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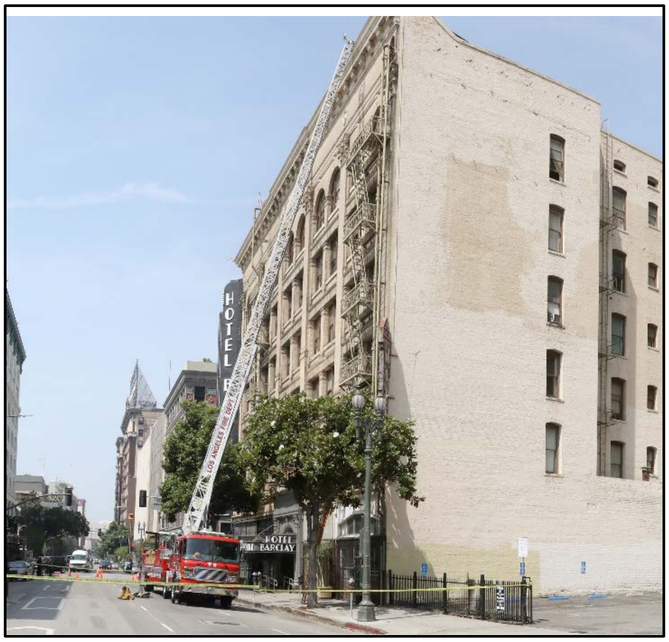
National Institute for Occupational Safety and Health
NIOSH

A report from the NIOSH Fire Fighter Fatality Investigation and Prevention Program June 18, 2018

Career Fire Fighter Falls from Aerial Ladder While Carrying Roof Kit During Training—California

Executive Summary

On June 3, 2017, a 29-year-old career fire fighter fell carrying a "roof kit" (two six-foot trash hooks strapped together with webbing for shoulder carry) up an aerial ladder during a training exercise. At the morning role call, the company was informed they would be conducting a training evolution later that morning simulating a fire incident on the fourth floor of a local six-story hotel. The training involved an aerial ladder, two engine companies, and a rescue, all from the same station. The fire fighters wore their personal protective equipment (PPE), including their self-contained breathing apparatus (SCBA). Many of the fire fighters were in acting positions and had transitioned to their acting roles prior to arriving at the hotel.



Training site
(*Courtesy of the Fire Department.*)

The apparatus operator properly positioned the aerial ladder in front of the hotel and raised the aerial ladder at a 73-degree angle, and extended the 100-foot ladder to 86 feet, which placed the tip of the ladder near the roof line. The engine companies pulled hoselines and entered the hotel to ascend to the fourth floor. The truck company was to ascend the aerial ladder, enter the hotel through the roof bulkhead door, and descend to the fourth floor. The fire fighter who was first to ascend (the top member) grabbed the roof kit cradling it on his left shoulder, and stepped onto the pedestal. The top member began to ascend, and as soon as the tiller member saw the top member reach the top of the bed section of the aerial ladder, the tiller member began to ascend. The tiller member entered the inner mid-section of the aerial ladder and noticed the top member had stopped approximately 60 feet up the aerial ladder, to adjust the roof kit on his shoulder. Then the tiller member noticed that the apparatus operator was starting to ascend behind him. The tiller member heard a yell and looked up to see the top member falling down the left side of the ladder. The tiller member tucked in close to the ladder as the top member brushed by him and landed on the deck portion of the apparatus below. He was attended to by on-scene paramedics and transported to the local trauma center. On June 5, 2017, the fire fighteer succumbed to his injuries.

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Contributing Factors

- *Loss of three-point contact carrying roof kit*
- *Life belts not used*
- *Overall weight of PPE and tools*
- *Angle of aerial ladder*

Key Recommendations

- *Fire departments should ensure that carrying methods for equipment/tools are safe and secure.*
- *Fire departments should ensure that a designated safety officer is appointed for training evolutions.*
- *Fire departments should ensure that fire fighters minimize risks by using a life belt any time they stop to do work while ascending/descending an aerial ladder.*
- *Fire departments should ensure that the overall weight of equipment/tools does not compromise safety.*
- *Fire departments should ensure that the placement of aerial ladders yields the optimal climbing angle for fire fighter safety.*
- *Fire departments should ensure that all standard operating guidelines are reviewed and updated regularly.*

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Introduction

On June 3, 2017, a 29-year-old career fire fighter fell while carrying a “roof kit” (two six-foot trash hooks strapped together with webbing for shoulder carry) up an aerial ladder during a training excerise. On June 5, 2017, the fire department’s arson section contacted the National Institute for Occupational Safety and Health (NIOSH) inquiring about an investigation. On June 20–23, 2017, a general engineer and a medical officer from the NIOSH Fire Fighter Fatality Investigation and Prevention Program traveled to California to investigate this incident. The NIOSH investigators met with the fire department’s risk management section, International Association of Fire Fighters local union officers, county emergency management director, California Division of Occupational Safety and Health representatives, and a California Department of Public Health representative. The NIOSH investigators and the California Department of Public Health representative visited the incident scene and conducted interviews with the officers and fire fighters who were involved with the training incident. The NIOSH investigators collected department standard operating guidelines (SOGs) and officers’ and fire fighters’ training records and met with the assistant chief of training.

Fire Department

At the time of this incident, this career fire department had 114 stations with 3,588 uniformed members serving a population of over 4,000,000 within an area of about 471 square miles. All department members work a 24-hour duty shift for 3 out of 9 days or an average of 56 hours per week. In 2016, the fire department responded to nearly 15,000 actual fire incidents with 90% of the responses on-scene in less than 5 minutes.

At the time of the incident, the fire department had 127 ambulances, 101 engines, 49 trucks, 15 brush apparatus, 4 foam tenders, 4 rehab air tenders, 2 fuel tenders, 1 heavy rescue apparatus, 5 marine boats, 2 emergency lighting units, and 6 helicopters. Specialty units consisted of swift water rescue teams, airport companies, hazardous material squads, bicycle medic teams, and urban search and rescue companies. All fire department apparatus were maintained by the city's fleet maintenance division with annual testing of fire apparatus and ambulances conducted by qualified vendors. All advanced life support ambulances were staffed by the fire department.

Training and Experience

The state requires all career fire fighters to complete training equivalent to the National Fire Protection Association (NFPA) 1001, *Standard for Fire Fighter Professional Qualifications* [NFPA 2013]. The fire department provides up to 20 months of recruit training to certify fire fighters to the state’s Fire Fighter I curriculum, a combination of NFPA 1001 and International Fire Service Training Association

(IFSTA) essentials [IFTSA 2013]. This is followed by a 1-year probationary period of supervised training. Additional training during the probationary period focuses on equipment and operations, of which 5 months are spent with an engine company and 5 months with a truck company. At 4 months and 9 months into the probationary period, the probationary fire fighter returns to the academy for a written test. Emergency medical technician certification is obtained by candidates on their own prior to going to the academy, and then a 1-week recertification is completed during the last 5 weeks of the academy.

Table 1 summarizes the documented training of the fire fighter and the acting captain (incident commander).

Table 1. Training records for the fire fighter and the captain (incident commander)

Fire Fighter	Training Courses	Years of Experience
Fire Fighter	Fire Fighter I, Emergency Medical Technician-Basic, General Fire Fighting Principles, Roof Operations, Mayday Training, Fire Suppression and Rescue, and various other administrative and technical courses.	2
Acting Captain (Incident Commander)	Fire Fighter I, Emergency Medical Technician-Basic, Fire Fighting Tactics and Strategy, Fireground Survival, High Rise Operations, Rapid Intervention Company, HAZMAT, Air Management, Swiftwater Rescue, and various other administrative and technical courses.	10

Structure

The incident occurred at a commercial structure that was built in 1897. The six-story, center hallway structure was comprised of 165 guest rooms and was approximately 100,000 square feet. The structure to the top of the parapet wall was approximately 65 feet high. This structure has been used routinely by the fire department for training exercises. The hotel was in operation at the time of the incident.

Equipment and Personnel

On June 3, 2017, Fire Station 9 was briefed by the station captain at the morning lineup that a training exercise would be conducted later that day. Table 2 identifies the apparatus and staff involved in the training.

Table 2. Equipment and personnel involved in the training.

Resource Designation	Staffing
Truck 9	acting captain, apparatus operator, and 3 fire fighters
Task Force Commander	acting captain
Engine 9	acting captain, acting engineer, and 2 fire fighters
Engine 209	captain, engineer, and 2 fire fighters
Rescue 9	3 captains (training observers) and an acting engineer

Personal Protective Equipment

During the training evolution, the fire fighter was wearing his bunker coat and pants, hood, boots, helmet, and self-contained breathing apparatus (SCBA) (off-air) with an integrated personal alert safety system (PASS), and he was carrying a radio in the radio pocket of his bunker coat. The fire fighter's facepiece was in its storage pouch attached to the SCBA harness, and his gloves were in his bunker coat pocket.

Weather Conditions

At the time of the incident, the sky conditions were a light haze with 5-mile visibility. The temperature was 72 degrees F. Dew point was 61 degrees F. Relative humidity was 60%. Winds were calm. Barometric pressure was 29.88 [Weather Underground 2017].

Investigation

On June 3, 2017, a 29-year-old career fire fighter fell carrying a roof kit up an aerial ladder during a training exercise. The fire fighter started his shift at 0700 hours that day after having been off-duty for the previous 48 hours. At the morning lineup, the station captain informed the company that they would conduct a training evolution on center hall operations that would simulate a fire incident on the fourth floor of a local six-story hotel, (the hotel was occupied and operating at the time of the drill).

The training involved the aerial ladder, two engines, and one rescue, (i.e. a paramedic ambulance from the station). The fire fighters wore their personal protective equipment (PPE) including their self-contained breathing apparatus (SCBA). Many of the fire fighters were up for promotion and would be stepping up to act in their promotable positions. After 0900 hours, the station's apparatus headed to the training site and stopped two blocks before in order for members to transition into their acting roles, and switch their radios to the training tactical channel 19.

Upon arrival, the incident commander gave a size-up and crew assignments. The apparatus operator spotted the aerial ladder in front of the hotel (see Photo 1), raised the aerial ladder at a 73-degree angle (see Photo 2), and extended the 100-foot ladder to 86 feet, which placed the unsupported ladder tip near the roof line, in accordance with manufacturer guidelines (see Photo 3).

Photo 1. Positioning of apparatus and aerial ladder.
(Courtesy of the Fire Department.)

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Photo 2. Position of climbing angle indicator for aerial ladder at the time of the incident.
(Courtesy of the Fire Department.)

Photo 3. View of aerial ladder from base.
(Courtesy of the Fire Department.)

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The engine companies pulled hoseline and entered the hotel to ascend to the fourth floor. The truck company was to ascend the aerial ladder, enter the hotel through the roof bulkhead door, and descend to the fourth floor. The fire fighter who was first to ascend (the top member) grabbed a roof kit (see Photo 4), which was two six-foot rubbish hooks strapped together, (totaling 20 pounds), and cantilevered them over his left shoulder with the D-handles facing to the rear. *Note: The roof kit is supposed to be carried over the shoulder using the webbed strap. It is unknown why the fire fighter did not utilize the strap. After the incident, it was noted that part of the strap was missing but it is not known if this occurred prior to or during the incident.*

Photo 4. Example of a roof kit similar to the one carried by the fire fighter. A roof kit consists of two six-foot rubbish hooks and a webbed carrying strap weighing a total of 20 pounds.
(Courtesy of the Fire Department)

At approximately 3 minutes and 44 seconds upon arrival, the top member stepped upon the pedestal and began to ascend. As soon as the tiller member saw the top member reach the top of the bed section of the aerial ladder, the tiller member began to ascend. When the tiller member had reached the inner mid-section of the aerial ladder he noticed that the top member had stopped, approximately 60 feet up the aerial ladder, to adjust the roof kit strap on his right shoulder. Then the tiller member noticed that the apparatus operator was starting to ascend behind him. Approximately 4 minutes and 44 seconds upon arrival, the tiller member heard a yell and looked up to see the top member, falling down the left side of the ladder. The tiller member tucked in close to the ladder as the top member brushed by him and the apparatus operator. The station captain, who was the training organizer and an observer, heard yelling and saw the fire fighter fall the last 15 feet and immediately looked for available paramedics. The fire fighter landed on the deck portion of the apparatus below, just to the left of the turntable (see Photo 5). The incident commander was in the command vehicle and heard a crash and noticed a helmet on the street. The incident commander radioed that the exercise was completed and ran over to the truck and saw the apparatus operator attending to the fallen fire fighter.

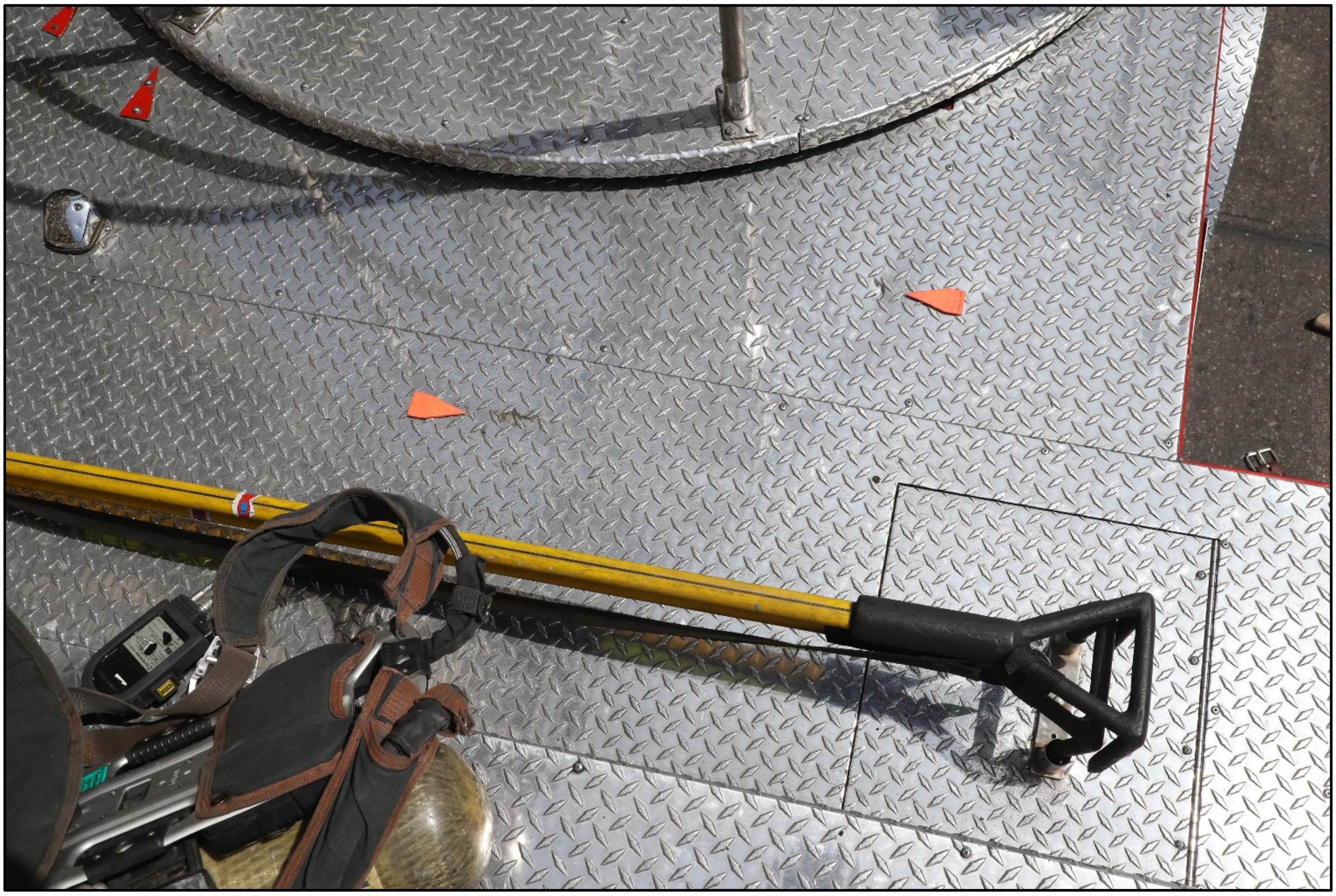

Photo 5. General area where the fire fighter landed.
(Courtesy of the Fire Department.)

The acting engineer from Engine 9 heard yelling and a loud thud and went running to the truck to see the apparatus operator removing the top member's SCBA and the truck captain holding the fire fighter's head. The Engine 9 acting engineer proceeded to get the backboard from Rescue 9. The acting engineer on Engine 209, who was a paramedic, and the hydrant member on Engine 9, who was on the fourth floor when he heard the fire fighter had fallen, ran over to assist. Approximately 4 minutes after the fall, the incident commander drove the rescue unit to the local trauma center with the station's captain in the officer's seat and two paramedics in the rear attending the fire fighter. On June 5, 2017, the fire fighteer succumbed to his injuries.

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Contributing Factors

Occupational injuries and fatalities are often the result of one or more contributing factors or key events in a larger sequence of events that ultimately result in the injury or fatality. NIOSH investigators identified the following items as key contributing factors in this incident that ultimately led to the fatality:

- Loss of three-point contact carrying roof kit
- Life belts not used
- Overall weight of PPE and tools
- Angle of aerial ladder

Cause of Death

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

Recommendations

Recommendation #1: Fire departments should ensure that carrying methods of equipment/tools are safe and secure.

Discussion: Fire fighters carry equipment such as hoses, axes, ladders, chain saws, and extinguishers into and around the fire scene to rescue victims and extinguish the fire. This may include climbing many flights of stairs or ladders. One of the most common tools in the fire service for carrying, raising, or lowering various tools and equipment from one elevation to another is rope and webbing. The IFSTA *Essentials of Fire Fighting and Fire Department Operations* states: "To use rope safely and effectively during fires and rescue operations, fire fighters must know the various types of rope and their applications. Fire fighters must be capable of tying a variety of knots and hitches quickly and correctly" [IFTSA 2013]. Webbing generally is used as a sling to carry various types of equipment and tools. The use of webbing, rope, and knots is an essential part of Fire Fighter I training and fire departments should conduct annual refresher training on these skills.

This fire department trains using the above mentioned reference but a specific fire department standard operating guideline (SOG) should be generated to address specific methods for securing and carrying each type of equipment or tool. Another source for training and proficiency guidelines is NFPA 1410, *Standard on Training for Initial Emergency Scene Operations*, Section 9.3.1, which details recommended performance criteria for truck company personnel and the use of ropes, knots, and hitches for the hoisting of tools and appliances [NFPA 2015a].

If customized packs or slings are used, a thorough evaluation should be conducted to determine their effectiveness and safety. Another option is mounting some tools near the tip of the aerial or ladder provided the apparatus manufacturer endorses the method of attachment and the effects of the tool's dimensional properties on the aerial ladder stability.

In this incident, the fire fighter was carrying two six-foot rubbish hooks strapped together with a web sling and weighing 20 pounds cantilevered over one shoulder and not utilizing the web sling to support the load. It is unknown why the fire fighter did not utilize the web sling as taught in the training academy. The tiller member had noticed that the fire fighter had stopped to adjust the roof kit on his shoulder prior to his fall. After the incident, the rubbish hooks were found missing the cinch strap for the D handles as part of the web sling (see Photo 6).

Photo 6. Roof kit (two 6-foot rubbish hooks weighing 20 pounds) carried by the fire fighter. Note the cinch strap for the D handles is missing.
(Courtesy of the Fire Department.)

Recommendation #2: Fire departments should ensure that a designated safety officer is appointed for training evolutions.

Discussion: Fire departments should appoint a qualified safety officer (meeting the qualifications defined in NFPA 1521 *Standard for Fire Department Safety Officers Professional Qualifications [NFPA 2015b]*) at all skills training environments (training division or station) if the training poses potential hazards related to injury or death. NFPA 1521 Chapter 5.3.4 also states, "The health and safety officer shall ensure that safety supervision is provided at all live training activities" [NFPA

2008]. Safety supervision should be provided throughout the training and continue throughout breakdown and termination of the training.

The Fire Department's Risk Management Section's commander is NFPA 1521 certified and ensures that safety supervision is in place during training and other activities.

In this incident, prior to the training event the station captain held a briefing to describe the training scenario, identify everyone's role, and assign three captains as acting instructors/observers. It is not clear if any of them where NFPA 1521 trained.

Recommendation #3: Fire departments should ensure that fire fighters minimize risks by using a life belt any time they stop and do work while ascending/descending an aerial ladder.

Discussion: The use of ladders in the fire service is well established. In order to maintain the safe and efficient use of these ladders, fire fighters must be rigorously trained to know the characteristics and proper uses of these various types of ladders [IFTSA 2013]. Fire fighters are expected to wear full PPE and carry/hoist needed equipment and/or tools while climbing. This causes a safety concern when trying to maintain a three-point contact while climbing ladders. Three-point contact means two hands and one foot, or two feet and one hand, are in contact with the ladder at all times, which is a recommended safety practice [OSHA 2005]. It is a good safety practice per NFPA 1932, *Standard on Use, Maintenance, and Service Testing of In-Service Fire Department Ground Ladders*, Section 5.1.9, that a Class I harness or ladder belt be worn when a ladder with a vertical angle greater than 70 degrees is used [NFPA 2015c]. It is also a good safety practice, regardless of the angle, that a ladder belt be used when working off a ladder or whenever the hands must be used to complete any task, resulting in the loss of three-point contact

In this incident, the fire fighter was observed stopping to adjust the shoulder strap on the roof kit. This action may have caused him to lose his balance and three-point contact. A life belt would have enabled him to hook to the ladder prior to adjusting the shoulder strap, thus serving as the third point of contact.

Recommendation #4: Fire departments should ensure that the overall weight of equipment/tools does not compromise safety.

Discussion: Firefighting is physically demanding. Fire fighters carry 80 to 100 pounds of equipment, such as hoses, axes, ladders, chain saws, and extinguishers, into and around the fire scene to rescue victims and extinguish the fire. This may include climbing flights of stairs or ladders. One of the most common tools in the fire service for carrying, raising, or lowering various tools and equipment from one elevation to another is rope and webbing. The IFSTA *Essentials of Fire Fighting and Fire Department Operations* states: "To use rope safely and effectively during fires and rescue operations, fire fighters must know the various types of rope and their applications. Fire fighters must be capable of tying a variety of knots and hitches quickly and correctly" [IFTSA 2013]. Webbing generally is used as a sling to carry various types of equipment. The use of webbing, rope, and knots is an essential part of Fire Fighter I training and fire departments should conduct annual refresher training on these skills.

Oftentimes, equipment/tools can be mounted on brackets on the aerial ladder near the tip, provided the apparatus manufacturer endorses the method of attachment and the effects of the tool's dimensional properties on the stability of the aerial ladder, for access by fire fighters using ladder belts or access by fire fighters on the roof. This would minimize the weight being carried by the fire fighter climbing the ladder.

In this incident, the fire fighter was carrying approximately 50 percent of his body weight up the ladder. PPE and tools accounted for approximately 110 pounds of gear that the fire fighter was carrying (PPE and accessories – 47 pounds, SCBA – 36 pounds, roof kit – 20 pounds, and axe – 7 pounds). In addition to the sheer weight, how it was distributed and carried may have been a factor.

Recommendation #5: Fire departments should ensure the placement of aerial ladders yield the optimal climbing angle for fire fighter safety.

Discussion: There are several variables that have to be considered when positioning an aerial ladder. They include proper distance between the structure or object and the aerial to achieve maximum stability, best climbing angle, and adequate extension ability. Long extensions at low angles place maximum stress on the aerial [MFRI 2010; IFSTA 2009]. Steepening the angle, even when kept within accepted standards, can make climbing and tool carrying more difficult for some persons. If the structure is on fire, the incident commander must also consider the condition of the building and the extent and location of the fire when positioning the aerial.

Choosing an optimal climbing angle may require more than simply implementing a 1:4 or 75 degree angle "rule". This rule has been derived from OSHA standards that may not account for to the heights firefighters may climb nor the bulk, weight and positioning relative to the body of the tools that they carry. Specifically, no other industry routinely climbs to heights experienced by firefighters using aerial ladders. Furthermore, firefighters' tools, PPE and SCBA place burdens on the body that are unique among workers that use ladders. For example:

- Firefighting helmets are heavier than the traditional hard hat, putting excess weight high on the body, engaging the neck, shoulder, and back muscles.
- Turn out ensembles are heavier and bulkier and thus restrict movement more than most any other traditional "work clothes".
- Firefighting boots are heavier than most any other work boot, putting more strain on the leg muscles. Furthermore, their bulk and rigidity affect the wearers' ability to "sense" the surface or object they are placing their feet upon.

- The SCBA places 30 pounds or more behind the wearer, engaging muscles throughout the body and affecting balance. Furthermore, the optimal place for carrying heavy loads (the back and waist) is no longer readily available for other tools and equipment. Traditional slings and harnesses often need modification to accommodate the wearing of SCBA.

- The tools firefighters routinely carry up ladders are often much heavier than those that would be expected to be carried in other industries. They must often be carried further and with more urgency.

Fire departments should also consider these human factor issues that affect all climbers:

- On a steeper ladder, there is a greater risk in misplacing the feet.
- The role of the hands is more important. Climbing at a steeper angle, the horizontal distance between the sacrum/buttocks and the ankle at midpoint in stride would be wider, ~7.5 cm; 26 cm - 18.5 cm [Dewar 1977]. Therefore, if the hands slip, there is less chance that the climber would be able to regain his balance.
- People of “average” height (approx. 5 foot 10 inches for U.S. males) are most suited for the separation/distance between rungs on a ladder which are spaced 12 inches apart. At a steeper angle there is a greater difference in the rotation patterns for taller and shorter people. Those who are taller or shorter must modify their movement while climbing, and thus in theory would have a greater chance of misplacing their feet while climbing [Dewar 1977]. (Note: The fire fighter in this incident was a male of above average height.)
- A common sense conclusion not from the literature: a steeper climbing angle is more precarious when heavy gear is loaded on the back, because it tends to “pull” the climber backward. Also, the horizontal distance between the shoulders and the rungs would be shorter, so there would be less space to “lean forward” with the torso. If this distance were longer (i.e. a less steep climbing angle), then it would be more natural for the climber to lean forward with his torso while climbing, which would reduce the distance between his shoulders and the rungs of the ladder and thus where his hands are placed. Leaning forward would also reduce the momentum/tendency of the gear on his back to pull him backward.

In this incident, the aerial ladder was parked parallel to the building with the aerial ladder extended 86 feet at a 73-degree angle and perpendicular to the street (see Photos 1, 2, and 3) which is in accordance with fire department and manufacturer guidelines. The manufacturer does not recommend an angle greater than 75 degrees. The above mentioned tactical, firefighting specific, and general human factors considerations should be incorporated into the SOGs and pre-incident plans that suit a fire department’s local situation, and training should occur often. Given the additional demands and stresses placed on firefighters during ladder climbs, fire departments should consider adopting a maximum angle of 70 degrees or less for aerial (and perhaps all) ladder operations.

Most research has focused on falls with ladders (e.g., base of ladder slipping) and not falls from ladders [Pliner et al. 2014]. The aerial ladder having a fixed base avoids the usual danger of ground (non-fixed base) ladder slipping when a less steep angle increases the risk of the foot/base of the ladder slipping. Additional research on falls from aerial ladders is warranted. A current NIOSH study is evaluating fire truck aerial ladder systems, including telescopic ladders and associated steps, rails, and handholds, for making design recommendations for improving aerial apparatus systems.

Recommendation #6: Fire departments should ensure that all standard operating guidelines are reviewed and updated regularly.

Discussion: The fire service faces and responds to change on a routine basis. These changes involve new management/administration personnel and policies, expanding missions with shrinking resources, increasing legal and regulatory requirements, growing complexity in equipment and tactics, and dealing with other agencies and reporting. Well-developed and maintained SOGs will help fire departments respond to and manage these changes. Fire departments cannot operate safely or effectively in modern society without a comprehensive set of SOGs and having the management systems needed to develop and maintain them [FEMA 1999].

Periodic evaluations are necessary to address these changes. There is no set rule about frequency and timing to review and update SOGs. A large department may want to review these SOGs every six months, or perhaps a portion of them, and conduct a total review and update every two years. Small departments should consider conducting the review at least annually when developing their annual budget. Evaluating and revising SOGs can be complex and time-consuming, so their review must be well planned [FEMA 1999].

In reviewing the SOGs for the department, it was noticed that some were decades old. Fire departments deal with changes regularly, and should consider periodic review of their SOGs.

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Investigator Information

This incident was investigated by Matt E. Bowyer, General Engineer, with the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Surveillance and Field Investigations Branch, Division of Safety Research, located in Morgantown, West Virginia, and by Wendi Dick, Medical Officer, with the NIOSH Division of Surveillance, Hazard Evaluations, and Field Studies located in Cincinnati, Ohio. Hank Cierpich, Fatality Investigator and Safety Engineer, with the Department of Public Health, State of California assisted in the investigation. An expert technical review was provided by Peter Van Dorpe, Fire Chief, Algonquin-Lake in the Hills Fire Protection District. A technical review was also provided by the National Fire Protection Association, Public Fire Protection Division.

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