharp curve while responding to a structure fire. The Safety Advisory contains information from a recent investigation in which a fire fighter was struck and killed by an unsecured waterway that separated and was "launched" off an aerial ladder as the apparatus was being put into service for master stream operation.

The reports are in the public domain and may be copied, duplicated, or distributed in any way you see fit. We encourage you to use the information contained in these reports to improve the safety of our nation's fire fighters. To help us improve communication of this information, we would appreciate any feedback regarding the usefulness of these reports and how you used or further distributed the information. You may send comments to me at the address shown above. Your input will help us better meet your needs for information on the risks and prevention of fire fighter injuries and deaths.

Additional information on the NIOSH Fire Fighter Fatality Investigation and Prevention Program, along with copies of all individual investigation reports, can be accessed via the NIOSH web page at http://www.cdc.gov/niosh/fire/. NIOSH is committed to improving the health and safety of our nation's fire fighters and appreciates the opportunity to work with the fire fighting community to reach that goal.

Sincerely yours,

Nancy Stout

Nancy Stout, Ed.D.
Director
Division of Safety Research

Enclosure

2007
01
NIOSH
Fire Fighter Fatality Investigation and Prevention Program

Death in the line of duty...

A summary of a NIOSH fire fighter fatality investigation *July 06, 2007*

Career Fire Fighter Dies and Chief is Injured When Struck by 130-Foot Awning that Collapses during a Commercial Building Fire – Texas

SUMMARY

On December 30, 2006, a 31-year-old male career fire fighter (the victim) died when he was struck by a collapsing awning while applying water to hot spots at a structure fire in a one-story commercial building. The Chief of the department was also struck by the collapsing awning. Both the victim and the chief were trapped under the awning. Extrication took approximately 10 minutes. The 130-foot long building was approximately 45 years old and at the time of the fire was divided into three separate business areas. The front of the building was mostly glass with wood and concrete blocks between and above the glass panels and doors. The structure had a flat roof consisting of plywood sheeting covered by layers of tar and was supported by open-web, pin-connected metal and wood trusses. An awning constructed of wooden 2" X 4" framing lumber, plywood, and asphalt shingles was attached to the top of the front wall and extended the entire length of the building (see photo 1). The fire was reported at approximately 0841 hours and fire fighters were on-scene within 5 minutes containing the fire to the building. Interior operations were suspended after the fire intensified and fire fighters worked to suppress the fire from the exterior. The open-web truss roof collapsed approximately 20 minutes after fire fighters arrived on scene. At approximately 0910 hours, the victim was directed by the Chief to stretch a 1 ¾ inch handline to the south end of the front of the structure to put water on hotspots burning in bundles of rolled roofing material located near the front of the structure. Minutes later, the awning broke loose from the front wall, rolled forward and fell, striking both men and pinning them beneath the overturned awning. A third fire fighter, at the north end of the building was struck on the leg and foot by falling debris, narrowly missing serious injury.

Incident scene. Photo courtesy of fire department

The Fire Fighter Fatality Investigation and Prevention Program is conducted by the National Institute for Occupational Safety and Health (NIOSH). The purpose of the program is to determine factors that cause or contribute to fire fighter deaths suffered in the line of duty. Identification of causal and contributing factors enable researchers and safety specialists to develop strategies for preventing future similar incidents. The program does not seek to determine fault or place blame on fire departments or individual fire fighters. To request additional copies of this report (specify the case number shown in the shield above), other fatality investigation reports, or further information, visit the Program Website at www.cdc.gov/niosh/fire/ or call toll free 1-800-35-NIOSH.

NIOSH investigators concluded that, to minimize the risk of similar occurrences, fire departments should:

- ***establish and monitor a collapse zone for structures that have become unstable due to fire damage***
- ***train all fire fighting personnel in the risks and hazards related to structural collapse***
- ***conduct pre-incident planning and inspections of buildings within their jurisdictions to facilitate development of safe fire ground strategies and tactics***
- ***ensure that adequate numbers of staff are available to immediately respond to emergency incidents***
- ***ensure that a separate Incident Safety Officer, independent from the Incident Commander, is appointed at each structural fire***
- ***ensure that the Incident Commander maintains the role of director of fireground operations and does not become involved in fire fighting efforts***
- ***ensure that switching from offensive to defensive operations are coordinated and communicated to everyone on the fireground***
- ***ensure that fire fighters wear a full array of turnout clothing and personal protective equipment (i.e. SCBA and PASS device) appropriate for the assigned task while participating in fire suppression and overhaul activities***

Additionally, manufacturers, equipment designers, and researchers should:

- ***continue to develop and refine durable, easy-to-use systems to enhance verbal and radio communication in conjunction with properly worn SCBA***
- ***continue to pursue emerging technologies for evaluating and monitoring the stability of buildings exposed to fireground conditions***

INTRODUCTION

On December 30, 2006, a 31-year-old male career fire fighter (the victim) died when he was struck by a collapsing awning while applying water to hot spots at a structure fire in a one-story commercial building. The Chief of the department was also struck by the collapsing awning and pinned beneath the debris. A third fire fighter working at the opposite end of the building was struck on the leg and

foot by falling debris, narrowly missing serious injury. On January 03, 2007, the U.S. Fire Administration (USFA) notified the National Institute for Occupational Safety and Health (NIOSH) of the fatality. On January 16, 2007, a Safety Engineer and the Senior Investigator from the NIOSH, Division of Safety Research, Fire Fighter Fatality Investigation and Prevention Program traveled to Texas to investigate the incident. Meetings were conducted with the Fire Chief, Assistant Chief, City Attorney, City Fire Marshal, a representative of the International Association of Fire Fighters

Photo 1. Front of incident structure prior to awning collapse. Photo courtesy of fire department.

(IAFF) union local and the building owner. Interviews were conducted with officers and fire fighters who were at the incident scene. The NIOSH investigators discussed the incident with the Deputy State Fire Marshal in charge of the state investigation. The NIOSH investigators reviewed the victim's training records, the Incident Commander's (IC) training records, and floor plans and photographs of the structure. The incident site was visited and photographed. However, the site had already been razed and debris was being cleared at the time of the NIOSH investigation, so details of the building construction were limited.

Fire Department

The fire department involved in this incident is comprised of 49 career fire fighters and 5 administrative and support staff (Chief, Assistant Chief, Fire Marshal, Training Officer, and

Maintenance Officer), has 3 fire stations, and serves a population of approximately 23,000 in the immediate municipality and a total population of approximately 28,000 in an area of about 96 square miles that includes urban, suburban, forest and farm land.

Fire fighters at this department are assigned to one of three rotating shifts. The fire fighters typically work 24 hours on and 48 hours off duty. At the time of the incident, there were 12 fire fighters on duty.

Training and Experience

This municipal fire department requires that fire fighters receive basic fire fighter certification from the Texas State Fire Commission and also basic emergency medical technician (EMT) certification from the Texas Department of Health. The Texas basic fire fighter certification is roughly equivalent to National Fire Protection Association (NFPA) Level II Fire Fighter Certification. New recruits typically work day shift and receive on-the-job training from all three shifts before being assigned to a regular shift. The fire department holds regular training classes on a variety of fire service topics.

The victim had been a fire fighter for approximately one year, was assigned to a regular shift, and received monthly training on subjects such as SCBA use and maintenance, hazmat awareness, hazardous materials, ladders, forced entry, ventilation, incident command, and fire critiques.

The Incident Commander (IC) at this fire had 34 years of fire fighting experience and had been an officer for 16 years. At the time of the incident, the IC served as a Captain and shift commander. He had previously served the department as Safety Officer and Training Officer. He was certified as an EMT and participated in regular on-the-job training and classroom training throughout his career.

Equipment and Personnel

There were 3 apparatus, 1 ambulance, 8 fire fighters, the Chief and the Assistant Chief (C2) on scene prior to the awning collapse. The Assistant Chief and the Chief responded from their homes in separate fire department vehicles.

The timeline for fire department response to the incident included:

0841 hours
Initial Alarm

0844 hours
Engine 101 [Captain (IC), lieutenant, engineer, and fire fighter] leaves Central Station

0846 hours
Engine 301 [fire fighter] leaves Station 3
Ambulance 301 [fire fighter (victim)] leaves Station 3
Engine 103 [two fire fighters] leaves Central Station

0848 hours
Engine 101 (attack crew) arrives on-scene and reports heavy smoke showing
Engine 301 arrives on-scene
Ambulance 301 arrives on-scene
Engine 103 (pumper) arrives on-scene

0850 hours
IC requests Chief, Fire Marshal, and additional manpower be dispatched to scene
Note: The Chief and Fire Marshal were notified but additional manpower was not called out.

0900 hours
Car 2 [Assistant Chief (C2)] arrives on-scene

0903 hours
C2 radios IC and requests additional manpower at rear of structure
Structure is evacuated – switch to defensive operations (time approximate)
Engine 103 is sent to rear of structure to protect exposures

0907 hours
IC radios dispatch and requests Aerial Ladder L100 be dispatched to scene

0910 hours
Chief arrives on scene (time approximate)
Roof collapses
Aerial Ladder L100 [fire fighter] leaves Central Station
Ambulance A101 [fire fighter] leaves Central Station
C2 radios dispatch and requests mutual aid to stand-by at Central Station

0913 hours
L100 and A101 arrive on-scene shortly after awning collapse
C2 radios dispatch to send Rescue 105 and mutual aid crew to scene

0915 hours
C2 radios dispatch to request second mutual aid department be dispatched

0923 hours
Chief is extricated

0925 hours
Victim extricated

Personal Protective Equipment

At the time of the incident, the victim was wearing a full array of personal protective clothing consisting of turnout gear (coat and pants), Nomex® hood, helmet, gloves, boots and a self-contained breathing apparatus (SCBA) with an integrated personal alert safety system (PASS). The victim also carried a radio. The Chief was dressed in street clothes

Structure

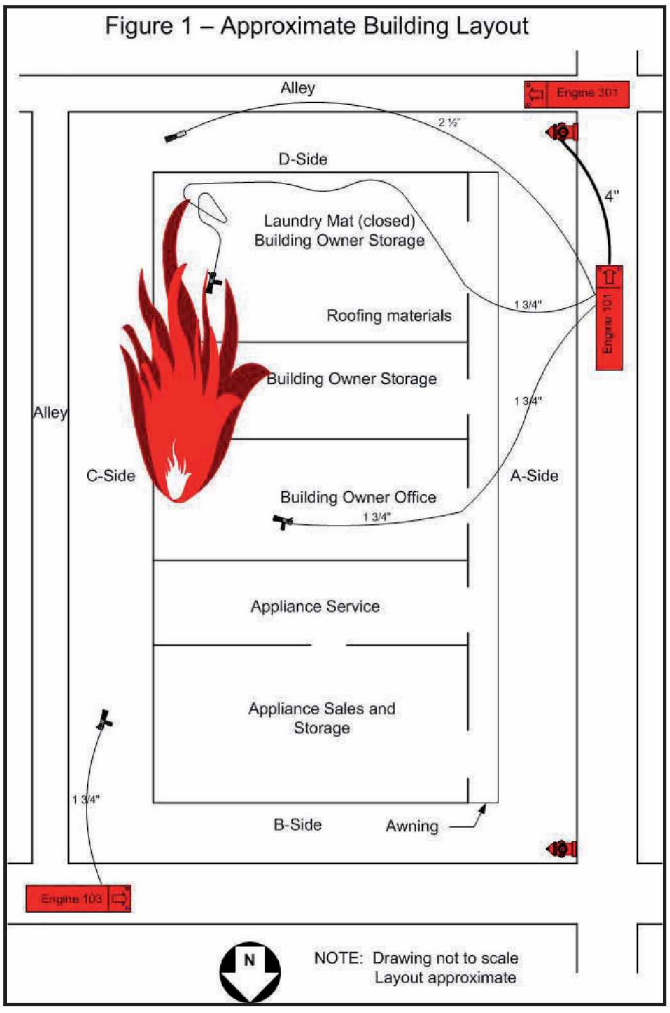
The structure involved in this incident was a one-story class-III commercial building (ordinary construction) built in the early 1960s (see Photos 1 and 2). The structure consisted of concrete block, brick, and poured-in-place concrete walls. The building dimensions were 45 feet wide by 130 feet long providing approximately 5800 square feet of floor space. The building was originally divided into 5 separate store areas, each having its own doorway access to the street (see Figure 1).

Photo 2. View from North end of building – post collapse. Photo courtesy of fire department.

The commercial building faced west with head-in parking separating the building from the street (see Figure 1). The front wall (A-side) contained large plate windows and doors for entrances to the different businesses located within the building. The north wall (B-side) was constructed of stacked

concrete block and bricks. The east (C-side) and south (D-side) walls were poured concrete. The majority of the rear wall (C-side) and the south end wall (D-side) were below grade. A triangular-shaped awning constructed of 2 X 4 framing lumber, plywood sheeting, and covered with asphalt shingles extended across the front of the building. The awning measured approximately 6 feet 8 inches by 6 feet 8 inches by 9 feet (see Figure 2). The awning was connected to 18 inch steel beams of various lengths that extended end-to-end across the front wall directly above the windows and doors and to concrete blocks stacked above the steel beams (see Figure 2 and Photo 3). The building had a flat roof constructed of plywood sheeting covered with layers of tar. The structure was approximately 16 feet high at the top of the awning. The roof was supported by open-web pin-connected metal trusses. The top and bottom chords of these trusses were constructed using wooden lumber measuring approximately 2 inch X 3 ½ inches. The metal webs were constructed from metal tubing of approximately one-inch diameter (see Figure 3 and Photo 4). The only static load on top of the roof was an air-conditioning condenser unit located near the rear wall at the north end of the structure that serviced the retail facilities at the north end. The bottom side of the trusses supported a suspended ceiling system and electrical junction boxes. There were no fire walls in place separating the different businesses and the structure had a common truss void above the suspended ceiling. At the time of the incident, the building was divided into three separate areas (see Figure 1). The northern end of the building contained a large-appliance sales business and an appliance repair business. The center area was used by the building owner as office and storage space for a number of businesses operated by the owner. The south end of the building contained a laundry that was closed at the time of the incident and was used by the owner to store roofing materials and supplies. *Note: It is believed the fire originated somewhere above the suspended ceiling in the center office area. Falling burning ceiling material ignited materials stored in the structure which contributed to the fire load and may have accelerated the roof collapse.*

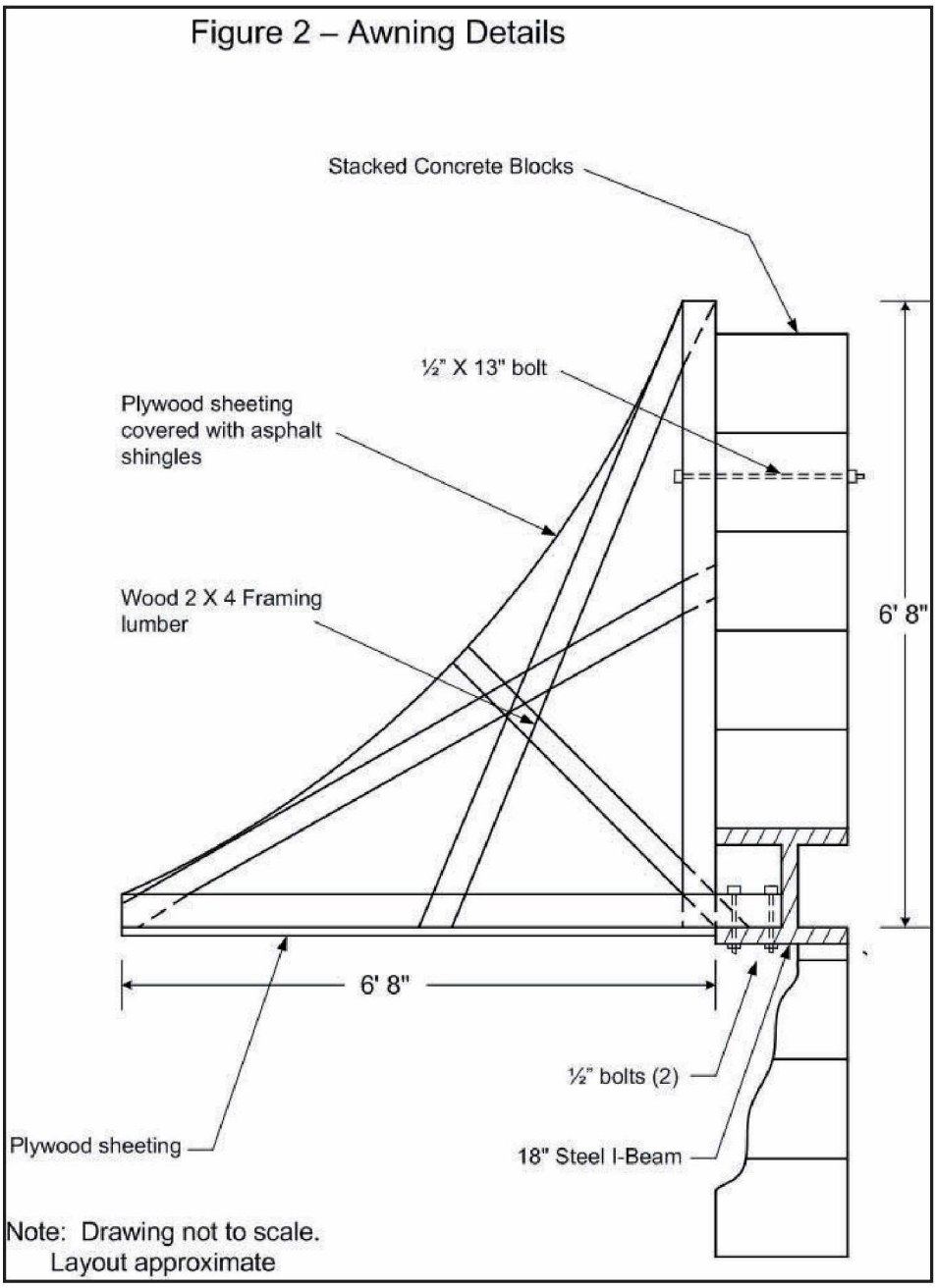
Figure 1 – Approximate Building Layout



Weather

On the day of the incident the air temperature was approximately 51 degrees Fahrenheit with cloudy skies and 88% relative humidity. The wind was blowing from the west at approximately 4 miles per hour.

Figure 2 – Awning Details



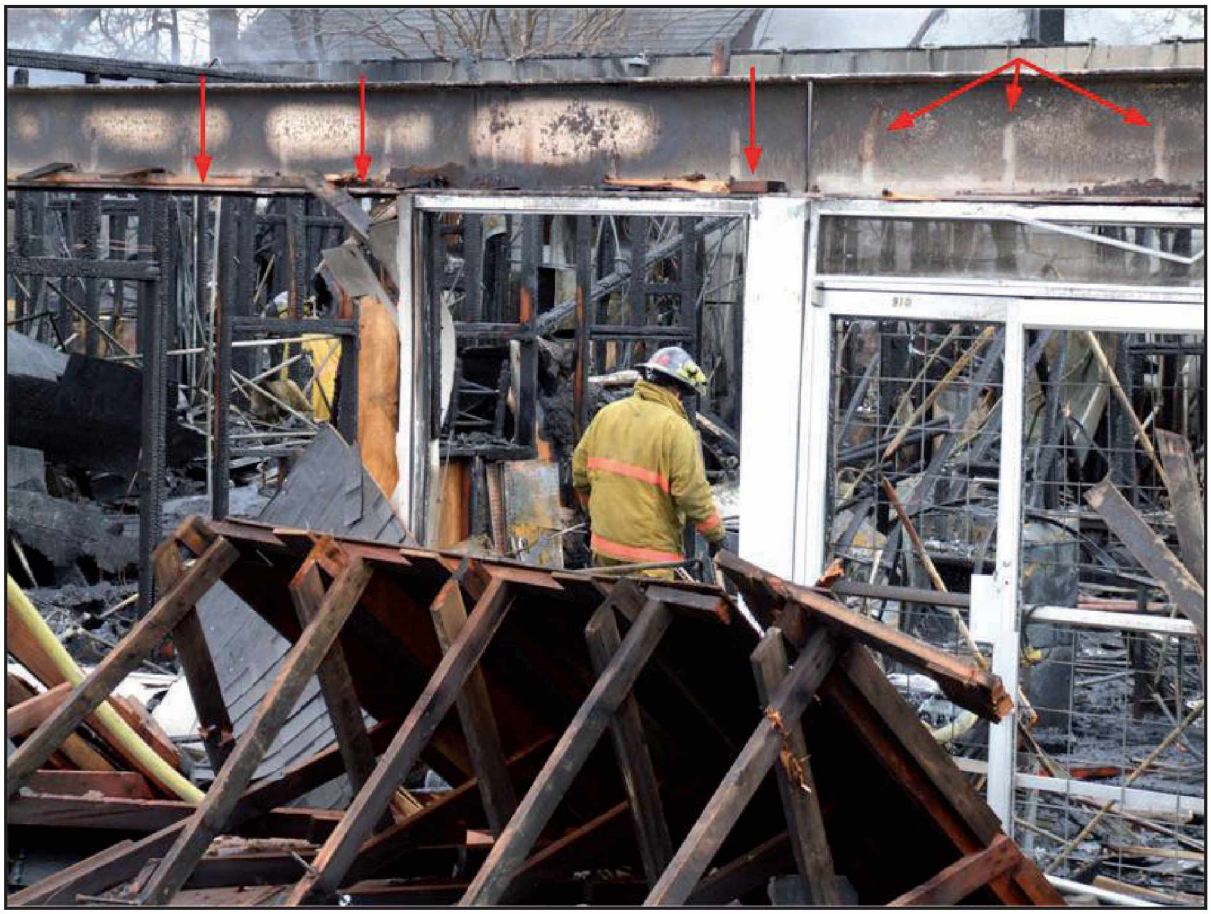


Photo 3. Note steel I-beams running across front wall above windows and doors. Note wood fragments where awning frame was connected to the I-beam. Burn patterns also indicate location of awning frame. Photo courtesy of fire department.

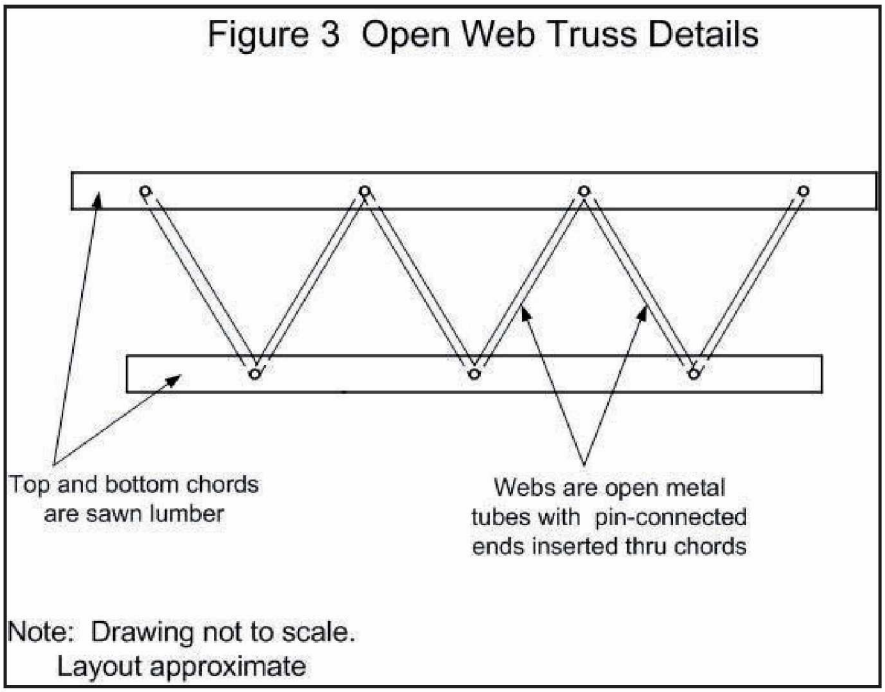


Photo 4. View from south-end of structure after awning collapse. Note the pin-connected metal webs still connected to the awning. The top and bottom chords of the trusses have been consumed by the fire. Also note the steel I-beam in place above the windows and doors. Refer to Figure 3 and Photos 5 and 6 for more details of the truss construction. Photo courtesy of fire department.

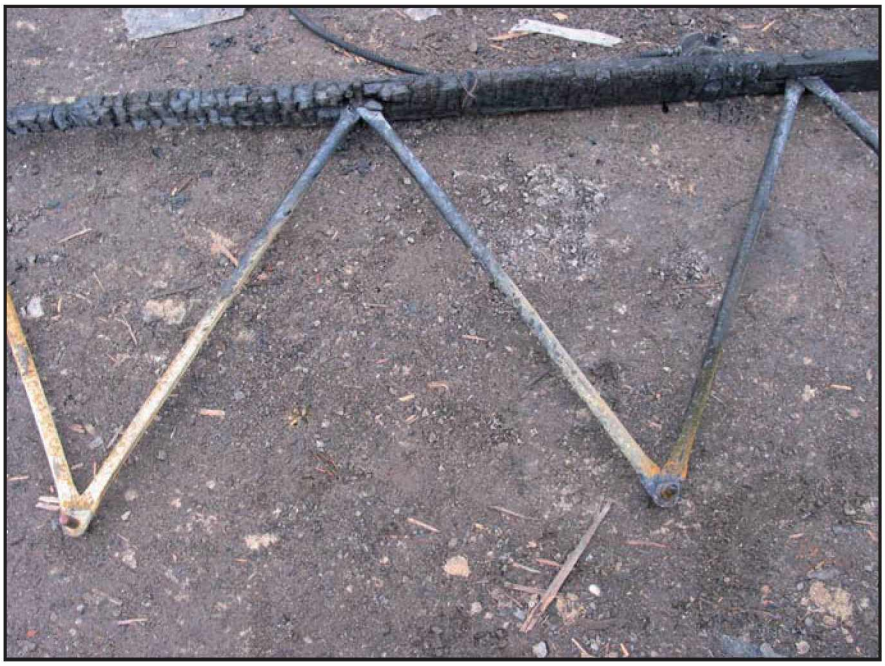


Photo 5. Open-web pin-connected trusses after fire. Photo courtesy of fire department.

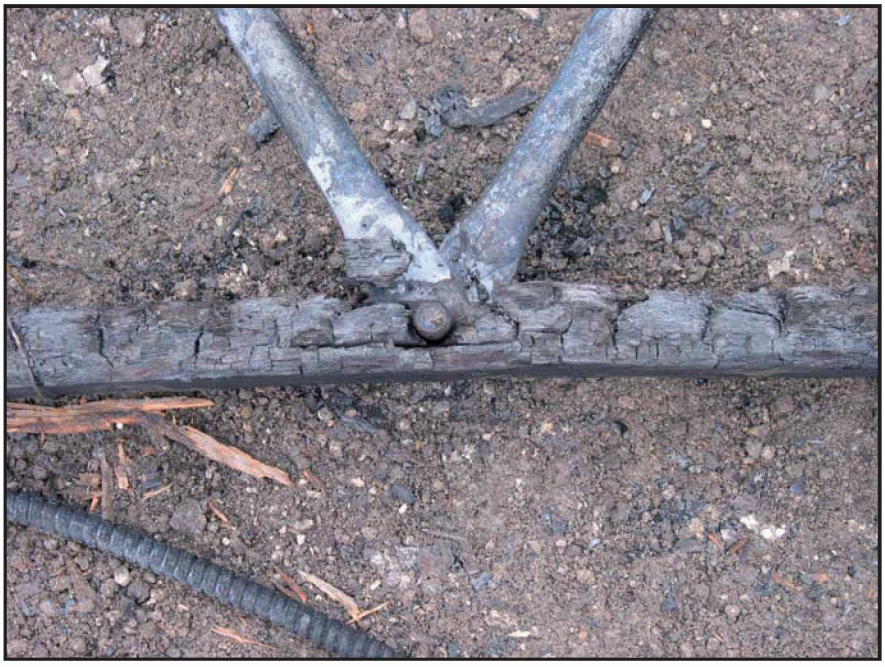


Photo 6. Close-up of pin connection in open-web pin-connected trusses Photo courtesy of fire department.

Career Fire Fighter Dies and Chief is Injured When Struck by 130-Foot Awning that Collapses during a Commercial Building Fire – Texas

INVESTIGATION

On December 30, 2006, at approximately 0841 hours a fire was reported at a one-story commercial building located approximately 10 blocks from the center of town. The dispatch center immediately notified the local fire and police departments. Following normal procedures, Engine 101 (E101) and Engine 103 (E103) were dispatched from Central Station and Engine 301(E301) and Ambulance 301 (A301) were dispatched from Station 3. *Note: A crew was just returning to Central Station from putting fuel in the aerial ladder truck when the call came in. Engine 101 left the station at 0844 hours. The second apparatus assigned to respond (Pumper 102) would not start so the crew had to take the backup engine (E103).*

Engine 101 (E101) left Central Station with a captain, lieutenant, engineer and fire fighter at 0844 hours and was the first apparatus to arrive on scene at 0848 hours. Engine 301 (E301) and Ambulance 301 (A301) left South Side Station 3 at 0846 hours, with a single fire fighter on board each apparatus. E301 and A301 arrived on scene just after E101. Engine 103 (E103) left Central Station at 0846 with two fire fighters and arrived on scene after the Station 3 crew at approximately 0848 hours.

As E101 approached the fire scene, the captain sized-up the building and noted the conditions. E101 parked in the street near the south-west corner of the building. The captain assumed Incident Command (IC) and radioed dispatch and reported heavy smoke showing. Dispatch acknowledged the transmission at 0848 hours. The lieutenant and fire fighter on E101 formed the interior attack crew and began stretching a 200-foot 1 ¾-inch pre-connected handline to the front of the building. The engineer took a haligan bar and a set of bolt cutters to the front of the building, then assisted the attack crew in pulling the hose and readied the pumps for operation. The IC radioed the attack crew to make forcible entry and to proceed to the south-east corner of the building to search for fire at 0849 hours. The IC then radioed E103 to lay a 4-inch supply line from a hydrant located near the south-west corner of the building into E101. The IC established the command post at the front of E101 and collected passport tags from the engineer. The two fire fighters who arrived on E301 and A301 were initially assigned as the rapid intervention team (RIT). E103 arrived on scene and the crew began laying the 4-inch supply line into E101. A second 1 ¾-inch pre-connected handline was pulled off E101 toward the center of the building. After pulling hoses, the E103 crew was instructed to put on their SCBA and prepare to back up the interior attack crew.

The E101 attack crew attempted to force open the door to the business at the southern end of the building. A cable was passed through the door handles and locked on the inside of the doors so the fire fighters had to use the bolt cutters on the cable. The bolt cutters would not cut through the cable so the IC directed the attack crew to break out the window to the left of the door. Heavy gauge wire mesh with approximately 8-inch-square openings was stretched across the window opening on the inside of the building as a security measure. The attack crew used the bolt cutters to cut through the wire mesh and then advanced into the building. While the attack crew was forcing entry, fire fighters from E103 and E301 began breaking out the storefront windows. At 0850 hours, the IC radioed dispatch and requested more manpower be called out due to the conditions at the fire scene. He also

requested that dispatch call the Chief and the city Fire Marshal. *Note: The Chief, Assistant Chief and Fire Marshal were notified but additional fire fighters were not called out, apparently because part of this radio communication was un-intelligible.*

During initial entry, the conditions inside the building were good. The attack crew encountered light smoke with no heat and they were able to walk upright. The E301 crew (two fire fighters including the victim) followed the attack crew inside. Visibility was good and they could see 10 – 15 feet in front of them, but they could not see the ceiling. They could not see any fire. The lieutenant on the attack crew radioed the IC that they could not find any fire. The IC told them to go toward the southeast corner. The attack crew asked the E301 crew to retrieve a thermal imaging camera (TIC) from E101. The E301 crew went outside, got the TIC, and took it to the attack crew. The attack crew advanced to the south-east corner of the building and then turned and followed the wall north where they began to hear the sound of fire overhead. The attack crew was inside the structure for approximately 3 – 5 minutes when the conditions suddenly changed dramatically. The temperature suddenly increased and heavy black smoke reduced visibility to near zero. The fire fighters were forced to their knees to avoid the heat. *Note: at some point, fire fighters began to experience problems with radio communications. Some messages recorded at the dispatch center were un-intelligible and other reported messages were not recorded at all. As examples, recorded radio traffic at 0852 and 0856 hours are broken and un-intelligible.* The attack crew told the E301 crew that they needed to back out of the building. They had to follow the handline by feel since visibility was very poor. The E301 crew exited safely. The attack crew became disoriented at a pile of looped hose and returned to the nozzle. They reversed direction and followed the hose to the front window where they exited the structure.

While the IC directed operations from the front of E101, a man approached and identified himself as the building owner. He stated that he had keys for an old flat-bed truck containing roofing materials and supplies parked on the sidewalk close to the building. The truck was blocking the IC's view of the building so the owner was allowed to approach the building and move the truck. When the building owner returned, he told the IC that the center part of the building was his office and contained a number of important papers. After some discussion about not entering the building, the IC asked the building owner if he (the IC) would be able to find the papers. The building owner stated the papers were on the desk just inside the door. The building owner and the IC approached the structure and the IC unlocked the door and went to the desk and gathered up an armload of papers. The IC had to make two trips into the office to retrieve all the papers from the desk. *Note: The IC was dressed in his station uniform, bunker coat and helmet. He did not have an SCBA.* The building owner then stated that there were a few more papers located in a file cabinet in the office that he needed to retrieve as well. After more discussion about where to find the papers, the IC told the business owner he (the owner) could make one trip into the office to get the papers. The IC remained outside the door until he saw the business owner approaching the door to exit the building, then he turned and walked back to the command post at E101. *Note: while inside the building, the IC observed fire in another room at the back of the building. He also reported he could feel the heat and could hear debris falling. He radioed the Lieutenant about the location of the fire. The Lieutenant*

attempted to tell the IC that he could not find any fire but radio transmissions were breaking up. According to the city fire marshal's report, the exact cause of the fire could not be determined due to the extensive fire damage to the structure. The fire marshal's report stated the fire originated in the concealed attic space somewhere above the center of the structure where the owner's business office was located.

Shortly after the IC returned to the command post (after entering the office two times to retrieve papers for the owner), the attack crew exited the building. The attack crew discussed the deteriorating conditions inside the south end of the structure with the IC. The IC directed the attack crew to take the second 1 ¾ inch handline from E101 (previously pulled) and enter the office area and proceed to the rear of the building where he had observed fire while retrieving the building owner's papers. One of the E103 firefighters and one of the E301 firefighters also helped drag the handline into the center office area. The attack crew entered the office area and encountered good conditions at the front of the office. They could still see the ceiling in this area and there was little heat. As they advanced the handline to the rear of the building, they encountered fire above them and applied water to the fire, but the water did not seem to have much effect. *Note: It is believed that the fire intensified in the area behind the office after the door was opened to retrieve the building owner's papers. When the attack crew advanced the handline into this area, they noted that the front door had been propped open (possibly by the building owner). This may have provided an influx of oxygen to feed the fire. Ventilation ducts for the laundry mat at the south end of the structure were still in place which may have aided in pulling the smoke and fire toward the south-east corner.*

The Assistant Chief (C2) arrived on scene at 0900 hours, reported to the IC and then began a walk-around of the building to observe the conditions at the other sides. The IC again radioed dispatch and requested additional manpower be called out to bring the aerial ladder truck (L100) to the scene because fire was beginning to vent through the roof at the rear of the building. The IC had to repeat this request over the radio. At 0903 hours, C2 radioed the IC and stated that there was an electric power pole at the rear of the building that was on fire. C2 also stated that a detached garage east of the fire building was in danger of catching fire. The IC acknowledged and said he would send the E103 crew (two fire fighters) around to the rear of the building. C2 radioed back that the local gas utility company needed to be called out to shut off the gas because a gas meter at the rear of the building was getting hot.

C2 returned to the front of the building and yelled for a 2 ½ inch hose line to be stretched around to the C-D corner (south-east corner) of the building. The firefighter on E101 was the last man on the hose line inside the building. He heard C2 yell for the 2 ½ inch hose line and went outside to assist the E101 engineer with stretching the hose.

Since the 1 ¾ inch handline was not having an effect on knocking down the fire, the crew decided to back out of the building. Once outside, they discussed the deteriorating conditions and the Lieutenant told the rest of the fire fighters to stay out from under the awning. *Note: At this point, all operations became defensive but this was not officially declared over the radio.*

C2 and the Lieutenant went back to the rear of the fire building to do forcible entry on one of the apparently vacant exposure buildings to make sure it was unoccupied. The E103 crew drove E103 around the block to the rear of the building and parked at the B-C corner. A lot of fire was showing along the top of the back wall. They used a 1 ¾ inch pre-connected handline to put water on the back wall and also on the burning utility pole. The E103 crew quickly emptied the 500 gallon water tank on E103. After quickly searching the exposure building at the rear, C2 and the Lieutenant returned to the front of the building. At approximately 0905 hours, C2 called the IC and stated that he needed someone to lay a supply line to E103. At approximately 0907 hours, the IC called dispatch and asked that the ambulance crew at Central Station bring L100 to the scene since the fire venting through the roof was intensifying. Dispatch had to ask that these instructions be repeated twice. The E103 crew walked along the B-side wall to the front of the building to look for a hydrant from which to establish a water supply to E103.

C2 and the Lieutenant went around to the southeast corner to assist with setting up the 2 ½ hose line. An additional 50 foot section of hose had to be retrieved from E101 and added in order for the hose line to reach to the C-D corner. The 2 ½ hose line was put into operation directing water onto the exposure buildings at the rear and then onto the roof. The C2 directed the IC to put the E101 deck gun into operation on the flames venting the roof. The IC climbed onto E101 and began operating the deck gun. The Chief arrived on scene at approximately this time but did not report to the IC. The E301 crew were positioned in the parking lot in front of the structure (A-side) using the two 1 ¾ handlines from E101 to direct water through the front doors. The victim was located near the south corner of the building and the other E103 fire fighter was between the center and the north end. At approximately 0910 hours, the roof collapsed in two steps. The roof area from the center to the south end of the building collapsed first and the rest of the roof collapsed shortly after. Also at approximately 0910 hours, the ambulance crew (two fire fighters) at Central Station departed for the scene with one fire fighter driving the aerial ladder truck (L100) and the other fire fighter driving ambulance A101. C2 called dispatch and asked that a mutual aid department be dispatched to Central Station to stand by for backup. The lieutenant stayed at the 2 ½ inch hose line nozzle while C2 returned to the front of the building.

Several rolls of roofing located just inside the front of the building near the south end began to burn which generated a large quantity of thick black smoke. The Chief directed the victim to put water on the roofing material in an effort to suppress this smoke. The victim moved closer to the building to direct his nozzle through a window and began putting water on the roofing material. The victim's low air alarm began to sound so the Chief took the nozzle while the victim went to E101 to get a new air cylinder. When the victim returned, the Chief handed the nozzle back and stepped behind the victim, placing his hand on the victim's shoulder.

Moments later, at approximately 0913 hours, the awning broke loose at the south end of the structure, rolled over and fell, pulling the entire awning down. It struck the victim and the Chief, pinning them under the debris. The victim was standing approximately 28 feet from the south wall and

approximately 2 feet from the building. The Chief was approximately 26 feet from the south wall and approximately 4 feet from the building. The victim was knocked down and pushed against the front wall in a sitting position with the awning pinning his lower body and legs. The Chief was knocked down flat in a position roughly parallel to the building with his head to the south. The awning came to rest with the concave surface facing downward creating a void between the awning and the sidewalk. The Chief was entirely within the void. The victim was standing closer to the building and was struck and pinned by the awning's edge. (see Photo 7).

Photo 7. Awning after collapse. Note holes cut through awning during extrication to free the trapped fire fighters. Also note how curvature of awning creates a void underneath Photo courtesy of fire department.

The awning collapse was witnessed by the IC, C2, and the E101 engineer in front of the building, as well as the E103 crew at the north end. The E301 fire fighter near the north end of the building was struck on the leg and foot by falling debris. A police officer directing traffic near the north end was also struck by flying debris. C2 immediately called dispatch and declared "Man down". He requested that the mutual aid department be sent directly to the scene. He also requested rescue vehicle E105 be dispatched from Central Station to the scene. The IC also radioed "Man down" but this transmission was not recorded. C2 then radioed L100 and told the L100 driver to come directly

to the front of the building. He radioed A101 and told the driver to bring the ambulance to the front of the building. Dispatch called C2 to verify what was needed.

The fire fighters on scene immediately rushed to where the victim and the Chief were standing when the awning collapsed and began throwing debris out of the way. Civilian bystanders also joined in to move debris. The IC quickly determined precisely where the two were standing at the time of the collapse. The victim's PASS device was heard by the rescuers. The victim was located pinned by the awning against the front wall. A chain saw was retrieved from E101 and used to cut into the awning. The victim's facepiece was removed and he was checked for vitals. A fire fighter detached the victim's SCBA regulator and used the purge valve to flow air into the victim's mouth and nose while an oxygen resuscitator was retrieved from A101. It was quickly determined that the victim was in grave condition so one fire fighter remained with the victim while the rest of the rescuers focused on locating the Chief. At approximately 0920 hours, dispatch radioed that there was nobody at Central Station to bring E105 to the scene. C2 instructed dispatch to have more fire fighters called out. C2 told the IC to take charge of the rescue operation since he (the IC) knew precisely where the Chief was trapped. C2 assumed incident command and radioed dispatch that he was taking over as IC. The rescue crews continued to use the chain saw to cut through the awning to locate the Chief. A K-12 saw was also used to cut through metal bars attached to the awning.

At 0923 hours a second hole was cut through the awning and the Chief was able to crawl out. C2 radioed dispatch that one man was freed and walking. At 0925 hours, the victim was extricated and C2 radioed dispatch to notify the local hospital that they would be transporting the victim. At 0927 hours, C2 requested a personal accountability report (PAR) for all personnel at the scene. At 0930 hours, A101 left the scene with the victim and arrived at the local hospital at 0934 hours where the victim was pronounced dead.

CAUSE OF DEATH

According to the medical examiner's findings, the cause of death was blunt force trauma.

RECOMMENDATIONS

Recommendation # 1: Fire departments should establish and monitor a collapse zone for structures that have become unstable due to fire damage.

Discussion: During fire operations, two rules exist about structural collapse: (1) the potential for structural failure always exists during and after a fire, and (2) a collapse danger zone must be established.[1-6] A collapse zone is an area around and away from a structure in which debris might land if a structure fails. The collapse zone area should be equal to the height of the building plus an additional allowance for debris scatter and at a minimum should be at least 1½ times the height of the building. For example, if the wall was 20 feet high, the collapse zone would be established at least 30 feet away from the wall. In this incident, the structure was approximately 16 feet high at the top of the awning so the collapse zone would have extended at least 24 feet from the structure.

Fire fighters must recognize the dangers of operating underneath or near overhanging awnings, porches, and other areas susceptible to collapse. Immediate safety precautions must be taken if factors indicate the potential for a building collapse. An external load, such as a parapet wall, steeple, overhanging porch, awning, sign or large electrical service connections reacting on a wall weakened by fire conditions may cause the wall to collapse. Other factors include fuel loads, damage, renovation work, deterioration caused by the fire as well as pre-existing deterioration, support systems and truss construction.[2] Whenever these contributing factors are identified, all persons operating inside the structure must be evacuated immediately and a collapse zone should be established around the perimeter. Once a collapse zone has been established, the area should be clearly marked and monitored to make certain that no fire fighters enter the danger zone. Defensive master streams should be used to soak smoldering remains and to prevent rekindling.[7] Positioning companies at the corners of the building is usually safer than a frontal attack.[8]

In this incident, the fireground tactics were switched from offensive to defensive when the attack crew pulled out of the office area, but was not officially declared over the radio. The Lieutenant told the fire fighters to stay out from under the awning and handlines were moved back and operated from the parking area. When hot spots began to flare up among rolled roofing material, the Chief and the victim moved closer to the building to put water on the roofing material, positioning themselves underneath the awning. The exterior walls became unstable when the roof collapsed. The awning was connected to the front wall which received lateral support from the roof trusses. Once the trusses failed, this lateral support was lost and the awning broke loose from the exterior wall.

Recommendation # 2: Fire departments should train all fire fighting personnel in the risks and hazards related to structural collapse.

Proper training is an important aspect of safe fire ground operation. Both officers and fire fighters need to be aware of different types of building construction and their associated hazards.[4, 6, 7] For example, collapsing roof systems can exert pressure on supporting exterior walls, increasing the potential for wall collapse. Different roof systems may collapse at different rates.[7] While heavy timber roof systems will withstand more degradation by fire than lightweight engineered roof trusses, both types are subject to failure.[7] Different phases of the fire suppression activities, such as the initial attack, offensive, defensive, and overhaul phases will have different hazards. However, the potential for collapse exists in any fire-damaged structure.[7] One source of information related to structural collapse hazards is the National Institute of Standards and Technology, Building and Fire Research Laboratory (NIST / BFRL). A DVD containing videos and reports related to structural collapse can be obtained from the NIST website http://www.bfrl.nist.gov/.

Establishing priorities is another primary factor in safe fire ground operation that should be included in fire fighter training programs. The protection of life should be the highest goal of the fire service. When there is no clear danger to civilians, the first priority of firefighting should be the protection of fire fighters' lives and when no other person's life is in danger, the life of the fire fighter has a higher priority than fire containment or property consideration.[9]

Recommendation # 3: Fire departments should conduct pre-incident planning and inspections of buildings within their jurisdictions to facilitate development of safe fire ground strategies and tactics.

Discussion: National Fire Protection Association (NFPA) 1620 *Recommended Practice for Pre-Incident Planning, 2003 Edition,* § 4.4.1 states "the pre-incident plan should be the foundation for decision making during an emergency situation and provides important data that will assist the incident commander in developing appropriate strategies and tactics for managing the incident." This standard also states that "the primary purpose of a pre-incident plan is to help responding personnel effectively manage emergencies with available resources. Pre-incident planning involves evaluating the protection systems, building construction, contents, and operating procedures that can impact emergency operations."[10] A pre-incident plan identifies deviations from normal operations and can be complex and formal, or simply a notation about a particular problem such as the presence of flammable liquids, explosive hazards, modifications to structural building components, or structural damage from a previous fire.[4, 6]

In addition, NFPA 1620 outlines the steps involved in developing, maintaining, and using a pre-incident plan by breaking the incident down into pre-, during- and post-incident phases. In the pre-incident phase, for example, it covers factors such as physical elements and site considerations, occupant considerations, protection systems and water supplies, hydrant locations, and special hazard considerations. Building characteristics including type of construction, materials used, occupancy, fuel load, roof and floor design, and unusual or distinguishing characteristics should be recorded, shared with other departments who provide mutual aid, and if possible, entered into the dispatcher's computer so that the information is readily available if an incident is reported at the noted address.

A building inspection and pre-incident plan for this single-story commercial building could have potentially identified the flat roof supported by lightweight open-web metal and wood trusses, the 130 foot awning attached to the front wall, fuel load considerations (i.e. asphalt roofing materials stored inside the building), and other pertinent information such as hydrant locations. The front wall was mostly glass (both windows and doors) with concrete blocks stacked above the windows and doors. The pre-incident planning process could have noted this information which may have aided the Incident Commander in developing a safer and more effective defensive strategy.

Recommendation # 4: Fire departments should ensure that adequate numbers of staff are available to immediately respond to emergency incidents.

NFPA 1710 *Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments (2004 Edition)* contains recommended guidelines for minimum staffing of career fire departments.[11]

NFPA 1710 § 5.2.2 (Staffing) states the following: "On-duty fire suppression personnel shall be comprised of the numbers necessary for fire-fighting performance relative to the expected fire-fighting conditions. These numbers shall be determined through task analyses that take the following factors into consideration:

1. Life hazard to the populace protected
2. Provisions of safe and effective fire-fighting performance conditions for the fire fighters
3. Potential property loss
4. Nature, configuration, hazards, and internal protection of the properties involved
5. Types of fireground tactics and evolutions employed as standard procedure, type of apparatus used, and results expected to be obtained at the fire scene."

The NFPA standard states that both engine and truck companies shall be staffed with a minimum of four on-duty personnel. The standard also states that in jurisdictions with tactical hazards, high hazard occupancies, high incident frequencies, geographical restrictions, or other pertinent factors identified by the authority having jurisdiction, these companies shall be staffed with a minimum of five or six on-duty members. Jurisdictions where fire companies deploy quint apparatus designed to operate as either an engine company or a ladder company should also follow these same staffing guidelines.

NFPA 1710 also states that the fire department's fire suppression resources shall be deployed to provide for the arrival of an engine company within a 4-minute response time and/or the initial full alarm assignment within an 8-minute response time to 90 percent of the incidents as established in Chapter 4. The fire department shall have the capability to deploy an initial full alarm assignment within an 8-minute response time to 90 percent of the incidents as established in Chapter 4. The initial full alarm assignment shall provide for the following:

(1) Establishment of incident command outside of the hazard area for the overall coordination and direction of the initial full alarm assignment. A minimum of one individual shall be dedicated to this task.

(2) Establishment of an uninterrupted water supply of a minimum 1520 L/min (400 gpm) for 30 minutes. Supply line(s) shall be maintained by an operator who shall ensure uninterrupted water flow application.

(3) Establishment of an effective water flow application rate of 1140 L/min (300 gpm) from two handlines, each of which shall have a minimum of 380 L/min (100 gpm). Each attack and backup line shall be operated by a minimum of two individuals to effectively and safely maintain the line.

(4) Provision of one support person for each attack and backup line deployed to provide hydrant hookup and to assist in line lays, utility control, and forcible entry.

(5) A minimum of one victim search and rescue team shall be part of the initial full alarm assignment. Each search and rescue team shall consist of a minimum of two individuals.

(6) A minimum of one ventilation team shall be part of the initial full alarm assignment. Each ventilation team shall consist of a minimum of two individuals.
(7) If an aerial device is used in operations, one person shall function as an aerial operator who shall maintain primary control of the aerial device at all times.
(8) Establishment of an Incident Rapid Intervention Crew (IRIC) that shall consist of a minimum of two properly equipped and trained individuals.

Due to staffing and manpower limitations within the department, the small size of the initial responding crews at this incident could not appropriately and safely respond to the necessary fireground operations–e.g. incident command, scene size-up, search-and-rescue, a staged Incident Rapid Intervention Crew (IRIC), hydrant connections, ventilation, and medical aid and transport. Additional manpower was requested and off-duty fire fighters were called to return to work. Fire fighters assigned to an ambulance crew had to be dispatched to drive the aerial ladder to the scene. When staffing is an issue, chief officers need to modify strategies and tactics to fit the number of available personnel.

Recommendation #5: Fire departments should ensure that a separate Incident Safety Officer, independent from the Incident Commander, is appointed at each structural fire.

Discussion: According to NFPA 1561 *Standard on Emergency Services Incident Management System, 2005 Edition*, paragraph 7.1.1, "The Incident Commander shall have overall authority for management of the incident (7.1.1) and the Incident Commander shall ensure that adequate safety measures are in place (7.1.2)." This shall include overall responsibility for the safety and health of all personnel and for other persons operating within the incident management system. While the Incident Commander (IC) is in overall command at the scene, certain functions must be delegated to ensure adequate scene management is accomplished.[12] According to NFPA 1500 *Standard on Fire Department Occupational Safety and Health Program, 2007 Edition*, "as incidents escalate in size and complexity, the incident commander shall divide the incident into tactical-level management units and assign an incident safety officer (ISO) to assess the incident scene for hazards or potential hazards (8.1.6)."[13] These standards indicate that the IC is in overall command at the scene, but acknowledge that oversight of all operations is difficult. On-scene fire fighter health and safety is best preserved by delegating the function of safety and health oversight to the ISO. Additionally, the IC relies upon fire fighters and the ISO to relay feedback on fireground conditions in order to make timely, informed decisions regarding risk versus gain and offensive versus defensive operations. The safety of all personnel on the fireground is directly impacted by clear, concise, and timely communications among mutual aid fire departments, sector command, the ISO, and IC.

Chapter 6 of NFPA 1521, *Standard for Fire Department Safety Officer*, defines the role of the ISO at an incident scene and identifies duties such as recon of the fire ground and reporting pertinent information back to the Incident Commander; ensuring the department's accountability system is in place and operational; monitoring radio transmissions and identifying barriers to effective

communications; and ensuring established safety zones, collapse zones, hot zone, and other designated hazard areas are communicated to all members on scene.[14]

Larger fire departments may assign one or more full-time staff officers as safety officers who respond to working fires. In smaller departments, every officer should be prepared to function as the ISO when assigned by the IC. The presence of a safety officer does not diminish the responsibility of individual fire fighters and fire officers for safety. The ISO adds a higher level of attention and expertise to help the individuals. The ISO must have particular expertise in analyzing safety hazards and must know the particular uses and limitations of protective equipment.[15]

The department involved in this incident did not have a permanent safety officer position and limited manpower and staffing at the incident did not allow for the designation of a separate Incident Safety Officer. A designated safety officer could have assisted with continual size-up and timely communications regarding safety on the fireground, including the need to establish a collapse zone. For example, chief officers arriving on-scene could have functioned as safety officers instead of becoming more directly involved in fire fighting tasks.

Recommendation # 6: Fire departments should ensure that Incident Command maintains the role of director of fireground operations and does not become involved in fire-fighting efforts.

Discussion: According to NFPA 1561, §7.1, "The incident commander shall have overall authority for management of the incident."[12] In addition to conducting an initial size-up, Incident Command must maintain a command post outside of the structure to assign companies and delegate functions, and continually evaluate the risk versus gain of continued fire fighting efforts. According to NFPA 1561, §7.1.7, the incident commander should take the following actions in establishing incident command:

> Following the initial stages of an incident, the incident commander shall establish a stationary command post. In establishing a command post, the incident commander shall ensure the following:
> (1) The command post is located in or tied to a vehicle to establish presence and visibility.
> (2) The command post includes radio capability to monitor and communicate with assigned tactical, command, and designated emergency traffic channels for that incident.
> (3) The location of the command post is communicated to the communications center.
> (4) The incident commander, or his or her designee, is present at the command post.

§7.1.8 states the incident commander shall continually conduct a thorough situation evaluation.

It is essential that adequate staff are available for immediate response to ensure that the Incident Commander is not required to become involved in fire-fighting efforts, thus reducing the IC's ability

to effectively coordinate and direct fire-fighting operations on the scene. Due to staffing and manpower restrictions, the Incident Commander entered the structure to assist the building owner in retrieving papers from the office area. Additionally, tasks were assigned at the incident by the assistant chief (C2) and the Chief, as well as the IC, including C2 directing the IC to operate the E101 deck gun. While there was no evidence of conflicting assignments, all task assignments should be coordinated through a single incident commander.

Recommendation # 7: Fire departments should ensure that switching from offensive to defensive operations are coordinated and communicated to everyone on the fireground.

Discussion: According to retired Chief Alan Brunacini, a major goal of the Incident Commander is to extend an aggressive, well-placed and adequate interior attack, whenever possible. The offensive strategy is an interior attack with the related support needed to bring the fire under control. The defensive strategy is an exterior attack with related support. The purpose of the defensive attack is to stop the forward progress of the fire and then control it. If a fire is unmanageable, it must be attacked with priorities given to protecting endangered exposures and stopping the forward progress of the fire. The Incident Commander must be sensitive to the changing modes of the fire which can occur over minutes or hours and not hesitate to order interior crews out of the structure when the situation is deteriorating.[15]

Whenever signs of potential collapse are observed, the offensive operation must be immediately abandoned. All units must be notified and immediately move to the exterior. Usually, an announcement is given over the radio followed by a pre-planned signal such as several long blasts on an air horn (ten three-second blasts, for example). Forces operating on the outside must be moved back to a safe distance from the building (outside of the collapse zone).[2]

In this incident, the attack crew followed proper procedures in backing out of the building as the conditions deteriorated. Once outside, the lieutenant discussed the conditions with the Incident Commander and told fire fighters to stay out from under the awning. However, a collapse zone was not established and defensive operations were not officially declared. The roof collapsed approximately 3 minutes before the awning fell. Once the trusses failed, lateral support to the front wall was lost. The front wall could no longer support the weight of the awning.

Recommendation # 8: Fire departments should ensure that fire fighters wear a full array of turnout clothing and personal protective equipment (i.e. SCBA and PASS device) appropriate for the assigned task while participating in fire suppression and overhaul activities.

Discussion: While the lack of personal protective equipment (PPE) and clothing did not contribute to the fatality or injuries that occurred at this incident, the proper selection and use of PPE is required by OSHA regulations, recommended in NFPA standards, and is good safety practice. Chapter 7.1.1 of NFPA 1500, *Fire Department Safety and Health Program, 2007 Edition*, states "the fire department shall provide each member with protective clothing and protective equipment that is designed to

provide protection from the hazards to which the member is likely to be exposed and is suitable for the tasks that the member is expected to perform." Chapter 7.1.2. states "protective clothing and protective equipment shall be used whenever a member is exposed or potentially exposed to the hazards for which the protective clothing (and equipment) is provided."[13] The incident commander should establish the level of protective clothing necessary to enter the fire zones (hot, warm, and cold). The *OSHA Respirator Standard* Title 29, Code of Federal Regulations (CFR) 1910.134 lists requirements for SCBA use in immediately dangerous to life or health (IDLH) atmospheres.

During this incident, the Incident Commander entered the structure without a self-contained breathing apparatus and the Chief was engaged in operating a handline in close proximity to the structure while dressed in street clothes.

Recommendation # 9: Manufacturers, equipment designers, and researchers should continue to develop and refine durable, easy-to-use systems to enhance verbal and radio communication in conjunction with properly worn SCBA.

Discussion: Recent testing of portable radios in simulated fire fighting environments by the National Institute for Standards and Technology (NIST) has identified that radios are vulnerable to exposures to elevated temperatures. Some degradation of radio performance was measured at elevated temperatures ranging from 100^{O}C to 260^{O}C, with the radios returning to normal function after cooling down. Additional research is needed in this area.[16]

The use of Personal Protective Equipment (PPE) and an SCBA make it difficult to communicate, with or without a radio.[17, 18] Faced with the difficult task of communicating while wearing an SCBA, fire fighters sometimes momentarily remove their face pieces to transmit a message directly or over a portable radio. Considering the toxic and oxygen-deficient hazards posed by a fire and the resulting products of combustion, removing the SCBA face piece, even briefly, is a dangerous practice that should be prohibited. Even small exposures to carbon monoxide and other toxic agents present during a fire can affect judgment and decision making abilities. To facilitate communication, equipment manufacturers have designed face piece-integrated microphones, intercom systems, throat mikes and bone mikes worn in the ear or on the forehead.[17, 18]

During this incident fire fighters experienced intermittent radio communication problems and interruptions. The interior attack crew had difficulty communicating with the Incident Commander. The central dispatch center had to ask the Incident Commander and the Assistant Chief to repeat radio transmissions. Radio communications reported to NIOSH investigators were not recorded on the dispatch tapes. While this may not have directly contributed to the fatality, effective radio communication is an important part of safe fireground operations.

Recommendation # 10: Manufacturers, equipment designers, and researchers should continue to pursue emerging technologies for evaluating and monitoring the stability of buildings exposed to fireground conditions.

Discussion: The National Institute of Standards and Technology has recently been researching different technologies that offer the potential for evaluating structural stability of fire buildings.[19-21] This research may lead to more accurate and reliable means of predicting building collapse. Much of this research has focused on field-based monitoring techniques that utilize measurements of fire-induced vibration within the fire building. Such devices should be further researched, refined, and hardened for possible use in the fire service with the ultimate goal of having low-cost reliable and more accurate methods for predicting building collapse available to all fire departments and fire fighters across the country.

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INVESTIGATOR INFORMATION

This incident was investigated by Timothy Merinar, Safety Engineer, and Richard Braddee, Senior Investigator with the NIOSH, Division of Safety Research, Fire Fighter Fatality Investigation and Prevention Program located in Morgantown, WV. The report was authored by Timothy Merinar. An expert technical review was provided by Deputy Chief Colleen Walz, Pittsburgh Bureau of Fire.

2007
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NIOSH
Fire Fighter Fatality Investigation and Prevention Program

Death in the line of duty...

A summary of a NIOSH fire fighter fatality investigation

May 16, 2008

Career Fire Fighter Dies in Wind Driven Residential Structure Fire – Virginia

Revised June 10, 2008 to clarify Recommendation #2

SUMMARY

On April 16, 2007, a 24-year-old male career fire fighter (the victim) was fatally injured while trapped in the master bedroom during a wind-driven residential structure fire. At 0603 hours, dispatch reported a single family house fire. At 0609 hours, the victim's ladder truck was second to arrive on scene. Fire was visible at the back exterior corner of the residence. Noticing cars in the driveway, no one outside, and no lights visible in the house, the lieutenant from the first arriving engine called in a second alarm. A charged 2 ½" hoseline was stretched to the front door by the first arriving engine crew. The engine crew stayed at the door with the attack line while the cause of poor water pressure in the hoseline was determined. The victim and his lieutenant, wearing their SCBA, entered the residence through the unlocked front door. With light smoke showing, they walked up the stairs to check the bedrooms. The victim and lieutenant cleared the top of the stairs and went straight into the master bedroom. With smoke beginning to show at ceiling level, the victim did a right-hand search while the lieutenant with thermal imaging camera (TIC) in-hand checked the bed. Suddenly the room turned black then orange with flames. The lieutenant yelled to the victim to get out. While verbal communication among the crew was maintained, the lieutenant found the doorway and moved toward the stairs. He ended up falling down the stairs to a curve located midway in the staircase. The lieutenant tried to direct the victim to the stairs verbally and with a flashlight. As the wind gusted up to 48 miles per hour, the wind-driven fire and smoke engulfed the residence. The incident commander (IC) ordered an evacuation and the lieutenant was brought outside by the engine and rescue company crews. The ladder truck lieutenant received burns on his ears and right index finger. At 0614 hours, the rescue company officer issued a Mayday followed by the victim's Mayday. With protection from hose lines, several attempts were made by the engine and rescue company crews to reach the second floor. On the third attempt the stair landing was reached but the ceiling started collapsing and flames intensified. At 0621 hours, due to the intensity of the fire throughout the structure, all fire fighters were evacuated, operations turned defensive, but the incident continued in rescue mode. At 0657 hours, the victim was found in the master bedroom partially on a couch underneath the front windows.

NIOSH investigators concluded that, to minimize the risk of similar occurrences, fire departments should:

- ***ensure that standard operating procedures (SOPs) for size-up and advancing a hoseline address the hazards of high winds and gusts***
- ***ensure that primary search and rescue crews either advance with a hoseline or follow an engine crew with a hoseline***
- ***ensure that staffing levels are sufficient to accomplish critical tasks***
- ***ensure that fire fighters are sufficiently trained in survival skills***
- ***ensure that Mayday protocols are reviewed, modified and followed***
- ***ensure that water supply is established and hoses laid out prior to crews entering the fire structure***
- ***ensure that fire fighters are trained for extreme conditions such as high winds and rapid fire progression associated with lightweight construction***

Additionally, municipalities should:

- ***ensure that dispatch collects and communicates information on occupancy and extreme environmental conditions***

Although there is no evidence that the following recommendation could have specifically prevented this fatality, NIOSH investigators recommend that fire departments:

- ***ensure that radios are operable in the fireground environment***

INTRODUCTION

On April 16, 2007, a 24-year-old male career fire fighter (the victim) was fatally injured while trapped in the master bedroom during a residential structure fire. On April 17, 2007, the fire department, U.S. Fire Administration (USFA), and the International Association of Fire Fighters (IAFF) notified the National Institute for Occupational Safety and Health (NIOSH) of this fatality. On May 6 - 9, 2007, a General Engineer and a Safety and Occupational Health Specialist from the NIOSH Fire Fighter Fatality Investigation and Prevention Program investigated the incident. Photographs of the incident scene were taken and meetings were conducted with the Battalion Chief of Health and Safety (fire department's Investigating Team Leader), Fire Marshal, and an IAFF representative. Interviews were conducted with officers and fire fighters who were at the incident scene. The NIOSH investigators reviewed the department's standard operating guidelines (SOGs), the officers' and victim's training records, photographs of the incident scene, written witness statements, the coroner's report, and a weather station report. At the request of the fire department, NIOSH examined and evaluated the

victim's SCBA. The SCBA was examined component by component to determine conformance to the NIOSH approved configuration. The SCBA was too damaged to test performance. (see Appendix)

Fire Department

The combination department has nineteen fire stations, three administrative worksites, a warehouse, and a training facility. A total of 1,478 fire and rescue personnel (452 career and 1,026 volunteer) serve a population of about 384,000 residents in a geographic area of about 348 square miles.

Personal Protective Equipment

At the time of the incident, the victim was wearing personal protective equipment consisting of turnout coat and pants, gloves, a helmet, hood, SCBA with an integrated PASS device, and he carried a radio. Given the condition of the victim's SCBA, the NIOSH post-incident evaluation could not determine if the SCBA performance contributed to the fatal incident. (see appendix).

Apparatus and Personnel

Dispatch reported a single family house fire at 0603 hours.

On scene at 0608 hours:

Engine #12 [E12] – Lieutenant (LT#1), engine operator, and a fire fighter

On scene at 0609 hours:

Truck #12 [T12] – Lieutenant (LT#2), truck operator, and two fire fighters (one the victim)

FireMedic #12 [M12] – Lieutenant and a fire fighter

On scene at 0610 hours:

Rescue #10 [R10] – Lieutenant, driver operator, and three fire fighters

Engine #10 [E10] – Technician II (Acting Officer), engine operator, and a fire fighter

On scene at 0611 hours:

Battalion Chief (Incident Commander (IC))

On scene at 0612 hours:

Engine #20 [E20] – Captain, engine operator, engine operator in training, and two fire fighters

Ambulance #10 [A10] – Lieutenant and two fire fighters

Safety #02 - Safety Officer

On scene at 0618 hours:

Engine #2 [E2] – Lieutenant, engine operator, and two fire fighters

Training/Experience

The victim had completed National Fire Protection Association (NFPA) Fire Fighter Level I and II training, Cardiopulmonary Resuscitation (CPR), Critical Incident Stress Management, Hazmat Operations, Fire Fighter Survival Skills I & II, Infection Control and several other technical courses. The victim was a career fire fighter with one year of fire fighting experience.

The Incident Commander had completed Intermediate and Advanced National Incident Management System training, Intermediate and Advanced Incident Command System Courses, several HAZMAT courses, and various other administrative, personnel and technical courses. The Incident Commander is a career fire fighter with 24.5 years in the fire service at the time of the incident.

Lieutenant #1 (LT#1) had completed Fire Fighter 1 and 2, Fire Officer 1, Incident Officer, several HAZMAT courses, Fireground Tactics, and various other administrative and technical courses. LT#1 is a career fire fighter with 8 plus years in the fire service at the time of the incident.

Lieutenant #2 (LT#2) had completed Fire Fighter 1 and 2, Fire Officer 1 and 2, Fire Fighter Survival Skills 1 and 2, Advanced Fire Fighter Safety Skills, several HAZMAT courses, and various other administrative and technical courses. LT#2 is a career fire fighter with 8 years in the fire service at the time of the incident.

The Safety Officer had completed Fire Fighter 1, 2, and 3, Fire Officer 1 and 2, Field Officer, Incident Officer, Fire Fighter Survival Skills 1 and 2, several HAZMAT courses, and various other administrative and technical courses. The Safety Officer is a career fire fighter with a total of 16.5 years in the fire service at the time of the incident.

Building Information

The building was an approximately 6000 square foot, two-story plus finished walkout basement, non-sprinklered residential structure that was constructed of wood framing with vinyl siding and a brick veneer front on the exterior. The residence had a large 700 square foot wood deck that ran three quarters the length of the rear of the structure on the first floor (C-side). The roof consisted of wood rafters with fiberglass shingles over oriented strand board sheathing (see Photo1).

Photo 1: A-side of the structure where the victim entered. The victim was found in the second floor master bedroom above the bay window.

Weather

At the time of the incident, the conditions were overcast with an approximate temperature of 45 degrees Fahrenheit and a measured sustained wind speed of 25 miles per hour (mph) from the Northwest with wind gusts up to 48 mph.

INVESTIGATION

On April 16, 2007, a 24-year-old male career fire fighter (the victim) was fatally injured while trapped in the master bedroom during a wind-driven residential structure fire. At 0603 hours, dispatch reported a single family house fire. At 0608 hours, the victim's ladder truck (T12) was second on the scene directly behind engine 12 (E12). The crews encountered fire in the B/C exterior corner of the residence underneath and along the deck on the first floor on the C-side on the structure. The wind was blowing at speeds of 25 to 48 mph. The residence was located at the top right side of a drainage

where the wind was directed onto the C-side of the house. The lieutenants from E12 and T12 (LT#1 and LT#2, respectively) walked around opposite sides of the structure and met in front to discuss the size-up. Noticing cars in the driveway, no-one outside, and no lights visible in the house, LT#1 called in a second alarm. *(Note: A neighbor drove to the residence and woke the residents. He walked them to another neighbor's house and walked back to move his vehicle in anticipation of the fire department's arrival. No-one relayed to the fire department that the residents were out of the house until after interior operations were underway.)*

A charged 2 ½" hoseline was stretched to the front door from E12 by the E12 crew. LT#2 and the victim donned their SCBA while waiting to enter the structure. The victim tried the door, which was unlocked, so the victim and LT#2 walked into the foyer. E10 arrived on scene and was instructed by LT#1 to pull 300 feet of 1 ¾" hose from E12 in case it would be needed in the rear. At 0611 hours, with a light haze of smoke visible on the first floor, the T12 crew walked up the stairs to check the bedrooms. The E12 crew was delayed at the door with the attack line due to poor water pressure. LT#1 straightened out several kinks in the hose prior to entering the structure. At the top of the stairs, LT#2 and the victim encountered smoke banked down 3 feet from the second floor ceiling and went to the D-side of the residence towards the master bedroom. At 0611 hours, a Battalion Chief arrived on scene and assumed incident command. E20 arrived on scene and was instructed by the IC to pull 200 feet of 1 ¾" hose from E12 and cover the D-side exposures. (see Diagram#1)

LT#2 and the victim came to a set of double doors. The right door was open and they entered the master bedroom. With smoke showing at ceiling level, the victim did a right-hand search and LT#2 with thermal imaging camera (TIC) in-hand checked the bed. Suddenly the room turned black then orange with flames. LT#2 yelled to the victim to get out. While verbal communication among the crew was maintained, LT#2 found the doorway and crawled towards the stairs, falling to the curve located midway in the staircase. LT#2 communicated verbally and visually (via a flashlight) in an attempt to direct the victim to the stairs. LT#2 had been burned on his ears and right index finger. (*Note: Personal protective equipment (PPE), such as hood and gloves were properly worn. However, the helmet liner was not properly down over the ears. The PPE received direct flame impingement and heat exposure.*)

LT#1 and his crew along with the R10 crew were still at the front door which had slammed closed. When the door was re-opened, fire engulfed the doorway and LT#1 started yelling for LT#2 and the victim to come down the stairs. LT#1 noticed the severe change in the fire conditions in the stairway and requested an emergency evacuation. At 0613 hours, the wind-driven fire and smoke engulfed the residence. Fire was coming out of the eaves on the D-side of the structure. The E20 crew was flowing water on the D-side and the E10 crew was flowing water on the A-side of the residence, but the wind hampered the attack. Several ladders were thrown on the A and D-sides to the second floor, and on the C-side deck to the first floor, but the high winds and extreme heat made it difficult to stabilize the ladders against the building.

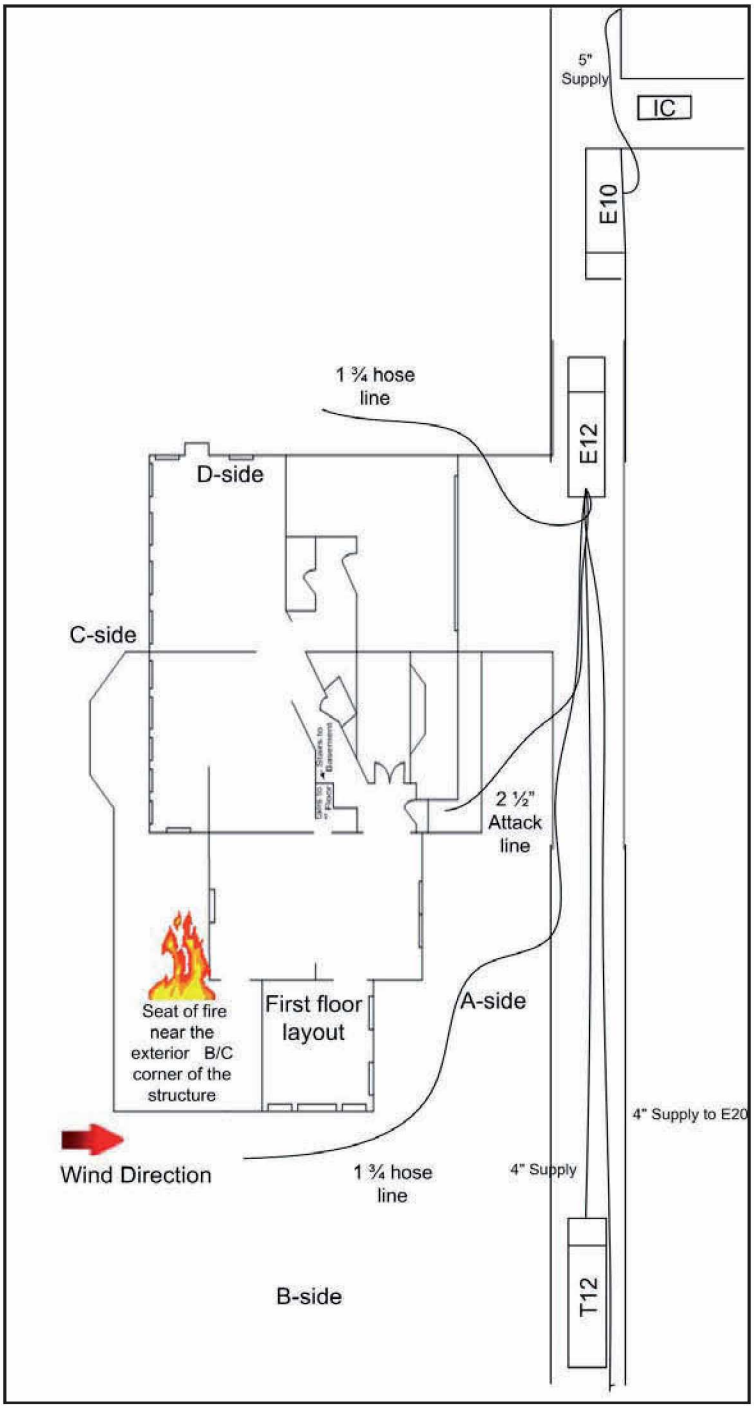

Diagram #1: Apparatus and hoseline location at time of incident

The engine operator from E12 blew the air horn for 10 seconds to signal an evacuation. The IC gave a follow-up order to evacuate over the fireground channel. Concurrently, the R10 crew located LT#2 in the staircase area and brought him outside. At 0614 hours, LT#2 informed them that the victim was near the stairs. The R10 lieutenant issued a Mayday. It was shortly followed on the radio by the victim's Mayday. Two lines, a 2 ½" and a 1 ¾", were flowing on the A-side of the structure with minimal impact. *(Note: From the beginning of the incident, low water pressure in two hoselines was an issue. Removing kinks in the hoses helped somewhat, but pressure problems persisted. It was undeterminable if the resultant low pressure was at the hydrant, engines, and/or due to hoseline deployment.)*

At 0615 hours, LT#1 and a R10 fire fighter made it to the top of the stairs, but heat pushed them down. Several attempts were made by the E12 and R10 crews to go back up to the second floor. On the third attempt to ascend the staircase, and the second time the landing was reached, the ceiling started collapsing and flames intensified.

At 0621 hours, the Safety Officer, seeing the intensity of the fire throughout the structure, instructed the IC to call for another evacuation. The engine operator from E12 blew the air horn for a second time. At this point, the incident turned to a defensive attack, but rescue mode continued. At 0621 hours, the E2 crew was designated as the RIT and entered the C-side of the structure with a 1 ¾" hoseline to search for the victim in case a floor collapse had occurred.

At 0631 hours, additional crews attempted to re-enter and search for the victim, but they were unable to reach the second floor due to intense heat and fire conditions. At 0634 hours, command requested dispatch of a third alarm. At 0643 hours, crews with TICs in hand were able to reach the second floor, but due to structural collapse and high-heat conditions, access to second floor areas was limited. (*Note: The victim's PASS was never heard by fire fighters on the fire ground. Due to extreme heat damage, post incident testing was not possible.*) At 0657 hours, the victim was found in the master bedroom partially on a couch underneath the bedroom A-side windows. (see Diagram #2)

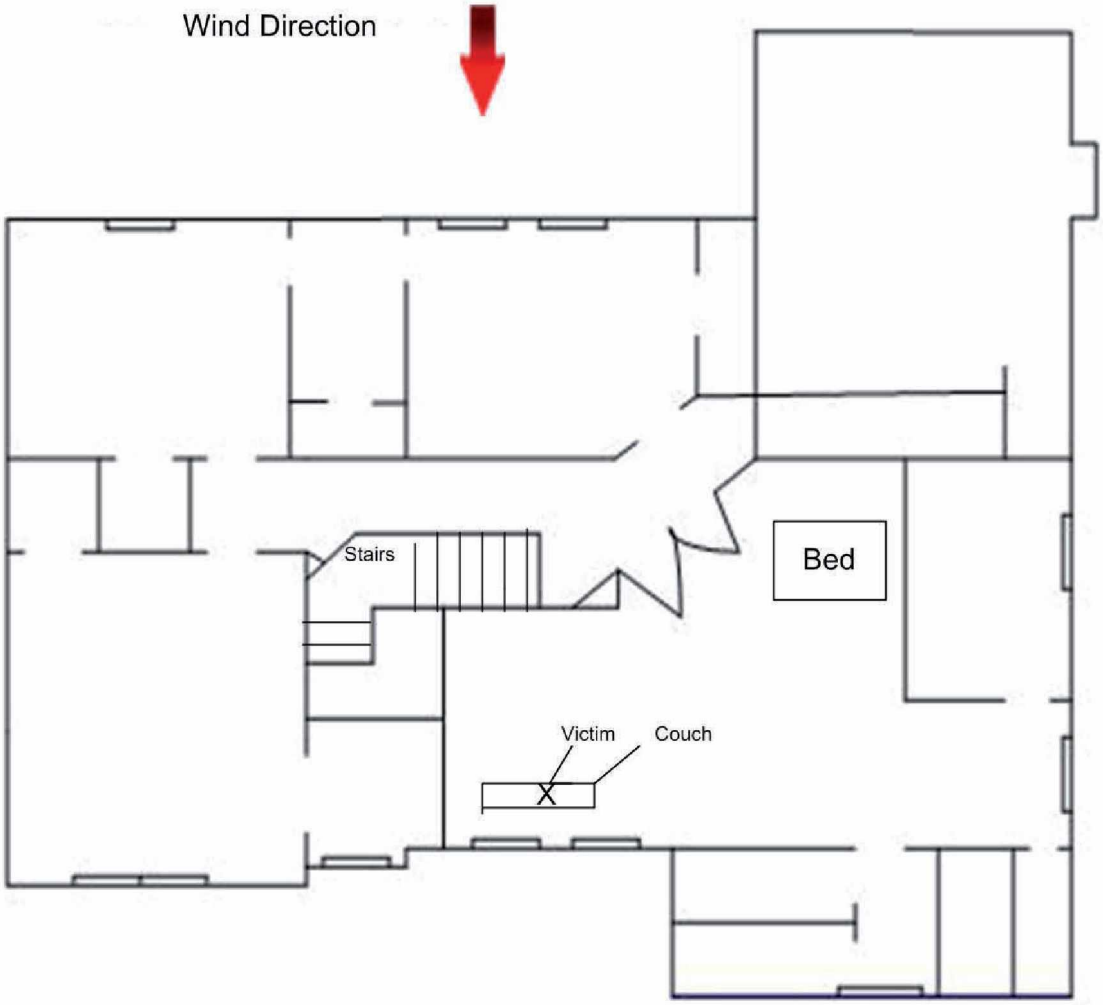

Diagram #2. Location of victim on second floor in master bedroom of fire structure

CAUSE OF DEATH

The coroner listed the cause of death as thermal and inhalational injuries.

RECOMMENDATIONS

Recommendation #1: Fire departments should ensure that standard operating procedures (SOPs) for size-up and advancing a hoseline address the hazards of high winds and gusts

Discussion: Fire departments should develop SOP's for incidents with high-wind conditions including defensive attack if necessary. Weather can be considered as critically important when at the extreme, and relatively unimportant during normal conditions.[1] Wind has a strong effect on fire behavior which includes supplying oxygen, reducing fuel moisture, and exerting physical pressure to move the fire and heat. Wildland fire fighters are very familiar with these effects of wind on the rate at which fire spreads. According to Dunn, "When the exterior wind velocity is in excess of 30 miles per hour, the chances of conflagration are great; however, against such forceful winds, the chances of successful advance of an initial hose line attack on a structure fire are diminished. The firefighters won't be able to make forward hoseline progress because the flame and heat, under the wind's additional force, will blow into the path of advancement."[2]

Fire fighters should change their strategy when encountering high wind conditions. An SOP should be developed to include obtaining the wind speed and direction, and guidelines established for possible scenarios associated with the wind speed and the possible fuel available, similar to that in wildland fire fighting.[2] When the interior attack line has little or no effect on the fire, the line should be withdrawn and a second hoseline should be advanced on the upwind side of the fire. This method may require the use of an aerial ladder or portable ladder, if safety permits.[2]

Recommendation #2: Fire departments should ensure that the primary search and rescue crews either advance with a hoseline or follow an engine crew with a hoseline

Discussion: Hoselines can be the last line of defense, and the last chance for a lost firefighter to find egress from a burning building. According to the USFA Special Report: *Rapid Intervention Teams and How to Avoid Needing Them*, the basic techniques taught during entry level fire fighting programs describe how to escape a zero-visibility environment using only a hoseline.[3] However, as years elapse from the time of basic training, fire fighters may overlook this technique. Exiting a structure in zero visibility should be simple, fast and easy for a fire fighter with a hoseline. A fire fighter operating on a hoseline should search along the hose until a coupling is found. Once found, the fire fighter can "read" the coupling and determine the male and female ends. The IFSTA manual *Essentials of Fire Fighting* teaches that the female coupling is on the nozzle side of the set and the male is on the water side of the set. In most cases, the male coupling has lugs on its shank while the female does not. Once oriented on the hose, a fire fighter can follow the hoseline in the direction away from the male coupling which will take you toward the exit.[4] There are a number of ways that fire hose can be marked to indicate the direction to the exit, including the use of raised arrows and chevrons that provide both visual and tactile indicators. Fire departments may use a variety of techniques to train fire fighters on how to identify hoseline coupling and the direction to the exit, based on the model of hose used by the department. The key point is that this training needs to be conducted and repeated often so that fire fighters are proficient in identifying the direction to the exit in zero visibility

conditions while wearing gloves, the hose entangled, and with various obstructions present. This procedure should be incorporated into SOPs, trained upon, and enforced on the fireground.

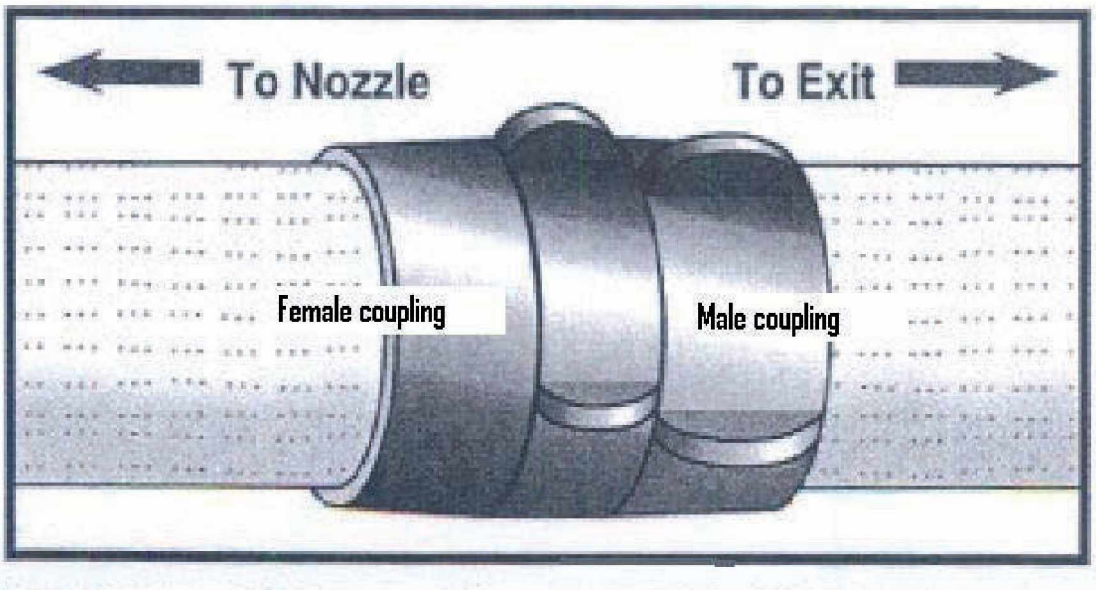

Diagram #3. Hose couplings will indicate the direction toward the exit. Adapted from IFSTA Essentials of Fire Fighting, 4th Edition.

In this incident, the truck crew went into the master bedroom doing a search without a hoseline. The engine crew with the hoseline was still at the front door when the truck crew went into the bedroom. Seconds later heavy smoke and flames blew through the upstairs hallway. The fire department's SOGs allow for the primary search and rescue crew not to have a hoseline as long as they are within sight of a crew with a hoseline. However, situations arise where conditions change in seconds preventing a fire fighter from following the hoseline to safety unless it is immediately available.

Recommendation #3: Fire departments should ensure that staffing levels are sufficient to accomplish critical tasks

Discussion: The National Fire Protection Association (NFPA) 1710 Standard identifies the minimum resources for an effective fighting force to perform critical tasks. These tasks include establishing water supply, deploying an initial attack line, ventilating, performing search and rescue, and establishing a RIT, etc. NFPA 1710 recommends that the minimum staffing levels for an engine company to perform effective and efficient fire suppression tasks is four. [5]

In this case, the first arriving engine (E12) was staffed with a lieutenant, an engine operator and a fire fighter. They stretched a charged 2 ½" attack line to the front door of the involved building for the

initial attack. It is extremely difficult for a two man crew (Lieutenant and fire fighter) to advance or operate a 2 ½" hoseline without assistance. For large diameter hoselines a 3 or 4 man operation significantly increases mobility and efficiency. Had the attack line been a 1 ¾" hoseline, they would have been much better able to rapidly advance a charged line up the stairs.

Recommendation #4: Fire departments should ensure that fire fighters are sufficiently trained in survival skills

Discussion: Fire fighters trapped or disoriented inside a room should be trained to rapidly locate doors and windows in order to escape. This is a skill that every interior structural fire fighter should possess and is typically taught in Firefighter Survival Skills I & II classes. Understanding when to self-rescue, and when to stay in a location to be rescued are critical. Fire departments should provide periodic refresher training to ensure fire fighters can effectively apply this training in different scenarios.

Recommendation #5: Fire departments should ensure that Mayday protocols are reviewed, modified and followed

Discussion: Fire fighters must act promptly when they become lost, disoriented, injured, low on air, or trapped.[6-10] First, they must transmit a distress signal while they still have the capability and sufficient air. The next step is to manually activate their PASS device. To conserve air while waiting to be rescued, fire fighters should try to stay calm and avoid unnecessary physical activity. If not in immediate danger, they should remain in one place to help rescuers locate them. They should survey their surroundings to get their bearings and determine potential escape routes, and stay in radio contact with Incident Command and rescuers. Additionally, fire fighters can attract attention by maximizing the sound of their PASS device (e.g., by pointing it up in an open direction), pointing their flashlight toward the ceiling or moving it around, and using a tool to make tapping noises.

A crew member or other fire fighter who recognizes a fellow fire fighter is missing or in trouble should quickly try to communicate with the fire fighter via radio and, if unsuccessful, initiate a mayday for that fire fighter providing relevant information as described above.

Department protocol requires that when a Mayday is transmitted, the IC must either personally handle the situation or designate another officer to do so. Part of "handling" a mayday is to communicate with the trapped or lost fire fighters and with any other fire fighters or officers involved. The IC or designated officer must communicate the emergency to all fireground personnel to minimize extraneous radio communication and designate another radio channel for normal fireground operations.

Recommendation #6: Fire departments should ensure that the water supply is established and hoses laid out prior to crews entering the fire structure

Discussion: Successful fire suppression and fire fighter safety depends upon discharging a sufficient quantity of water to remove the heat being generated and provide safety for the interior attack crews.

When advancing a hoseline into a fire structure, air should be bled from the line once it is charged, and before entering the structure.[4] Fire fighters should continually train in establishing a water supply, proper hose deployment, and advancing and operating hoselines to ensure successful interior attacks.

In this incident, after the 200 feet of 2 ½" attack line and 300 feet of 1 ¾" hoseline were deployed from E12, there were complaints of low water pressure in both lines. The officer from E12 removed some kinks from the 2 ½" attack line which had a positive effect on the pressure. The pressure at both the E12 and the supply pumper E20 supposedly reported no fluctuations. There may have been a combination of factors contributing to low water pressure, such as fluctuating residential water pressure, pressure problems at one or both engines, and/or supply line issues. There was insufficient information in this incident to make a determination as to the cause of low water pressure.

Recommendation #7: Fire departments should ensure that fire fighters are trained for extreme conditions such as high winds and rapid fire progression associated with lightweight construction

Discussion: Training is one of the most important steps in fire fighter safety. Fire fighters must strive to retain information and skills that are presented in training.[2] Training provides the necessary tools and fundamental knowledge to keep a fire fighter safe from injury. Just taking the training is not enough; the fire fighter needs to use their skills/information routinely on the fireground or at an actual emergency. Time is necessary to actually become proficient in those skills which are necessary for operational success in the field. In this era of new lightweight construction, training procedures covering strategy and tactics in extreme operational conditions, such as high winds and lightweight building construction (i.e., materials and design) are needed for all levels of fire fighters. Lightweight constructed buildings fail rapidly and with little warning, complicating rescue efforts.[11] The potential for fire fighters to become trapped or involved in a collapse may be increased. There are twenty-nine actions fire fighters can take to protect themselves when confronted with buildings utilizing lightweight building components as structural members. They range from looking for signs or indicators that these materials are used in buildings (such as, newer structures, large unsupported spans, and heavy black smoke being generated) to getting involved in newer building code development.[11]

Additionally,

Recommendation #8: Municipalities should ensure that dispatch collects and communicates information on occupancy and extreme environmental conditions

Discussion: The dispatch center should be aware of extreme environmental conditions on an hourly basis. Local weather forecasts and conditions are ready available in various media forms. When extreme weather conditions are present or the possibility exists, this information should be transmitted to the responding station when the call goes out. In addition, if the 911 caller does not relay any information about the occupancy of the fire structure, the dispatcher should explicitly ask the caller if they know if the structure is occupied.

Although there is no evidence that the following recommendation could have specifically prevented this fatality, NIOSH investigators recommend that:

Recommendation #9: Fire departments ensure that radios are operable in the fireground environment

Discussion: The fireground communications process combines electronic communication equipment, a set of standard operating procedures, and the fire personnel who will use the equipment. To be effective, the communications network must integrate the equipment and procedures with the dynamic situation at the incident site, especially in terms of the environment and the human factors affecting its use. The ease of use and operation may well determine how consistently fire fighters monitor and report conditions and activities over the radio while fighting fires. Fire departments should review both operating procedures and human factors issues to determine the ease of use of radio equipment on the fireground to ensure that fire fighters consistently monitor radio transmissions from the IC and respond to radio calls.[12] The need to have properly functioning equipment during fire operations is critical.

In this incident, several fire fighters commented that radios were malfunctioning due to water shorting out the lapel microphone. However, the victim's radio was heard loud and clear during his mayday, along with several communications describing his believed location and request for water due to the extreme heat.

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INVESTIGATOR INFORMATION

This incident was investigated by Matt Bowyer, General Engineer, and Virginia Lutz, Safety and Occupational Health Specialist, with the Fire Fighter Fatality Investigation and Prevention Program, Division of Safety Research at NIOSH. Vance Kochenderfer, NIOSH Quality Assurance Specialist, National Personal Protective Technology Laboratory, conducted an evaluation of the victim's self-contained breathing apparatus. An expert technical review was conducted by Battalion Chief of Safety John J. Salka, Jr., New York City Fire Department.

APPENDIX

Summary of Status Investigation Report

NIOSH Task No. TN-15210

Background

As part of the ***National Institute for Occupational Safety and Health (NIOSH) Fire Fighter Fatality Investigation and Prevention Program***, the Technology Evaluation Branch agreed to examine and evaluate one Mine Safety Appliances 4500 psi self-contained breathing apparatus (SCBA).

This SCBA status investigation was assigned NIOSH Task Number TN-15210. The submitter was advised that NIOSH would provide a written report of the inspections and any applicable test results.

The SCBA, sealed in a corrugated cardboard box, was delivered to the NIOSH facility in Bruceton, Pennsylvania on May 25, 2007. Upon arrival, the sealed package was taken to the Firefighter SCBA Evaluation Lab (Building 108) and stored under lock until the time of the evaluation.

SCBA Inspection

The package was opened and the SCBA inspection was performed on June 20, 2007. The SCBA was inspected by Vance Kochenderfer, Quality Assurance Specialist, of the Technology Evaluation Branch, National Personal Protective Technology Laboratory (NPPTL), NIOSH. The SCBA was examined, component by component, in the condition as received to determine its conformance to the NIOSH-approved configuration. The entire inspection process was videotaped. The SCBA was identified as a Mine Safety Appliances (MSA) model; however, the damage was too extensive to determine the exact type.

The unit is extremely fire-damaged. Most of the plastic, rubber, and fabric components of the SCBA have been consumed. No performance testing could be conducted on the unit.

Personal Alert Safety System (PASS) Device

An ICM 2000 Plus Personal Alert Safety System (PASS) device was incorporated into the pneumatics of the SCBA. During the inspection, the PASS device could not be activated. The case was opened and representatives of MSA were able to retrieve stored data from the unit, and the last five uses are

presented in **Appendix II** of the full Status Investigation Report. The data indicate that the unit's battery was exhausted six minutes into the last use while the cylinder pressure was 3350 psi and the internal temperature 130°F. From the limited data available there is no indication of unusual performance of the SCBA.

Summary and Conclusions

An SCBA was submitted to NIOSH for evaluation. The SCBA was delivered to NIOSH on May 25, 2007 and inspected on June 20, 2007. The unit was identified as an MSA 4500 psi SCBA, but the exact model and NIOSH approval number could not be determined. The SCBA has suffered severe fire damage and is not functional.

It is difficult to draw conclusions about the unit given its state. The cylinder valve was found to be fully open and the cylinder empty, which would be consistent with the SCBA being used to cylinder exhaustion. Data retrieved from the ICM 2000 Plus PASS device do not suggest any malfunction during the last recorded use.

In light of the information obtained during this investigation, the Institute has proposed no further action at this time. Following inspection and testing, the SCBA was returned to the package in which it was received and stored under lock in Building 108 at the NIOSH facility in Bruceton, Pennsylvania, pending return to the submitter.

Due to the extensive damage to the unit, it does not appear possible for it to be returned to service and it should be replaced.

2007
13
NIOSH
Fire Fighter Fatality Investigation and Prevention Program

Death in the line of duty...

A summary of a NIOSH fire fighter fatality investigation *July 26, 2007*

Fire Fighter Suffers a Heart Attack and Dies Several Hours After Assisting at a Structure Fire – Illinois

SUMMARY

On July 29, 2006, a 43-year-old male paid/call Fire Fighter (FF) responded to a residential fire at 1917 hours. The fire occurred on a very hot (81 degrees Fahrenheit [°F]) and humid (77% relative humidity) evening. On-scene, the FF assisted in stretching the booster hose from the engine and setting up a positive pressure ventilation fan. During fire suppression operations, the FF and two other crew members had symptoms consistent with heat strain.

About 2 hours later, units returned to their fire station, and the FF returned home for the evening. Crew members called the FF at about 2130 hours to check on him, and he stated that he was feeling better. About an hour later, a crew member called the FF again, but this time the FF did not answer the telephone. The crew member asked his spouse to drive over to the FF's house and check to make sure he was alright. After ringing the doorbell and not getting any response, she entered the house and found the FF collapsed on the floor. She called 911 and began cardiopulmonary resuscitation (CPR). An ambulance arrived at his home 14 minutes later. Paramedics attached a cardiac monitor which revealed asystole (no heart beat). The coroner was notified and pronounced the FF dead via telephone. The death certificate (completed by the coroner) and autopsy (completed by the forensic pathologist) listed "fatal cardiac arrhythmia" due to "thrombosis of a severely narrowed artery" due to "clogged artery" as the cause of death. NIOSH investigators concluded that the heat and physical stress of fire suppression probably triggered this FF's fatal heart attack.

NIOSH investigators offer the following recommendations to address general safety and health issues. However, it is unclear if any of these recommendations would have prevented the FF's sudden cardiac death.

- ***Institute incident scene rehabilitation (rehab) during extensive structural fires.***
- ***Perform pre-placement and periodic medical evaluations consistent with National Fire Protection Association (NFPA) 1582,* Standard on Comprehensive Occupational Medical Program for Fire Departments.**
- ***Develop a structured wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.***

The Fire Fighter Fatality Investigation and Prevention Program is conducted by the National Institute for Occupational Safety and Health (NIOSH). The purpose of the program is to determine factors that cause or contribute to fire fighter deaths suffered in the line of duty. Identification of causal and contributing factors enable researchers and safety specialists to develop strategies for preventing future similar incidents. The program does not seek to determine fault or place blame on fire departments or individual fire fighters. To request additional copies of this report (specify the case number shown in the shield above), other fatality investigation reports, or further information, visit the Program Website at

http://www.cdc.gov/niosh/fire/

or call toll free

1–800–CDC–INFO (1–800–232–4636)

- ***Perform an annual physical performance (physical ability) evaluation to ensure fire fighters are physically capable of performing the essential job tasks of structural firefighting.***

- ***Ensure fire fighters are cleared for duty by a physician knowledgeable about the physical demands of firefighting, the personal protective equipment used by fire fighters, and the various components of NFPA 1582.***

- ***Provide fire fighters with medical evaluations and clearance to wear self-contained breathing apparatus (SCBAs).***

- ***Ensure members report any medication use to the fire department physician.***

INTRODUCTION and METHODS

On July 29, 2006, a 43-year-old male paid/call FF died after responding to a structure fire. NIOSH was notified of this fatality on August 8, 2006 by the United States Fire Administration. NIOSH contacted the affected Fire Department on September 6, 2006 to obtain further information, and on May 11, 2007 to initiate the investigation. On May 21, 2007, a Safety and Occupational Health Specialist from the NIOSH Fire Fighter Fatality Investigation Team traveled to Illinois to conduct an on-site investigation of the incident.

During the investigation, NIOSH personnel interviewed the following people:

- Career Fire Chief
- FF's mother

NIOSH personnel reviewed the following documents:

- Fire Department incident reports
- Fire Department annual 2006 response report
- Fire Department standard operating guidelines
- Ambulance report
- Death certificate
- Autopsy report
- Primary care provider medical records

INVESTIGATIVE RESULTS

On July 29, 2006, the Fire Department was dispatched to a residential structure fire at 1917 hours. Equipment and personnel (1 engine, 1 tanker, 1 rescue/service truck, and 18 personnel) responded to the call, arriving on-scene at 1923 hours. Fire fighters found fire breaking through the roof directly above the kitchen area. Fire fighters, wearing full bunker gear and SCBA, entered the structure with a charged 1¾-inch hoseline and extinguished the fire. The weather conditions at this time included a temperature of about 81°F with 77% relative humidity, giving a heat index of 86°F.[1]

The FF, walking on a bike trail about ½-mile from his vehicle, heard the dispatch and ran to his vehicle; then drove four blocks to the scene. He arrived at the scene at about 1933 hours, donned bunker gear, and assisted in stretching a booster hose from the engine. He then obtained a positive pressure ventilation fan and put it into operation. After about 10

minutes, the FF became the third fire fighter to have symptoms of nausea, apparently due to the heat and humidity. The entire operation took about 1½-hours. The emergency was declared under control, and units departed the scene at 2100 hours.

During fire suppression operations, the Chief (the Incident Commander for this fire) recommended the three fire fighters seek medical treatment at the local hospital, but all three refused. No rehab sector was established at the fire scene but hydrating fluids were available. Their symptoms persisted through the remainder of the incident (about 75 minutes). Prior to leaving the scene, the Fire Chief checked on the FF, who stated he was going home. A crew member called the FF to check on him at 2130 hours, and the FF reported he vomited once, but had taken a shower and was feeling better, despite some persistent indigestion. About an hour later, crew members again tried to check up on the FF via telephone. This time they were unable to reach him. A crew member's spouse drove to the FF's house to check on him (2227 hours). She rang the doorbell but received no response. She peered into the window and saw him lying on the floor. She entered the house and found the FF unresponsive, without a pulse, and not breathing. She called 911 (2230 hours) and began CPR.

The ambulance was dispatched at 2231 hours and responded at 2234 hours, arriving at the scene at 2244 hours (it had been on standby at an event in another town). Ambulance paramedics found the FF unresponsive, not breathing and without a pulse, cool and cyanotic, with CPR in progress. A cardiac monitor attached to the FF revealed asystole (no heart beat) in two leads. Police officers arrived and notified the coroner, who pronounced the FF dead at 2244 hours via telephone. There was discrepancy of a few minutes between the ambulance and death certificate timeline.

Medical Findings. The death certificate (completed by the coroner) and autopsy (completed by the forensic pathologist) listed "fatal cardiac arrhythmia" due to "thrombosis of a severely narrowed artery" due to "clogged artery" as the cause of death. Pertinent findings from the autopsy, performed on July 30, 2006, included the following:

- Atherosclerotic cardiovascular disease
  - Severe (80%) narrowing of the left anterior descending coronary artery
  - Thrombus in the left anterior descending coronary artery
  - Moderate (50%) narrowing of the right coronary artery
- Cardiomegaly (heart weighed 580 grams [g]) (normal weight is <400 g)[2]
  - Left ventricular hypertrophy (left ventricle 16-20 millimeters [mm] thick) (normal thickness is 7.6-8.8 mm)[3]
- No evidence of a pulmonary embolus (blood clot in the lung arteries)
- Negative alcohol tests
- Drug testing was positive for prescription medication hydrocodone (13 nanograms [ng] per milliliter [mL]) (therapeutic level is 10 - 40 ng/mL)
- Carbon monoxide blood level of 5.6% (normal for a smoker)

The FF was 75" tall and weighed 304 pounds, giving him a body mass index (BMI) of 37.99.

A BMI >30.0 kilograms per meters squared (kg/m^2) is considered obese.[4] The FF had a history of hypertension and was prescribed two antihypertensive medications. His triglycerides were elevated while his high-density lipoprotein (HDL) was low on two occasions (2003 and 2006), but he was not diagnosed with hyperlipidemia, nor was he prescribed a low fat diet or a lipid-lowering medication. Also, he smoked cigars. There was no family history of coronary artery disease. The FF had a tooth pulled 3 days prior to his death and had been prescribed hydrocodone as a painkiller.

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, this Fire Department consisted of 27 uniformed personnel (1 career Fire Chief and 26 paid/call members), served a population of 7,500 in a 100-square-mile area, and had 1 fire station. In 2006, the Fire Department responded to 107 calls including: 21 structure fires, 11 tree/grass/brush fires, 6 vehicle fires, 1 rubbish fire, 7 rescue calls, 7 hazardous condition calls, 21 false alarm calls, 17 good intent calls, and 16 service calls.

Membership and Training. The Fire Department requires the following of all fire fighter applicants:

- complete an application
- possess a valid State driver's license
- be over 18 years of age
- pass an oral interview

The applicant is voted on by the general membership. The successful applicant is accepted into the Fire Department and is encouraged to enroll in fire science classes at the local college. Additional training is conducted at the Fire Department to train the applicant to the Fire Fighter 2 (FF2) level (230 hours). The new fire fighter must attend drills and respond to 25% of the calls. The State minimum standard for fire fighter certification is FF2.

The FF was certified as an FF2, Emergency Medical Technician (EMT), Instructor 1, and in Hazardous Materials awareness. He had 10 years of firefighting experience.

Pre-placement and Periodic Medical Evaluations. No pre-placement or periodic medical evaluations are required by this Fire Department. Medical clearance for SCBA use is not required. If someone is injured at work, a return-to-duty medical clearance is required from the fire fighter's primary care physician and provided to the City's Worker's Compensation clerk, who makes the final clearance decision.

Health/Wellness. An annual physical agility test is not required for members. No wellness/fitness program or aerobic and strength equipment are available.

DISCUSSION

Coronary Artery Disease (CAD) and the Pathophysiology of Sudden Cardiac Death. In the United States, CAD (atherosclerosis) is the most common risk factor for cardiac arrest and sudden cardiac death.[5] Risk factors for its development include increasing age, male gender, heredity, tobacco smoking, diabetes,

high blood cholesterol, high blood pressure, and physical inactivity/obesity.[6] The FF had four American Heart Association (AHA) risk factors for CAD: male gender, high blood pressure, tobacco smoking, and obesity. He had CAD based on his autopsy report, but the FF did not report symptoms of angina (e.g., chest pain on exertion) prior to his collapse or in the months/years prior to his death. However, he did report nausea and vomiting prior to his collapse. It is unclear if the symptoms were due to heat stress or his "angina equivalent" (cardiac symptom other than chest pain).

Patients with severe CAD are at risk for heart attacks. Heart attacks occur with the sudden development of complete blockage (occlusion) in one or more coronary arteries that have not developed a collateral blood supply.[7] This sudden blockage is primarily due to blood clots (thromboses) forming on top of atherosclerotic plaques. At autopsy, the FF had a thrombus in his left anterior descending coronary artery, thus confirming his heart attack.

Blood clots in coronary arteries are initiated by disruption of atherosclerotic plaques. Certain characteristics of the plaques (size, composition of the cap and core, and presence of a local inflammatory process) predispose the plaque to disruption.[7] Disruption then occurs from biomechanical and hemodynamic forces, such as increased blood pressure, increased heart rate, increased catecholamines, and shear forces, which occur during heavy exercise.[8]

Firefighting is widely acknowledged to be one of the most physically demanding and hazardous of all civilian occupations.[9] Firefighting activities are strenuous and often require fire fighters to work at near maximal heart rates for long periods. Even when energy costs are moderate (as measured by oxygen consumption) and work is performed in a thermoneutral environment, heart rates may be high (over 170 beats per minute), owing to the insulative properties of the personal protective clothing.[10] The FF ran ½-mile to his vehicle and responded to the structure fire. On-scene, the FF (while wearing full bunker gear) assisted in pulling the booster hose and setting up a positive pressure ventilation fan in high ambient temperature and humidity. This is considered a heavy level of physical exertion.[9,11]

Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks.[12-15] The physical stress of running ½-mile, pulling the booster hose and setting up a positive pressure ventilation fan (while wearing full bunker gear in high ambient temperature and humidity), and the FF's underlying CAD, could have triggered the thrombus, causing a heart attack which caused a heart arrhythmia and sudden cardiac death.[16,17]

Left Ventricular Hypertrophy. On autopsy, the FF was found to have left ventricular hypertrophy and an enlarged heart. Hypertrophy of the heart's left ventricle is a relatively common finding among individuals with long-standing high blood pressure (hypertension), a heart valve problem, or chronic cardiac ischemia (reduced blood supply to the heart muscle).[1] The FF's left ventricular hypertrophy was likely due to his

high blood pressure. Both conditions, the left ventricular hypertrophy and hypertension, increase the risk for sudden cardiac death.[1]

Heat Stress/Strain. Heat stress is the exposure to heat loads. Sources of heat include the metabolic cost of work, environmental factors, (i.e., air temperature, humidity, air movement, and radiant heat exchange), and clothing requirements.[18] Heat strain is the overall physiological response resulting from heat stress.[18] Sudden and severe fatigue, nausea, dizziness, or lightheadedness are symptoms of heat strain and should trigger removal from heat sources. Some common heat-related disorders include heat syncope, dehydration and loss of electrolytes, heat exhaustion, and heat stroke. Heat-related disorders vary in degree of severity, although all but heat stroke resolve with no lasting complications.[18]

The prime objective of heat stress management is the prevention of heat stroke, which is life-threatening and the most serious of the heat-related disorders.[18] The likelihood and severity of heat strain experienced by an individual for a given level of heat stress depends on the physiological capacity of that individual to respond to the stress.[18] Personal risk factors such as age, obesity, state of hydration, use of medications and drugs, gender, and acclimatization state may reduce an individual's tolerance for heat stress.[18] The environmental conditions and the fact that other fire fighters had nausea suggest that the FF's symptoms probably were due to heat exhaustion. However, we cannot rule out that his nausea and vomiting were symptoms of a heart attack.[19] Due to the environmental conditions and work activities, the Incident Commander should have set up a rehab unit to triage the symptomatic FFs and provide climatic relief from heat stress.

Occupational Medical Standards for Structural Fire Fighters. To reduce the risk of sudden cardiac death or other incapacitating medical conditions among fire fighters, the NFPA developed NFPA 1582.[20] NFPA 1582 recommends an electrocardiogram (EKG) as part of the annual medical evaluation. An EKG within the past year probably would have detected the FF's left ventricular hypertrophy. If left ventricular hypertrophy had been detected, perhaps the FF would have been referred for further medical evaluation (e.g., an echocardiogram).

NFPA 1582 considers use of narcotic painkillers to compromise the member's ability to safely perform 12 essential job tasks for structural fire fighting.[20] The FF should have reported this medication use to the Fire Department so a determination could be made regarding work restrictions. Because the Fire Department did not have a physician, the Fire Chief or the City Worker's Compensation clerk should have been notified.

RECOMMENDATIONS

NIOSH investigators offer the following recommendations to address general safety and health issues. However, it is unclear if any of these recommendations would have prevented the FF's sudden cardiac death.

Recommendation #1: Institute incident scene rehabilitation (rehab) during extensive structural fires.

The Incident Commander should consider the circumstances of each incident in determining the need for rehabilitation.[21] Members performing intense work for 20 minutes without SCBA should receive at least 10 minutes of self-rehab.[22] Rehab should be located sufficiently far away from the effects of the operation so that members can safely remove their personal protective equipment and SCBA.[22] On-scene rehab should be staffed, include at least basic life support, and have fluid and food available.[22] Members entering rehab should receive medical monitoring including rating of perceived exertion, heart rate, blood pressure, and temperature.[22] While the fire at this incident was considered a routine residential fire, fire fighters performed heavy physical exertion while effecting fire suppression activities during elevated temperature and humidity. Therefore, NIOSH investigators believe rehab should have been established, and the symptomatic FFs should have been assigned to rehab for evaluation and treatment. In addition, under the incident command system, the Incident Commander could have required the symptomatic FFs to go to the hospital's emergency department for evaluation.

***Recommendation #2: Perform pre-placement and periodic medical evaluations consistent with National Fire Protection Association (NFPA) 1582,* Standard on Comprehensive Occupational Medical Program for Fire Departments.**

NFPA 1582 requires fire departments to conduct pre-placement and annual medical evaluations. Guidance regarding the content and frequency of these evaluations can be found in NFPA 1582[20] and in the International Association of Fire Fighters (IAFF) / International Association of Fire Chiefs (IAFC) *Fire Service Joint Labor Management Wellness/Fitness Initiative*.[23] However, the Fire Department is not legally required to follow this standard or this initiative. Applying this recommendation involves economic repercussions and may be particularly difficult for small, volunteer or combination fire departments to implement. NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, Chapters 8-7.1 and 8-7.2[21] and the National Volunteer Fire Council (NVFC) *Health and Wellness Guide*[24] address these issues.

To overcome the financial obstacle, the Fire Department could urge current members to get annual medical clearances from their private physicians. Another option is having the annual medical evaluations completed by paramedics and EMTs from the Emergency Medical Service (vital signs, height, weight, visual acuity, and EKG). This information could then be provided to a community physician, perhaps volunteering his or her time, to review the data and provide medical clearance (or further evaluation, if needed). The more extensive portions of the medical evaluations could be performed by a private physician at the fire fighter's expense (personal or through insurance), provided by a physician volunteer, or paid for by the Fire Department. Sharing the financial responsibility for these evaluations between fire fighters, the Fire Department, and physician volunteers may reduce the negative financial impact on recruiting and retaining needed fire fighters.

Recommendation #3: Develop a structured wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.

Physical inactivity is the most prevalent modifiable risk factor for CAD in the United States. Physical inactivity, or lack of exercise, is associated with other risk factors, including obesity and diabetes.[25] NFPA 1500 requires that a Fire Department have a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being.[21] Wellness programs have been shown to be cost effective, typically by reducing the number of work-related injuries and lost work days.[26-28] Health promotion programs in the fire service have been shown to reduce CAD risk factors and improve fitness levels, with mandatory programs showing the most benefit.[29-31] One mandatory program was able to show a cost savings of $68,741 due to reduced absenteeism.[32] A similar cost savings has been reported by the wellness program at the Phoenix Fire Department, where a 12-year commitment has resulted in a significant reduction in their disability pension costs.[33] Guidance for implementation and components of a wellness/fitness program are found in NFPA 1583, *Standard on Health-Related Fitness Programs for Fire Fighters*,[34] in the IAFF/IAFC's *Fire Service Joint Labor Management Wellness/Fitness Initiative*,[23] and in the NVFC's *Health and Wellness Guide*.[24] Given the structure of the FF's Fire Department, the NVFC program might be the most appropriate model. NIOSH recommends a formal, structured wellness/fitness program to ensure all members receive the benefits of physical exercise. Even though the Fire Department does not have exercise equipment in the fire station, fire fighters could use other local facilities such as the school, fitness club, or equipment at home.

Recommendation #4: Perform an annual physical performance (physical ability) evaluation to ensure fire fighters are physically capable of performing the essential job tasks of structural firefighting.

NFPA 1500 requires Fire Department members who engage in emergency operations to be annually evaluated and certified by the Fire Department as having met the physical performance requirements identified in paragraph 8-2.1 of the standard.[21]

Recommendation #5: Ensure fire fighters are cleared for duty by a physician knowledgeable about the physical demands of firefighting, the personal protective equipment used by fire fighters, and the various components of NFPA 1582.

Guidance regarding medical evaluations and examinations for structural fire fighters can be found in NFPA 1582[20] and in the report of the IAFF/IAFC *Fire Service Joint Labor Management Wellness/Fitness Initiative*.[23] According to these guidelines, the Fire Department should have an officially designated physician who is responsible for guiding, directing, and advising the members with regard to their health, fitness, and suitability for duty as required by NFPA 1500.[21] The physician should review job descriptions and essential job tasks required for all Fire Department positions and ranks, in order to understand the physiological and psychological demands of fire fighters and the

environmental conditions under which they must perform, as well as the personal protective equipment they must wear during various types of emergency operations.

Recommendation #6: Provide fire fighters with medical evaluations and clearance to wear self-contained breathing apparatus (SCBAs).

The Occupational Safety and Health Administration (OSHA)'s *Revised Respiratory Protection Standard* requires employers to provide medical evaluations and clearance for employees using respiratory protection.[35] Such employees include fire fighters who utilize SCBA in the performance of their duties. These clearance evaluations are required for private industry employees and public employees in States operating OSHA-approved State plans. Illinois is a State-plan State, and public sector employers are required to comply with OSHA standards.

Recommendation #7: Ensure members report any medication to use the Fire department physician.

NFPA 1582 requires fire department members to "report to the fire department physician any medical condition that could interfere with the ability of the individual to safely perform essential job tasks, such as illness or injury, use of prescription or nonprescription drugs, and pregnancy."[20] If the Fire Department had a contract Fire Department physician, perhaps the FF would have provided this information.

However, it is unlikely the use of hydrocodone was a factor in the FF's sudden cardiac death.

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2007
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NIOSH
Fire Fighter Fatality Investigation and Prevention Program

Death in the line of duty...

September 21, 2007

Fire Fighter Suffers Sudden Cardiac Death during Physical Fitness Training—North Carolina

SUMMARY

On December 1, 2006, a 44-year-old male career Fire Fighter (FF) was participating in physical fitness training in preparation for the Fire Department's annual physical fitness examination and the job-related physical agility test (JRPAT). After running (sprinting) for about 15 minutes he collapsed. A passerby alerted the fire fighters in the fire station. Crew members found the FF unresponsive, not breathing, and without a pulse (1748 hours). Dispatch was notified, cardiopulmonary resuscitation (CPR) and advanced life support were begun, and the FF was transported to the hospital's Emergency Department. Inside the Emergency Department, advanced life support treatment continued with no improvement in the FF's condition. The attending physician pronounced the FF dead at 1819 hours and resuscitation efforts were discontinued. The death certificate and autopsy (completed by the Medical Examiner) listed "hypertrophic obstructive cardiomyopathy" as the cause of death.

NIOSH investigators offer the following recommendations to address general safety and health issues. However, it is unclear if any of these recommendations could have prevented the FF's sudden death.

- ***Perform periodic medical evaluations consistent with National Fire Protection Association (NFPA) 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments. The Fire Department and Union should negotiate the content and frequency of the evaluations to be consistent with NFPA 1582.***
- ***Fire fighters should be medically cleared prior to participating in the Fire Department's physical fitness examination and the job-related physical agility test, specifically, by taking the aerobic capacity (treadmill) test.***
- ***Provide fire fighters with medical evaluations and clearance to wear self-contained breathing apparatus (SCBAs).***

INTRODUCTION AND METHODS

On December 1, 2006, a 44-year-old male career FF died during physical fitness training. NIOSH was notified of this fatality on December 6, 2006 by the United States Fire Administration. NIOSH contacted the affected Fire Department on December 14, 2006 to obtain further information, and on March 22, 2007 to initiate the investigation. On April 30, 2007, a Safety and Occupational Health Specialist from the NIOSH Fire Fighter Fatality Investigation Team traveled to North Carolina to conduct an on-site investigation of the incident.

During the investigation, NIOSH personnel interviewed the following people:

- Fire Chief
- Health and Safety Officer
- Crew members
- FF's spouse

NIOSH personnel reviewed the following documents:

- Fire Department incident reports
- 9-1-1 dispatch records
- Witness statements
- Fire Department training records
- Fire Department annual 2006 response report
- Fire Department standard operating guidelines
- Ambulance report
- Hospital records
- Death certificate
- Autopsy report
- Primary care provider medical records

INVESTIGATIVE RESULTS

On December 1, 2006, the FF arrived at his fire station (Station 23) for duty at 0745 hours; his shift began at 0800 hours. From 0800 hours to 0900 hours, the FF and his crew members cleaned the fire station and checked the apparatus and equipment. At 1021 hours, Engine 23 (including the FF) was dispatched to a medical call at a nursing home facility. The FF carried the medical equipment bag into the facility and assisted with patient care by taking vital signs of a facility resident. At 1037 hours, Engine 23 was released and returned to the fire station.

At 1345 hours, Engine 23 was dispatched to fill-in at Station 34 while Engine 34 was out of the station. While at Station 34, the FF and crew washed Engine 23. At 1545 hours, Engine 23 returned to their fire station. At 1642 hours, Engine 23 responded to its' medical call of the day. The incident involved an 8-year-old child with difficulty breathing. The FF carried the medical equipment bag inside the dwelling and took the child's vital signs. He then moved the child onto a stretcher and loaded the stretcher into the ambulance. Engine 23 was released from the scene at 1704 hours.

At 1720 hours, the FF asked his Captain for permission to go outside and exercise, in preparation for the annual Fire Department physical fitness examination and the job-related physical agility test. The FF changed from his station uniform into his exercise clothing. Station 23 was adjacent to a large parking lot, where he trained by running wind sprints. At 1745 hours, a passing motorist rang the front doorbell at Station 23 and alerted the Captain of Ladder 23 that there was a person down in

the grass between the fire station and the church parking lot. Meanwhile, the motorist's spouse had walked to the rear of the station and advised the ambulance personnel (paramedics).

The Captain announced over the station's public address system that they had a "walk-in medical call." He then notified Dispatch via the hotline telephone and asked for a dedicated radio channel for emergency communication (1748 hours). Crew members retrieved their medical equipment (oxygen equipment and an automated external defibrillator [AED]), and, realizing that the "person down" was their FF crew member, alerted the Captain to that fact.

Paramedics found the FF unresponsive, not breathing, and without a pulse. CPR was begun while the AED was being attached. A shockable heart rhythm was read and a defibrillation "shock" was delivered. The AED did not advise to shock again and CPR continued. An oral airway was placed and oxygen was delivered via bag-valve-mask. Medic 24 was driven to the front of the station as the FF was placed onto a backboard/cot and placed into the Medic unit. CPR continued as an intravenous (IV) line was placed and cardiac resuscitation medications were given. The AED advised to shock again and a second defibrillation shock was delivered. Intubation (breathing tube inserted into the trachea) was attempted twice, but placement was unsuccessful. This was followed by the attempted placement of a laryngeal mask airway, but this was also unsuccessful. A cardiac monitor was attached, revealing ventricular fibrillation, and a manual shock was delivered. Medic 24 departed the scene at 1754 hours en route to the hospital's Emergency Department, and arrived 11 minutes later (1805 hours).

Inside the Emergency Department, advanced life support treatment continued, including intubation, an additional IV, and cardiac resuscitation medications. Cardiac monitoring revealed ventricular fibrillation multiple times, and numerous shocks (4-5) were administered. Despite these resuscitation measures, the FF's condition did not improve. At 1819 hours, the attending physician pronounced the FF dead, and resuscitation measures were discontinued.

Medical Findings. The death certificate and autopsy (completed by the Medical Examiner) listed "hypertrophic obstructive cardiomyopathy" as the cause of death. Pertinent findings from the autopsy, performed on December 2, 2006, included the following:

- Cardiomegaly (heart weighed 740 grams [g]; normal weight is <400 g)[1]
- Left ventricular chamber reduced in size due to a mass of bulging muscle from the interventricular septum
- Eccentric left ventricular thickening of the interventricular septum (3.1 centimeters [cm]; normal thickness is 0.6–1.1 cm)[2]
- Left ventricular free wall thickened (1.7 cm; normal thickness is 0.76–0.88 cm)[3] (normal echographic measurement is 0.6–1.1 cm)[2]
- Left ventricular front wall thickened (2.3–2.7 cm)
- Chronic ischemic damage involving the interventricular septum and left ventricular free wall (associated with scar formation)

- Recent fibrous scar tissue formation along the anterior lateral free wall of the left ventricle resulting in mottling and hemorrhage
- Minimal atherosclerosis in the coronary arteries
- No evidence of a thrombus (blood clot) in the coronary arteries
- Normal cardiac valves
- No evidence of a pulmonary embolus (blood clot in the lung arteries)
- Negative drug tests

Microscopic examination of the heart revealed "extensive transmural scarring with loss of myocytes, hypertrophic changes of the residual myocytes, and focal myocyte disarray."

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, this career Fire Department consisted of 972 uniformed personnel, and served a population of 665,000 in a 280-square-mile area. It had 38 fire stations, including 56 fire companies where fire fighters work 24-hour shifts (starting at 0800 hours) according to the following tour: 24 hrs-on, 24-off, 24-on, 48-off, 24-on, 24-off, 24-on, and 96-off. In 2006, the Fire Department responded to 85,194 calls. Engine 23 was the fourth busiest company within the Fire Department, responding to 3007 calls including: 201 fires, 1849 medical calls, 93 hazardous condition calls, 38 overpressure calls, 351 false alarm calls, 405 good intent calls, 212 service calls, and 28 natural/other calls. Engine 23 was sixth in fire responses. Engine 23 A-shift (the FF's shift) responded to 1,507 calls. Station 23 was the busiest fire station in the City, with about 6,300 responses. The ambulance service is provided by the County.

Membership and Training. The Fire Department requires all fire fighter applicants to

- be at least 18 years of age,
- possess a high school diploma or equivalent,
- possess a valid State Driver's license,
- have no felony convictions or misdemeanors involving moral turpitude,
- have no illegal drug use in the past 12 months,
- complete an application,
- pass a written general knowledge test,
- pass a candidate physical ability test (CPAT),
- pass a background interview,
- pass a polygraph and background check,
- pass a panel interview,
- pass a pre-placement medical evaluation, and
- pass a drug screen.

The successful applicant is placed in a hiring pool and hired when an opening occurs. New hires are placed into the 21-week Recruit School. The successful graduate is trained to the NFPA FF-I and Emergency Medical Technician (EMT) level, is assigned to a fire company, and placed on probation for 12 months. The new fire fighter continues training for the next 3 years to achieve the NFPA FF-II

level, and for an additional year to achieve the rank of FF/Engineer. All are certified to the EMT-defibrillator (EMT-D) level and are certified in CPR, AED use, and hazardous materials operations level (24-hour). The State voluntary minimum standard for fire fighter certification is NFPA 1001, *Standard for Firefighter Professional Qualifications*.[4]

The FF was certified as a Fire Fighter II, EMT-D, and in Hazardous Materials Operations. He had 17 years of firefighting experience.

Pre-placement Medical Evaluations. A pre-placement medical evaluation is required for all new hires, regardless of age. Components of this evaluation include:

- A complete medical history
- Height, weight, and vital signs
- Physical examination
- Blood tests (complete blood count [CBC], sequential multiple analysis [SMA] 6, liver function tests, lipid test, and Hepatitis B antibody and antigen titer testing)
- Urine dipstick test
- Chest x-ray
- Resting electrocardiogram (EKG)
- Pulmonary function tests/spirometry
- Audiometry
- Vision test
- Tetanus booster (if appropriate)

These evaluations are performed by the Fire Department contract physician, who makes a decision regarding medical clearance for firefighting duties based on recommended standards in NFPA 1582. The Fire Department is notified of any condition requiring modification or restriction. Results of the medical evaluation are kept confidential by the contract physician, and only the clearance status is reported to the Fire Department.

Periodic Medical Evaluations. Periodic medical evaluations are not required for all fire fighters. Biannual medical evaluations are required for Hazardous Material (Hazmat), Heavy Rescue, and Dive Team personnel. Components of this evaluation are the same as those of the candidate pre-placement medical evaluation. Hazmat personnel receive their annual medical evaluations per the State Occupational Safety and Health Administration (OSHA) Standard.[5-6] Medical clearance for SCBA use is not required for all fire fighters, only for Hazmat, Heavy Rescue, and Dive Team.

If a fire fighter is injured at work, a return-to-duty medical clearance is required from the City's Worker's Compensation panel. If an injury or illness prevents a fire fighter from performing his or her duty for 30 calendar days, a return-to-duty clearance with no indicated or implied physical restrictions is required from their primary care physician. This clearance requires the signature of the treating physician on a Fire Department "Medical Clearance Form." This form includes a job description that lists many of the physically challenging job duties required during fire suppression or rescue work. The clearance is then reviewed by the Fire Department's Occupational Specialist, who makes the final clearance decision. At the Supervisor's discretion, depending upon the severity/nature of the injury/illness, regardless of the length of absence, a medical clearance with no indicated or implied physical restrictions may be required. This must be

obtained from the fire fighter's primary care physician, using the Fire Department "Return-to-Work Medical Clearance" form. The Fire Department's Occupational Specialist reviews this clearance and makes the final return-to-duty decision. Employees involved in Worker's Compensation cases must provide proof of medical clearance from the City Department of Insurance and Risk Management. After receiving medical clearance, the employee must participate in and pass the job-related physical agility test in order to return to full duty.

Fire fighters who fail the job-related physical agility test are prescribed a physical reconditioning program designed by the Physical Fitness Coordinator. The fire fighter is assigned to the Fire Training Academy until they pass the job-related physical agility test. If the fire fighter cannot pass the job-related physical agility test within 30 days of assignment to the Academy, the situation is handled administratively on a case-by-case basis.

Health/Wellness. The Physical Fitness Coordinator administers the Fire Department's wellness/fitness program. A biannual physical fitness examination and a biannual physical agility test are required for members. The mandatory program is designed to meet the guidelines of the *Fire Service Joint Labor Management Wellness/Fitness Initiative,*[7] and consists of an individualized exercise program developed by the Physical Fitness Coordinator based on the fire fighter's physical fitness examination (described below). Each fire fighter is encouraged to devote time to physical fitness training during each 24-hour shift (Sundays and holidays are optional). All fire stations are equipped with exercise (strength and aerobic) equipment.

Physical Fitness Examination. The physical fitness examination evaluates fire fighters in three areas: aerobic capacity (treadmill to 15 [metabolic equivalent tasks] METs), muscle strength/ endurance, and body composition. The evaluation areas are weighted to generate a total/overall score, adjusted by gender and age. Exam results are utilized as follows:

- <50 on any item requires on-duty exercise participation in a prescribed program
- ≥50 on all items results in voluntary on-duty exercise participation
- ≥70 on all items results in the award of a uniform pin.

Job-Related Physical Agility Test. This test is administered biannually. During the job-related physical agility test, the participant wears full turnout gear, including SCBA. Participants either pass or fail the test based on time to completion. The job-related physical agility test consists of the following tasks:

- Pull a bundle of dry hose line (200-feet of 1¾-inch) from the truck shelf and place it on the ground. Pull a separate dry hose line (same size) 75-feet. Walk back to the truck.
- Remove a 16-foot ladder from the extended ladder bracket of the truck. Carry the ladder 75- feet. Raise the ladder to the wall. Walk to the stairwell of the fire tower.

- Pick up a high-rise pack at the base of the stairwell (100-foot section of 1¾-inch hose formed into a "soft pack"). While carrying the high-rise pack, climb the stairs to the 4th floor of the tower. Drop the high-rise pack in the breezeway. Begin breathing air from the SCBA (remain on air for the remainder of the test).
- Enter into the 4th floor room off the breezeway. Advance to the nozzle end of the charged hose section (50-feet of 1¾-inch hose filled with water and capped off at both ends). Crawl through the 25-foot L-shaped course while dragging the charged hose section. When reaching the end of the course, pull the remainder of the hose section across the event finish line while remaining on at least one knee. Go to the ground floor and exit the tower.
- Climb a fixed pre-positioned ladder to the 2nd floor window of the tower. Enter through the window into the breezeway.
- Advance to the forcible entry simulator (Keiser machine) and move the I-beam the entire length of the sled.

Failure to achieve a passing time (10 minutes or less) on the job-related physical agility test will result in the following actions:

- Immediate removal from operations duty assignment.
- A medical examination and medical clearance for duty determination. If the fire fighter is not medically cleared, the situation is handled as a medical fitness-for-duty issue.
- If the fire fighter is medically cleared, they are assigned to the Training Academy, under the supervision of the Chief of Training, for up to 90 days. During this period, the fire fighter will participate in an exercise regimen prescribed by the Physical Fitness Coordinator. The fire fighter may choose to take the job-related physical agility test at any time during the 90 days to return to full duty (if a passing time is achieved). After failure to successfully pass the job-related physical agility test within the initial 45 days, a meeting with the Fire Chief is scheduled.
- If the fire fighter is unable to pass the job-related physical agility test within 90 days, disciplinary action up to and including termination is possible.

DISCUSSION

Cardiomyopathies constitute a group of diseases involving damage to the heart muscle; damage not due to hypertension, ischemia (coronary artery), or valvular conditions.[8] There are three types of cardiomyopathy based on functional impairment:

- Dilated, the most common form, accounts for 60% of all CMs
- Hypertrophic (HCM), recognized by inappropriate left ventricular hypertrophy, often with involvement of the interventricular septum (as in this case)
- Restrictive, the least common form in Western countries, marked by impaired diastolic filling and in some cases with endocardial scarring of the ventricle8

This FF was diagnosed with HCM at autopsy based on the location of his marked left ventricular hypertrophy, and the characteristic microscopic findings of myocyte disarray and focal scarification.[9]

Hypertrophic Cardiomyopathy (HCM). Idiopathic HCM is a relatively rare heart condition, affecting approximately 0.2% of the population.[10] Diagnosis is typically made by echocardiogram which shows the subaortic obstruction, and EKG findings of left ventricular hypertrophy by voltage. The majority of patients are asymptomatic, and sudden cardiac death is often the first clinical manifestation.[11] Risk factors for sudden death among idiopathic HCM patients include young age (<30 years old) at diagnosis, a family history of idiopathic HCM with sudden death, an abnormal blood pressure response to exercise, severe symptoms, non-sustained ventricular tachycardia, marked hypertrophy, marked left atrial dilatation, and genetic abnormalities associated with increased prevalence of sudden death.[10-12] Approximately half of the idiopathic HCM cases are transmitted genetically, typically as an autosomal dominant trait. Because of this, medical evaluation of first-degree relatives is warranted to determine whether screening tests (e.g., echocardiogram) are appropriate.

The FF was asymptomatic, and prior medical evaluations did not detect any cardiac abnormality (e.g., a heart murmur). The FF never had an EKG, either with the fire department or by his personal physician. The FF did not have any risk factors associated with sudden death among HCM patients.

The FF was running in wind sprints, which is considered a heavy level of physical exertion.[13,14] The NIOSH investigator concludes that the FF had a fatal cardiac arrhythmia associated with his hypertrophic obstructive cardiomyopathy. The heavy exertion associated with the wind sprints probably triggered his sudden cardiac death.

Occupational Medical Standards for Structural Fire Fighters. To reduce the risk of sudden cardiac death or other incapacitating medical conditions among fire fighters, the NFPA developed NFPA 1582.[15] NFPA considers idiopathic hypertrophic subaortic stenosis a Category A medical condition for fire fighter candidates. Candidates with Category A medical conditions "shall not be certified as meeting the medical requirements of NFPA 1582."[15] NFPA considers HCM a Category B medical condition for fire fighter candidates; defined as "a medical condition that, based on its severity or degree, ***could*** (our emphasis) preclude a person from performing as a fire fighter in a training or emergency operational environment by presenting a significant risk to the safety and health of the person or others." Recently the medical community has determined that HCM and idiopathic hypertrophic subaortic stenosis are actually the same condition, the distinction only being the location of the hypertrophy. NFPA 1582 notes this distinction in its members section when it states, "Hypertrophic obstructive cardiomyopathy (idiopathic hypertrophic subaortic stenosis) might compromise the member's ability to function as an integral component of a team, where sudden incapacitation can result in mission failure or in risk of injury or death to civilians or other team members.[15]

NFPA recommends annual medical evaluations to include an EKG and a chest x-ray (as

indicated). Had an EKG or chest x-ray been conducted as part of the Fire Department's annual medical evaluation, and offered to all fire fighters, perhaps the FF's enlarged heart would have been detected. This may have led to further medical evaluation (e.g., an echocardiogram) and possible treatment (an implantable cardiac defibrillator).

Had the FF's HCM been identified, would this have prevented his death? Although a variety of symptoms and medical tests can provide prognostic information, patients at greatest risk of sudden death or who are in need of antiarrhythmic therapy are hard to identify. Given the FF's lack of risk factors for sudden death, the low degree of efficacy of antiarrhythmic agents and their numerous side effects, and the lack of symptoms in the FF, it is unclear that a diagnosis would have led to treatment. Therefore, it is unclear if the FF's sudden death could have been prevented, even if his condition had been identified.

RECOMMENDATIONS

NIOSH investigators offer the following recommendations to address general safety and health issues. However, it is unclear if any of these recommendations could have prevented the FF's sudden death.

Recommendation #1: **Perform periodic medical evaluations consistent with National Fire Protection Association (NFPA) 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments. The Fire Department and Union should negotiate the content and frequency of the evaluations to be consistent with NFPA 1582.**

NFPA 1582 requires fire departments to conduct pre-placement and annual medical evaluations. Guidance regarding the content and frequency of these evaluations can be found in NFPA 1582[15] and in the International Association of Fire Fighters (IAFF)/International Association of Fire Chiefs (IAFC) *Fire Service Joint Labor Management Wellness/Fitness Initiative*.[7] However, the Fire Department is not legally required to follow this standard or this initiative.

Applying this recommendation involves economic repercussions. NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, Chapters 8–7.1 and 8–7.2[16] addresses these issues.

Recommendation #2: **Fire fighters should be medically cleared prior to participating in the Fire Department's physical fitness examination and the job-related physical agility test, specifically by taking the aerobic capacity (treadmill) test.**

During physical fitness examination tests, fire fighters are required to measure their aerobic capacity on a treadmill. When on the treadmill, fire fighters can exercise to the point of maximum heart rates and metabolic work of up to 15 metabolic equivalents of task (METs). This level of physical exertion can trigger heart attacks in susceptible individuals.[17-20] Therefore, we recommend fire fighters receive medical clearance prior to participating in the physical fitness examination.

Recommendation #3: **Provide fire fighters with medical evaluations and clearance to wear self-contained breathing apparatus (SCBAs).**

OSHA's *Revised Respiratory Protection Standard* requires employers to provide medical evaluations and clearance for employees using respiratory protection.[21] Such employees include fire fighters who utilize SCBA in the performance of their duties. These clearance evaluations are required for private industry employees and public employees in States operating OSHA-approved State plans. However, North Carolina is a State-plan State, and public sector employers are required to comply with OSHA standards.

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INVESTIGATOR INFORMATION

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2006
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NIOSH
Fire Fighter Fatality Investigation and Prevention Program

Death in the line of duty...

A summary of a NIOSH fire fighter fatality investigation

April 11, 2007

Junior Volunteer Fire Fighter Dies and Three Volunteer Fire Fighters are Injured in a Tanker Crash – Alabama

SUMMARY

On July 26, 2006, a 17-year-old female volunteer junior fire fighter (the victim) died after the tanker truck she was riding in went off a narrow one-lane bridge. The tanker was enroute to a structure fire and failed to negotiate a sharp curve at the approach to the bridge. The tanker crashed through the bridge's guardrail and landed upside down below the bridge. The driver and two other fire fighters riding in the tanker were injured in the incident. The victim was extricated by emergency personnel and pronounced dead at the scene.

NIOSH investigators concluded that, in order to minimize the risk of similar occurrences, fire departments should:

- *ensure that fire fighters are always seated in an approved riding position any time the fire apparatus is in motion*
- *ensure that all fire apparatus are equipped with seat belts and that fire fighters always wear seatbelts*
- *ensure that tankers are operated at a safe and reasonable speed*
- *provide initial and refresher training (at least twice annually) to driver/operators as often as necessary for the safe operation of fire tankers*
- *develop and enforce written policies, procedures, and/or guidelines that identify the permissible and non-permissible tasks and activities of junior fire fighters*
- *establish an effective preventive maintenance program for all fire apparatus*
- *establish and develop written standard operating procedures for all fire fighting operations*
- *avoid using former fuel trucks as water tankers, if at all possible*

Additionally States should,

- ***consider developing a State-endorsed junior fire fighter program that addresses the tasks that minors are permitted to perform in the fire service***

- ***consider requiring vehicle safety inspections for fire apparatus.***

INTRODUCTION

On July 26, 2006, a 17-year-old female volunteer junior fire fighter (the victim) was fatally injured after the tanker truck she was riding in went off a narrow one-lane bridge. The tanker was enroute to a structure fire and failed to negotiate a sharp curve at the approach to the bridge. The driver and two other fire fighters riding in the tanker were injured in the incident. On July 28, 2006, the U.S. Fire Administration (USFA) notified the National Institute for Occupational Safety and Health (NIOSH) of this incident. On September 12-13, 2006, a safety and occupational health specialist from the NIOSH Fire Fighter Fatality Investigation and Prevention Program traveled to Alabama to investigate this incident. The NIOSH investigator met with the department Chief, a fire fighter who was riding in the apparatus at the time of the incident, and other department members who were relatives of the injured fire fighters and victim. The investigator visited the incident site and took photographs. The investigator also reviewed the 911 dispatch logs, the vehicle's maintenance log, the Alabama uniform traffic accident report, law enforcement photographs of the incident, and spoke with the county coroner.

Fire Department

The volunteer department has 35 members that serve a population of approximately 3,400 within a rural area of about 48 square miles. The department serves the community from a single station and provides coverage for an area school, several churches and several local businesses along with numerous poultry farms. The department has 3 engines, 2 tankers, a brush truck and a rapid attack rescue truck. The department is funded through the county and department-sponsored fundraising events. At the time of this incident, the department did not have written standard operating procedures (SOPs) or guidelines (SOGs). In addition, the department did not require any driver training.

According to department policy, junior members are prohibited from riding apparatus to calls or engaging in any suppression activities. (*Note: Junior fire fighters travel via privately owned vehicle*). Junior members are only permitted to participate in training at the station, assisting with fire fighter rehab on the fire ground, and assisting in activities after incidents such as rolling hose. The victim was the only junior member of the department. The victim's father and brother are also members of this department. *(Note: The victim's brother was also riding in the tanker during this incident).*

Training and Experience

The State of Alabama requires individuals be 18 years old and possess a valid driver's license before they can become a member of a volunteer fire department. Alabama labor laws prohibit any one under the age of 18 from riding in a fire apparatus enroute to emergency calls or performing duties that include fighting fires.[1]

The 17-year-old victim had been a volunteer junior fire fighter for approximately 4 years and had received first aid/cardiopulmonary resuscitation (CPR) and emergency responder training through the department.

Alabama has no state training requirements for volunteer or junior fire fighters. The Alabama Fire College has a non-mandatory 160-hour volunteer fire fighter certification course.[2, 3] None of the fire fighters involved in this incident had completed this training.

Road and Weather Conditions

The incident occurred on a one-lane bridge located at the bottom of a downgrade on a horseshoe curve (see Photo 1) approximately 4 miles from the fire station. The asphalt road leading to the bridge is approximately 23 feet wide and the road makes a very sharp right hand curve as it approaches the bridge. According to the fire department and County 911 dispatch, there have been several vehicular incidents (with one other fatality) at this location in the last three years.

The road has a speed limit of 45 mph and the State police estimated the speed of the tanker at 40 mph as it approached the bridge. The bridge has a posted cautionary speed sign of 25 mph and is approximately 15 feet wide. The road was dry and the weather was sunny on the day of the incident.

Equipment and Personnel

The tanker truck (also referred to as a tender in the western United States) was a 1982 model that was formerly a propane delivery truck (see Photo 2 and Photo 3). The tanker truck had an elliptical, 2,000-gallon tank and was full *(Note: The exact type of tank baffling is unknown. Prior to the NIOSH field investigation, the towing company scrapped the tanker. The fire department reported containment-type baffling with three longitudinal baffles, which were probably the compartment bulkheads)*. The tanker truck had a diesel engine, two axles, 6 tires, a manual transmission, and an air brake system. The tanker truck had a gross vehicle weight rating (GVWR) of 33,000 lbs and was not equipped with an auxiliary braking system. The tanker truck was purchased used by the department in early 2005. The department did its own vehicle maintenance and a review of the maintenance log indicated only that minor repairs had been performed on the apparatus. The vehicle had two seats and was not equipped with seat belts.

The State of Alabama motor vehicle regulations do not require that fire apparatus be inspected annually. The State has no requirements that emergency vehicle operators possess any special training or driver's licenses such as a commercial driver's license (CDL). The vehicle was totaled in the incident and the driver was not issued any moving violations.

INVESTIGATION

On July 26, 2006, at 1859 hours, the department was dispatched as mutual aid to a structure fire. Fire Fighter #1 arrived at the station at approximately 1900 hours and donned his bunker gear and proceeded to drive Tanker 1 from the station. *(Note: Three engines from the department were already enroute to the fire).* As Fire Fighter #1 was pulling out of the station, Fire Fighter #2, Fire Fighter #3 and the victim arrived at the station in a privately owned vehicle (POV). They parked the POV and jumped into the cab of the tanker. *(Note: Fire Fighter # 2 and Fire Fighter #3 were wearing street clothes but had their bunker gear bags with them. Since the victim was a junior member she was not issued bunker gear as it is department policy that junior members do not engage in fire suppression).*

Fire Fighter #2 sat in the passenger's seat with his gear bag at his feet. Since the tanker only had two seats, the victim sat on the floor of the cab between the seats in front of the engine hump. Fire Fighter #3 shared the inside edge of the passenger seat with Fire Fighter #2. None of the fire fighters were wearing a seat belt. *(Note: Although the vehicle was originally equipped with seat belts, they were either broken or missing).* The four fire fighters departed the station at approximately 1908 hours and the driver radioed dispatch that Tanker 1 was enroute. *(Note: County 911 Dispatch did not have a dispatch or enroute time for Tanker 1, but the log indicated that they were unable to copy a unit number due to siren noise in the background).*

At approximately 1915 hours, the tanker approached the bridge. The driver began braking as the tanker started downhill. One of the injured fire fighters remembers hearing "You're going too fast!" The driver replied "I've got it under control!" Then just prior to the horseshoe curve, the driver reported that the brakes failed. The driver downshifted as he reached the turn to the bridge, but the truck struck the guardrail on the driver's side. About midway over the bridge, the truck began to roll onto the driver's side. Prior to reaching the end of the bridge, the tanker rolled onto the driver's side, crashed through the guard rail and landed upside down approximately 20 feet below in the creek bed (see Diagram).

The accident was reported to 911 dispatch by an area resident. Department vehicles enroute to the structure fire turned around *(Note: Just prior to their arrival to the fire ground, the structural fire was brought under control by the initial responding volunteer department)* and responded to the incident scene (see Photo 4). Fire Fighter #1 (the driver) was able to wiggle out of his turnout coat and free himself from the wreckage. He crawled out the broken driver's side window. The other three fire fighters were trapped upside down in the wreckage of the tanker's cab. Emergency responders used hydraulic rescue tools to free the trapped fire fighters in an extrication that lasted approximately one hour. Between 1919-1946 hours, three additional departments arrived on scene to assist with the extrication and set up a landing zone for a Medical Evacuation (MedEvac) helicopter. At 2019 hours, the MedEvac helicopter arrived on scene to transport the injured fire fighters. At 2035 hours, the MedEvac helicopter departed for the hospital with Fire Fighter #2 and Fire Fighter #3. The victim was the last to be extricated from the wreckage and was pronounced dead at the scene at 2105 hours by the county coroner.

Fire Fighter #1 was treated and released from the emergency room with burns to the hands, head, shoulders and chest from hot engine oil that spilled into the cab *(Note: The engine oil escaped from the crushed engine valve cover)*. Fire Fighter #2 was transported to a regional trauma center with multiple broken vertebras, a head contusion, and numerous second degree burns from hot engine oil. Fire Fighter #2 was immediately transferred to a regional burn center and was hospitalized for about two weeks. Fire Fighter #3 was also transported to a regional trauma center. He fractured both wrists and two ribs, suffered a head contusion and multiple abrasions. Fire Fighter #3 was hospitalized for two weeks after the incident.

CAUSE OF DEATH

According to the county coroner, the cause of death was blunt force trauma with head and chest injuries.

RECOMMENDATIONS

Recommendation #1: Fire departments should ensure that fire fighters are always seated in an approved riding position any time the fire apparatus is in motion.

Discussion: The victim and one of the injured firefighters in this incident were not fully seated in the apparatus. The victim was seated on the floor of the cab between the driver's and passenger's seats and Fire Fighters #2 and #3 were sharing the passenger's seat. Fire fighters should never ride in fire apparatus in a location other than an approved seat. NFPA 1500, Standard on Fire Department Occupational Safety and Health Programs states that "All persons riding in fire apparatus shall be seated and belted securely by seat belts in approved riding positions and at any time the vehicle is in motion. Standing or riding on tail steps, sidesteps, running boards, or any other exposed position shall be specifically prohibited."[4] NFPA 1500 further states "On existing fire apparatus where there is an insufficient number of seats available for the number of members assigned to or expected to ride on that piece of apparatus, alternate means of transportation that provide seated and belted positions shall be used."[4]

Recommendation #2: Fire departments should ensure that all fire apparatus are equipped with seat belts and that fire fighters always wear seatbelts.

Although the tanker involved in this incident was originally equipped with seatbelts when it was manufactured, they were missing at the time of this incident. Fire departments should retrofit older vehicles with seatbelts for all approved riding positions. Seatbelts that are missing or damaged should be immediately replaced. Vehicles not equipped with seat belts should be taken out of service. A vehicle operator who is properly secured by a seatbelt will have a better chance at maintaining control of the vehicle in an emergency situation and belted occupants will have an increased likelihood of surviving a crash.[4-6] Fire departments should develop and enforce SOPs on the use of seatbelts. The SOPs should state that all fire fighters on board must be seated and secured in an approved riding position whenever the vehicle is in motion. Wearing a seatbelt can minimize the risks to the driver and other occupants in the event a crash occurs.[4-6]

Recommendation #3: Fire departments should ensure that tankers are operated at a safe and reasonable speed.

Discussion: The Alabama uniform traffic accident report estimated the speed of the tanker at 40 mph as it approached the bridge. The cautionary speed sign indicated 25 mph and this should be considered the maximum safe speed limit for a passenger vehicle *(Note: A cautionary speed sign is not intended for heavy trucks or commercial vehicles)*. Fire apparatus should be operated at a much slower speed though curves than the suggested speed that appears on the warning sign. Tankers should never be driven at a speed at which the vehicle cannot be controlled.[5-7] Many fire departments do not equip tankers with red lights and sirens as first response vehicles, but have opted to equip them with yellow or amber lights and use them as fire ground support vehicles.

Recommendation #4: Fire departments should provide initial and refresher training (at least twice annually) to driver/operators as often as necessary for the safe operation of fire tankers.

Discussion: Driver training should be conducted in accordance with NFPA 1451, Standard for a Fire Service Vehicle Operations Training Program and NFPA 1002, Fire Apparatus Driver/Operator Professional Qualifications.[8, 9] These standards state that departments should establish and maintain a driver training education program and each member should be provided driver training not less than twice a year. During this training, each driver should operate the vehicle and perform tasks that the driver/operator is expected to encounter during normal operations to ensure the vehicle is safely operated in compliance with all applicable State and local laws. Driver training should address vehicle characteristics, capabilities and limitations. Tankers, for example, tend to be heavier and to have a higher center of gravity than other fire vehicles.[6] Both of these factors affect the driver's ability to control a tanker. Based on physics and inertia, a top heavy vehicle, such as a tanker, is inclined to tip or roll over if driven through a curve at an unsafe speed.[6]

Recommendation #5: Fire departments should develop and enforce written policies, procedures, and/or guidelines that identify the permissible and non-permissible tasks and activities of junior fire fighters.

Discussion: Although this volunteer department did not have written SOPs, they did have an unwritten policy that junior members were not permitted to ride fire apparatus on calls. It was unclear why the victim responded during this call. Department personnel speculated that the victim's 18th birthday was less than a month away at which time she would have been a full department member. Guidelines and procedures for junior members should be in writing, readily available to members of the fire department, and incorporated into written departmental SOPs. Fire department personnel should be made aware of the requirements, responsibilities and permitted activities of junior fire fighters to help ensure that they are assigned appropriate tasks and that they are appropriately supervised. The victim was not under the supervision of an officer during this incident.

Recommendation #6: Fire departments should establish an effective preventive maintenance program for all fire apparatus.

Discussion: Used fire apparatus obtained by fire departments should be fully inspected, repaired as needed, and road tested by a qualified mechanic prior to being placed into service. NFPA 1911, Standard for the Inspection, Maintenance, Testing, and Retirement of In-Service Automotive Fire Apparatus states that fire apparatus should be serviced and maintained to keep them in safe operating condition and ready for response at all times.[10] Maintenance schedules should be established and recorded as an integral part of a well-planned maintenance program. The maintenance program should include daily, weekly, and periodic maintenance service checks. The maintenance checks should be based on the manufacturer's service manuals, local experience, and operating conditions. In this incident, the tanker was not equipped with seatbelts and the driver reported braking problems. Vehicles with mechanical deficiencies should be taken out of service until properly repaired. The department in this incident performs its own vehicle maintenance and there are no procedures in place on when to declare a vehicle unsafe and remove it from service until it is repaired.

Recommendation #7: Fire departments should establish and develop written standard operating procedures for all fire fighting operations.

Discussion: The fire department involved in this incident did not have written standard operating procedures. Unwritten directives are difficult to learn, remember, and apply.[11] Fire departments should develop SOPs for all fire fighting operations and these operational procedures should be committed to writing.[12] Each fire fighter should have a written copy of the SOPs and they should be the subject of company drills. NFPA 1500, Standard on Fire Department Occupational Safety and Health Programs 8.1.2 states, "an incident management system that meets the requirements of NFPA 1561, Standard on Emergency Services Incident Management System, shall be established with written standard operating procedures applying to all members involved in emergency operations."[4]

The International Association of Fire Chiefs (IAFC) has developed policies and procedures for emergency vehicle safety.[13] According to the IAFC, many vehicular accidents could be prevented through the proper implementation and application of SOPs. Their guidance document "Guide to IAFC Model Policies and Procedures for Emergency Vehicle Safety" should be used as a resource by fire departments for developing their own departmental SOPs. Other resources have been developed by the National Volunteer Fire Council (NVFC) "Emergency Vehicle Safe Operations for Volunteer and Small Combination Emergency Service Organizations" and the U.S. Fire Administration's "Emergency Vehicle Safety Initiative." [14, 15]

Recommendation #8: Avoid using former fuel trucks as water tankers, if at all possible.

Discussion: According to the U.S. Fire Administration a large percentage of serious crashes involving fire department tankers can be attributed to tankers that were crafted from non-fire service vehicles.[6] In some cases, the "new" tanker is placed on a used vehicle that is already in questionable

mechanical condition. In other cases, a reliable vehicle chassis is obtained and then an excessive amount of weight is added to it.

A common practice is to develop a fire department tanker using a converted fuel oil or gasoline tanker.[6] Even though these vehicles may be in excellent condition when the fire department acquires them, these chassis frequently are not designed for the weight of the water that will be carried on them. One gallon of water weighs 8.33 pounds. One gallon of gasoline weighs 5.6 pounds, and one gallon of fuel oil weighs 7.12 pounds. Thus, if the vehicle's tank holds 2,000 gallons, water will weigh 5,460 pounds more than gasoline and 2,420 pounds more than fuel oil. This added weight creates significant safety issues for the vehicle. Another weight-related issue commonly found on retrofit tankers is the addition of pumps, piping, and other associated equipment to the apparatus. This equipment may further complicate the overweight problems discussed above. The weight of equipment must be considered along with the weight of water when determining the safe carrying capacity of the equipment.

Another problem with converting fuel tankers is that in many cases the tanks are improperly baffled for fire department use.[6] These vehicles are often designed to be driven completely full or completely empty. Thus, when the vehicle is being driven with a partially filled tank, liquid surges within the tank can result in the vehicle going out of control. Fire departments considering converting these vehicles for emergency use must add baffles or baffle balls to the inside of the tanks before placing them in service. Another significant impact of the wear and tear on the vehicle is that fuel tankers generally only spend a fraction of every 24-hour period with a full tank. When parked and not in use, they most commonly have empty tanks. Fire department tankers are loaded with water 24-hours a day, every day. This constant load on the chassis and suspension will increase the amount of wear on the apparatus once it is converted to a fire tanker.

Additionally States should,

Recommendation #9: Consider developing a State-endorsed junior fire fighter program that addresses the tasks that junior members are permitted to perform in the fire service.

Discussion: The victim in this incident was a minor and Alabama does not have a written program addressing junior fire fighters. Junior fire fighter programs provide young people with the opportunity to experience the fire service first hand and junior fire fighters often become future fire fighters. Programs involving junior fire fighters must consider local and state laws for protection of youth from hazardous conditions, and should specify the permissible and non-permissible tasks and functions for youths. The Volunteer Firemen's Insurance Services (VFIS) has guidance in their publication Junior Fire and Emergency Services Programs.[16] According to the VFIS, "Sound safety policies must be in place to stipulate what youth members are permitted to do and prohibited from doing in and around the fire station, en route to and from emergencies, and on the emergency scene. These policies must be consistent with fire department regulations, and State laws, and in the case of organizations which are Explorer Posts, must be consistent with guidelines from the Boy Scouts of

America. These policies should be established through a comprehensive set of laws before group activities are initiated."

Recommendation #10: Consider requiring vehicle safety inspections for fire apparatus.

Discussion: States should consider taking a more active role to ensure the safety of fire apparatus by requiring annual vehicle safety inspections. State inspections should address NFPA 1911, Standard for the Inspection, Maintenance, Testing, and Retirement of In-Service Automotive Fire Apparatus, which defines the minimum requirements for establishing an inspection, maintenance, and testing program for in-service fire apparatus.[10]

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INVESTIGATOR INFORMATION

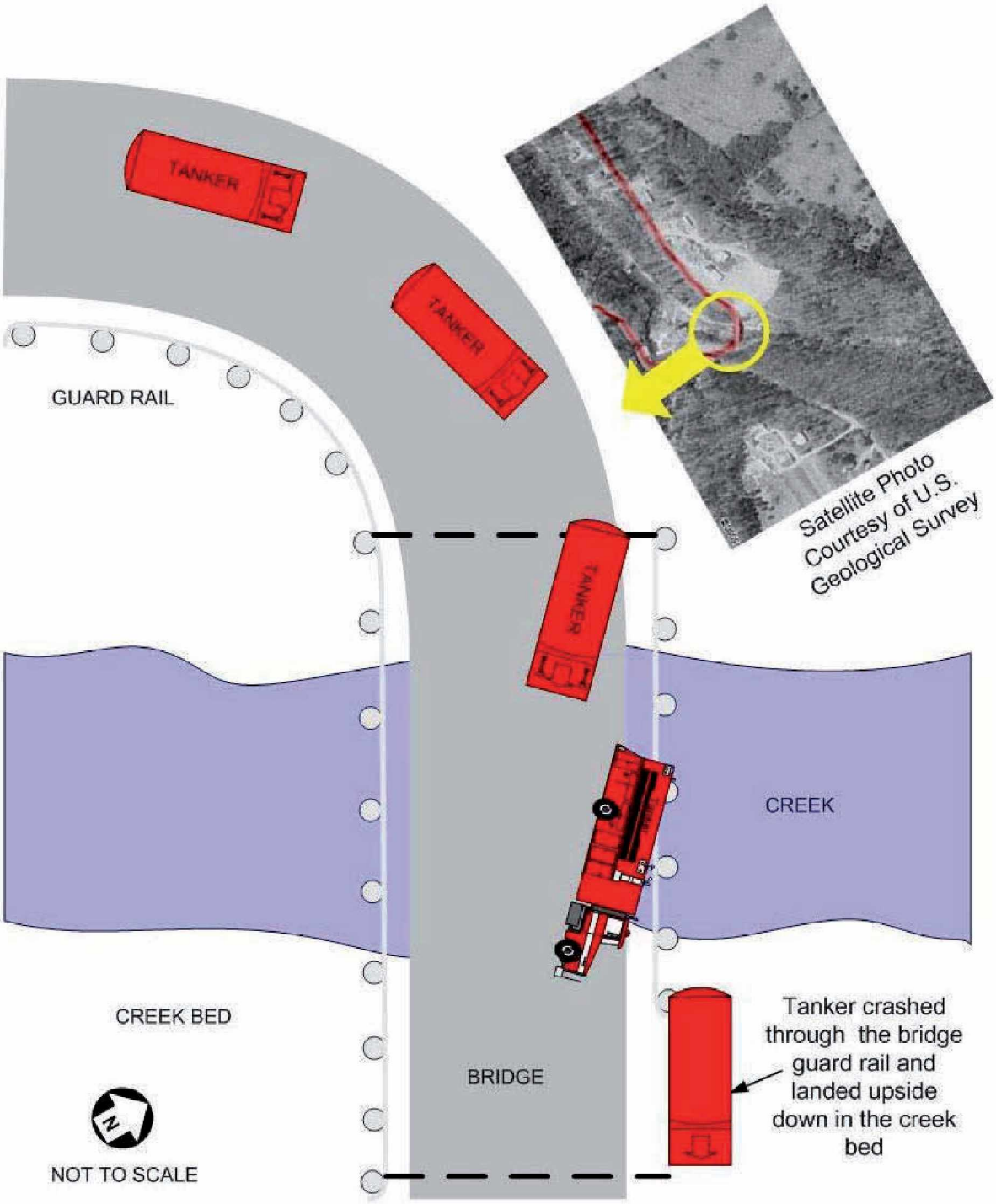
This incident was investigated by Steve Berardinelli, Occupational Safety and Health Specialist with the Fire Fighter Fatality Investigation and Prevention Team, Surveillance and Field Investigations Branch, Division of Safety Research, NIOSH located in Morgantown, WV. Technical reviews were provided by Bill Troup, U.S. Fire Administration and Mike Wilbur, nationally recognized in emergency vehicle operations and co-editor of www.EmergencyVehicleResponse.com.

Photo 1. Crash Location

Photo 2. Front of Tanker
(Photo Courtesy of Alabama State Troopers)

Photo 3. Rear of Tanker
(Photo Courtesy of Alabama State Troopers)

Photo 4. Incident Scene
(Photo Courtesy of Alabama State Troopers)


TANKER
TANKER
GUARD RAIL
TANKER
Satellite Photo
Courtesy of U.S.
Geological Survey
CREEK
CREEK BED
BRIDGE
N
NOT TO SCALE
Tanker crashed through the bridge guard rail and landed upside down in the creek bed

SAFETY ADVISORY

Fire Fighter Fatality Investigation and Prevention Program

NIOSH

Revised Date: June 24, 2008

Improper Set-up of Aerial Ladders with a Locking Waterway May Put Fire Fighters at Risk

NIOSH recommends that all fire departments utilizing aerial ladder trucks with locking (pin-anchored, lever actuated, clamped) waterways immediately take the following actions to reduce the risk of fire fighters being struck by unsecured waterways or parts of the waterway:

- **Ensure that Standard Operating Procedures (SOPs) and/or Guidelines (SOGs) on setting up multi-position waterways include steps to properly position the waterway and to inspect and verify that the locking mechanism (anchoring pin(s), lever, clamps, etc.) are properly installed and functioning as designed before pressurizing the waterway.**
- **Properly train and practice the correct method of securing waterways and verifying they are secured (per manufacturer's recommendations).**

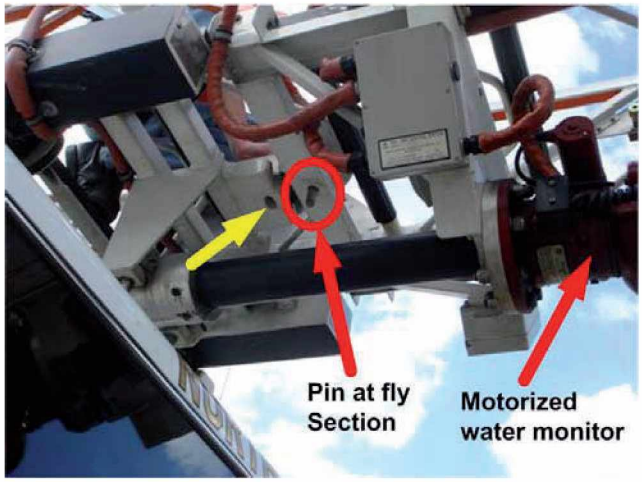


Photo 1 - A properly seated pin at the fly section for defensive water stream operations is highlighted in the red circle. The hole behind it (yellow arrow) shows the location where the pin would be inserted (from the top) to keep the monitor assembly back at the second ladder section for rescue mode. **NOTE:** Various methods are used throughout the fire apparatus industry to secure the waterway: this picture represents a pin-anchored waterway design.

NIOSH is currently investigating an April 8, 2008 fire fighter line-of-duty-death that illustrates that adhering to manufacturer recommended set-up procedures for aerial ladder operations is paramount to ensuring fire fighter safety. Preliminary findings in this investigation suggest that some equipment designs do not provide secondary stops for the waterway on aerial adders. **Thus, failure to properly secure the waterway in the proper position can lead to catastrophic waterway failure and possible serious or fatal injury to fire fighters working in the area.** The pin-anchored waterway design involved in this particular investigation is not limited to a single model or apparatus manufacturer. During this investigation, NIOSH became aware of at least 10 similar incidents that occurred in Delaware, Michigan, New Jersey, Texas, Virginia, California, Minnesota, Missouri and Ontario without serious injury. Newer aerial ladder trucks may incorporate different types of anchoring mechanisms and/or a more fail-safe design but proper set up still needs to be verified before operation.

Circumstances of incident under investigation by NIOSH

On April 8, 2008, a volunteer Deputy Fire Chief (the Incident Commander), was killed when struck by a motorized water monitor and 30 feet of aluminum pipe that was "launched" off an elevated aerial ladder at a fire at an industrial manufacturing plant in Pennsylvania. The truck was normally transported in the "rescue mode" with the monitor pinned to the second section of ladder so that the waterway would not be in the way if the ladder was set up for rescue operations. At the incident scene, when the waterway was pressurized, the monitor and its support bracket, along with the last 30-foot section of pipe were "launched" off the aerial ladder by the force of the water pressure in the pipe. The monitor flew approximately 75 feet and fell, striking the Incident Commander on the head, killing him instantly. After the incident, the anchor pin was found on the ground, in front of the truck's cab. The waterway did not include any secondary mechanical stops to prevent the separation of the water monitor in the event the anchoring pin was not properly seated. The NIOSH Fire Fighter Fatality Investigation and Prevention Program is currently investigating this incident and a full report will be available at a later date.

NIOSH would like to bring this information to the attention of all U.S. fire departments and fire fighters who operate or work around aerial ladder trucks with locking (pin-anchored, lever actuated, clamped) waterways so that future occurrences of waterway monitor "launches" or the unexpected movement of the waterway monitor can be prevented. If secondary mechanical stops are present, the unexpected impact of the waterway monitor against the mechanical stop could cause structural damage to the aerial ladder and jeopardize the safety of any fire fighter standing on the aerial ladder. While not a contributing factor in the fatal incident, NIOSH reminds fire departments to comply with relevant federal regulations and NFPA standards for fire apparatus inspections and certification.

Photo 2 – Aerial ladder with monitor at tip

Photo 3 – anchoring pin

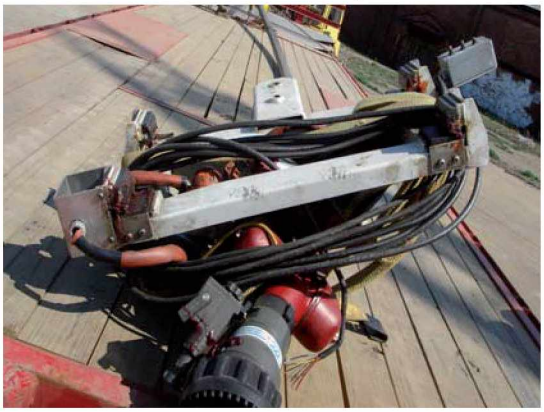


Photo 4 – Monitor and pipe that "launched"

Photo 5 - The receiver assembly where the pin is inserted

The **NIOSH Fire Fighter Fatality Investigation and Prevention Program** is conducted by the National Institute for Occupational Safety and Health (NIOSH). The purpose of the program is to investigate fire fighter line-of-duty-deaths and formulate recommendations for preventing future deaths and injuries. The program does not seek to determine fault or place blame on fire departments or individual fire fighters but to learn from these tragic events and prevent future similar events. For more information, visit the program website at www.cdc.gov/niosh/fire or call **1-800-CDC-INFO**.

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