Volunteer Captain Runs Low on Air, Becomes Disoriented, and Dies While Attempting to Exit a Large Commercial Structure – Texas

Executive Summary

On July 3, 2010, a 30-year-old male volunteer Captain died while attempting to locate and extinguish a late night fire in the back of an egg processing plant. The seat of the fire was located in a dry storage area at the back of the plant that housed paper and styrofoam products for packaging the eggs. When the fire department arrived, flames were visible from the roof of the dry storage area. The victim's crew attempted to breach a wall for more direct access to where they thought the seat of the fire was located. The access was blocked by stacks of wooden pallets. Two captains made entry with an uncharged hoseline through the front door to find and extinguish the fire. The front of the plant was charged with heavy dark smoke and high heat conditions. They became disoriented in the thick smoke, lost the hoseline and called a Mayday that was not heard and acted upon. While searching for the handline, the captains ran out of air, got more disoriented and were separated. One captain attempted to kick out a section of wall and was heard by exterior crews who breached the wall and rescued him. Intense fire conditions thwarted all further rescue efforts until the fire was extinguished. The victim was found the next morning.

Contributing Factors

- *lack of scene management and risk analysis*
- *inadequate water supply*
- *apparatus specifications and equipment*
- *ineffective tactics*
- *ineffective communications*
- *inefficient training concerns*
- *rapid intervention team (RIT) not established*
- *structure built with little or no protection against fire growth.*

Volunteer Captain Runs Low on Air, Becomes Disoriented, and Dies While Attempting to Exit a Large Commercial Structure –Texas

Key Recommendations

- *ensure that the incident commander conducts an initial size-up and risk assessment of the incident scene before beginning interior fire fighting operations and continually evaluates the conditions to determine if operations should become defensive*
- *train fire fighters to communicate interior and exterior conditions to the incident commander as soon as possible and to provide regular updates*
- *ensure that an adequate water supply is established and maintained*
- *conduct pre-incident planning inspections of buildings to facilitate development of safe fireground strategies and tactics*

Aerial view of egg processing plant.
(Photo courtesy of Texas State Fire Marshal)

The National Institute for Occupational Safety and Health (NIOSH), an institute within the Centers for Disease Control and Prevention (CDC), is the federal agency responsible for conducting research and making recommendations for the prevention of work-related injury and illness. In 1998, Congress appropriated funds to NIOSH to conduct a fire fighter initiative that resulted in the NIOSH "Fire Fighter Fatality Investigation and Prevention Program" which examines line-of-duty-deaths or on duty deaths of fire fighters to assist fire departments, fire fighters, the fire service and others to prevent similar fire fighter deaths in the future. The agency does not enforce compliance with State or Federal occupational safety and health standards and does not determine fault or assign blame. Participation of fire departments and individuals in NIOSH investigations is voluntary. Under its program, NIOSH investigators interview persons with knowledge of the incident who agree to be interviewed and review available records to develop a description of the conditions and circumstances leading to the death(s). Interviewees are not asked to sign sworn statements and interviews are not recorded. The agency's reports do not name the victim, the fire department or those interviewed. The NIOSH report's summary of the conditions and circumstances surrounding the fatality is intended to provide context to the agency's recommendations and is not intended to be definitive for purposes of determining any claim or benefit.

For further information, visit the program website at www.cdc.gov/niosh/fire or call toll free 1-800-CDC-INFO (1-800-232-4636).

Volunteer Captain Runs Low on Air, Becomes Disoriented, and Dies While Attempting to Exit a Large Commercial Structure – Texas

Introduction

On July 3, 2010, a 30-year-old male volunteer Captain died while attempting to locate and extinguish a late night fire in the back of an egg processing plant. On July 7, 2010, the U.S. Fire Administration notified the National Institute for Occupational Safety and Health of this incident. On July 7-9, 2010, a Safety and Occupational Health Specialist and a General Engineer from the NIOSH Fire Fighter Fatality Investigation and Prevention Program traveled to Texas to conduct meetings with the fire department, representatives of the State Fire Marshal's office, representatives of the Bureau of Alcohol, Tobacco and Firearms (ATF), and the county sheriff's office. The incident site was visited and photographed. On July 26-29, 2010 the NIOSH investigators returned to Texas to complete the investigation. Meetings were conducted with the state fire marshal's office, fire department, county sheriff's department, the state medical examiner and plant employees. Interviews were conducted with fire fighters and officers and law enforcement officers who were involved with this incident, plant employees, and the medical examiner. The investigators reviewed witness statements, dispatch logs, SOPs, training records, and the death certificate.

Fire Department

The fire department is a combination fire department with one full time Fire Inspector, four part time fire fighters, and approximately 26 volunteer members that operate out of one station. The combination department serves a population of more than 9,900 people in a rural geographic area of approximately 250 square miles. The department also provides automatic mutual aid for three other departments, increasing the response area to 410 square miles and approximately 20,000 residents.

The department provided written procedures covering items such as accountability, incident management, fireground factors, tactical priorities, risk management, personal protective equipment, fire ground strategies, rehabilitation, self contained breathing apparatus (SCBA), rapid-intervention team (RIT) operations, and health and fitness. The department did not have any guidelines for pre-planning structures within their jurisdiction or mutual aid areas.

Training and Experience

Texas does not require any specific training requirements to become a volunteer fire fighter. In the state, anyone over the age of 18 can become a volunteer fire fighter. The fire department involved in this incident requires their candidates to be at least 18 years of age; able to pass a background check; pass a physical and drug screening; have a clean driving record; and possess a high school diploma or equivalent. The combination department provides training to their fire fighters that meet the standards of the State Firemen's & Fire Marshals' Association of Texas.

The State Firemen's & Fire Marshals' Association of Texas uses Texas A&M's Texas Engineering Extension Service (TEEX) training programs which meet or exceed all requirements set by NFPA Standard 1001.

Volunteer Captain Runs Low on Air, Becomes Disoriented, and Dies While Attempting to Exit a Large Commercial Structure – Texas

Victim

The victim had more than 11 years of experience and had completed a five month recruit fire training program in 2009 that encompassed more than 35 courses and 612 hours of classroom, hands-on, and ride-along training. Courses included: fire science, fire fighter safety, building construction, save your own/rescue, and self contained breathing apparatus (SCBA). In addition to that program, he had also completed Introduction to Incident Command (ICS 100) National Incident Management System (IS-700) training.

Incident Commander

The Chief had more than 18 years of experience and had completed training in courses such as: Fire Science, Emergency Medical Technician Level II Instructor, Hazardous Waste Operations, Managing Company Tactical Operations, Leadership III, and Fire Service Officer Development V.

Personal Protective Equipment

The victim was wearing a full ensemble of structural fire fighting protective clothing and gear meeting the applicable National Fire Protection Association (NFPA) standards. The victim used a 1800-liter, 4500 psi (NIOSH rated 45 minute cylinder) SCBA with an integrated Personal Alert Safety System (PASS) device. The victim also had a radio equipped with a lapel microphone.

Weather

At the time of the incident, the temperature was approximately 82-degrees F° with light rain. The relative humidity was around 86%. The winds were out of the east at roughly 4.6 mph.

Structure

The commercial egg processing plant was classified as Type II construction which encompassed large open areas totaling more than 58,000 square feet. The building's primary use was to process eggs and pack them for shipment after they arrived via a conveyor belt from laying houses that were attached to the building (Photo1) .

Volunteer Captain Runs Low on Air, Becomes Disoriented, and Dies While Attempting to Exit a Large Commercial Structure – Texas

Photo 1. Conveyor belt that transported eggs for processing.
(Photo courtesy of Texas State Fire Marshal)

The building was a large, limited access structure which consisted of a 58,000 square foot egg processing room, with surrounding areas used for storage of packaging materials and two large drive-in coolers for holding packaged eggs prior to shipping (see Diagram and Photo 2). Building construction consisted of a combination of steel and wood framing with sheet metal exterior siding and roofing over a low-pitch roof built on a concrete slab foundation. Structural elements within the interior of the building were exposed and unprotected with no fire-resistance rated materials applied. The load bearing structural elements consisted of steel beams, and steel pipe columns, with steel open web trusses supporting the roof structure. Wood components were also used as part of the load bearing elements and wall framing. Perimeter walls of the cooler compartments were constructed of concrete masonry units (CMU). The building was not separated between other areas of use by fire-resistance rated assemblies. Ancillary facilities located within the building used for administrative offices and other incidental spaces were constructed of wood framing with a gypsum wallboard finish.

Volunteer Captain Runs Low on Air, Becomes Disoriented, and Dies While Attempting to Exit a Large Commercial Structure – Texas

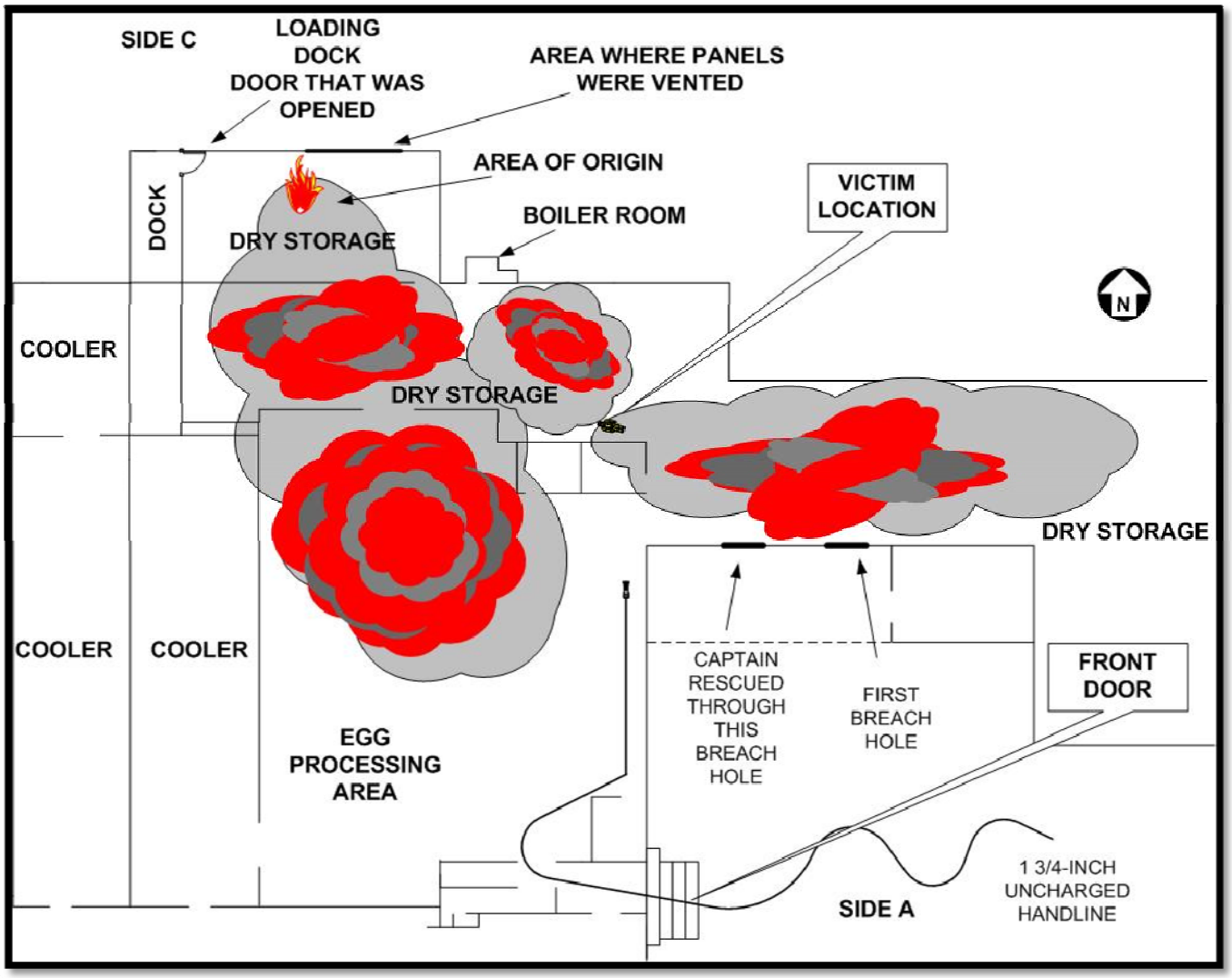

Diagram. Aerial view of plant where fire fighting operations took place.

Volunteer Captain Runs Low on Air, Becomes Disoriented, and Dies While Attempting to Exit a Large Commercial Structure – Texas

Photo 2. Typical dry storage area and room of origin prior to fire.
(Photo courtesy of Texas State Fire Marshal)

Water Supply

The egg processing plant's water supply came from an on-site well that pumped into two storage tanks that totaled almost 44,000 gallons of water. A single 5-inch connection located at the base of the water storage tanks was the only connection available for fire department use. Refilling tankers was by gravity feed only. The plant's main water supply pump did not include a fire department connection. There were no hydrants on the property. The building did not contain a fire sprinkler system or other means of passive fire protection.

Enforcement Agencies

The county did not have a fire or building code adopted. The State of Texas does not have a mandatory State-wide Fire or Building Code. The State has adopted National Fire Protection Association (NFPA) Standard 101, Fire and Life Safety Code 2009 edition. NFPA 101 is the applicable standard for Fire and Life Safety in unincorporated areas of a county that do not have an adopted code.

Volunteer Captain Runs Low on Air, Becomes Disoriented, and Dies While Attempting to Exit a Large Commercial Structure – Texas

In some states, such as Texas, agricultural facilities such as egg farms, chicken farms, and slaughter houses not located within incorporated areas are not required to meet many of the standard building and life safety codes that are enforceable through state or local fire marshals.

These facilities had federal oversight with regards to sanitation of food products and the facility by the US Department of Agriculture and the Food and Drug Administration. Representatives from these federal entities usually have an office inside these facilities and look for and enforce violations that pertain to sanitation only.

Investigation

On July 3, 2010, at approximately 2141 hours, central dispatch received a call of a fire in the back of an egg processing plant in an area housing paper and styrofoam products for packaging the eggs. The fire department was working a motor vehicle incident approximately four miles from the reported fire location and was able to clear the call and respond. The Assistant Chief was the first to arrive on-the-scene at approximately 2151 hours and radioed to Engine 1134 that there was heavy fire in back of the egg plant. The Chief Deputy of the county Sheriff's office was monitoring radio traffic and called central dispatch who advised him of a fire at the egg plant. While enroute, the Chief Deputy could see flames from the roof of the dry storage area in back of the main warehouse that was attached to the plant. He arrived on-the-scene just after the Assistant Chief. The Assistant Chief was talking with a company representative who said there was a road for access to the rear of the plant around the D-side of the structure. Engine 1134 arrived on-the-scene at 2153 hours, and the Assistant Chief, Chief Deputy, and E1134 proceeded to the rear of the structure.

The Assistant Chief and the Chief Deputy walked the road to confirm the road conditions. The road was covered with several inches of water due to recent rain storms. They backed Engine 1134 to the back storage dock. When they arrived at the rear they could see fire inside the structure through gaps in the sheet metal walls. All of the sheet metal on the walls was intact. They proceeded onto a storage dock and opened a door leading to the area where the fire was located (see Diagram). When the door was opened, air was drawn inward feeding oxygen to the fire. Visibility was approximately 3 feet and the smoke was so thick that they could not see any fire. The Chief arrived on-the-scene at 2156 hours, announced command in the front, and directed all units to switch to Tactical Channel 2. The Assistant Chief and the Chief Deputy left the storage dock and radioed the Chief that they could attack the fire from the back of the building.

A plant employee led the Chief with Tanker 1160 (T1160) along a road to the B-side of the structure; however, the road's condition was too poor (muddy) and the tanker could not make it. The Chief called for Engine 1130 (E1130) and T1160 to set up defensive operations in front of the building. The Assistant Chief and Chief Deputy made it back to the front to meet with the Chief. When they arrived at the front, the scene had become chaotic. Employees and managers were frantically retrieving documents from inside the structure and mutual aid departments had arrived on-the-scene. The Assistant Chief was deploying mutual aid companies to control and remove the employees from the fireground. The Chief and Assistant Chief then discussed the operations and decided to set up water operations in the rear and defensive operations in the front.

Volunteer Captain Runs Low on Air, Becomes Disoriented, and Dies While Attempting to Exit a Large Commercial Structure – Texas

The Chief was met by another plant employee who told the Chief that the fire had originated in the boiler room and that they thought it would be easier to access it by breaching the sheet metal wall of the dry storage area from the front of the building. The victim and a captain from E1130 and a mutual aid crew were attempting to breach the wall for access inside the structure to find and extinguish the seat of the fire. The victim and the captain were both on air while cutting the tin with a cut-off saw. They made a 3-foot "X" and bent the triangular sections to make an opening in the structure (see Diagram). There were rows of pallets stacked up against the wall inside. They noticed very little smoke and heat coming from inside the structure. The victim was attempting to move the pallets when the Chief stopped them and told them to go to the front door and meet with one of the employees who could open it for entry (see Diagram).

During this time, the Assistant Chief and Chief Deputy returned to the rear to set up water operations. E1134 was approximately 25 feet from the loading dock and was operating a 1-inch booster line and was out of water. A mutual aid tanker was brought to the back to supply E1134 and dropped a portable tank because it did not have a booster hose. E1134 also did not have a suction hose. The Assistant Chief returned to the front to locate another mutual aid tanker that had a suction hose and moved them to the rear in order to use their suction strainer. The victim's crew was preparing to make entry in the front. A crew in the rear took a 1¾-inch handline from E1134 and moved toward the C/D corner approximately 100 feet. They pulled a section of sheet metal off of the rear of the building where the fire was located to attack the fire. The Chief Deputy radioed the Chief at 2222 hours and notified him that they had opened a wall and had major fire in the building extending through the roof. *Note: They had removed sections of sheet metal from the rear wall of the room of origin.* The handline had no effect on the fire, which now produced flames in excess of 15 feet above the roof line. The Assistant Chief radioed to shut down the handline so that they could attack the fire with the deck gun from E1134. They operated the deck gun for approximately 5 minutes and were out of water. They attempted to run water shuttles to supply E1134, but were severely hampered due to the soggy road conditions and tankers becoming hung-up in the mud.

At approximately the same time the crew made an opening in the C-side of the structure, the victim, a captain and a fire fighter were entering the main door at the front of the plant. The Chief instructed them to take a 1¾ -inch, 200-foot handline off of E1130 and make entry to attempt to locate and extinguish the seat of the fire. *Note: E1130 attempted to draft from a drop tank but could not get the pump primed. The crew entered on tank water.* When the captain turned around to follow the victim to the front door he noticed how much the outside conditions had changed. Smoke was banked down and the wind was blowing it over the front covering Engine 1130.

The three man crew was at the open front door with minimal heat and heavy dark smoke banked down to the floor in the main processing area. Smoke was pressurized out of the doorway approximately 2 feet below the top of the door. The processing area was approximately 50 feet by 75 feet and the ceilings were approximately 35 feet high. Visibility was near zero inside the processing area forcing them down to their knees. The captain was on the nozzle of the handline followed by the victim. The fire fighter stayed at the door to flake hose. They crawled approximately 20 feet conducting a right hand search to find the seat of the fire and tried to stand, but the heat was too intense. They decided to back out of the structure and tell the chief that there was too much heat.

Volunteer Captain Runs Low on Air, Becomes Disoriented, and Dies While Attempting to Exit a Large Commercial Structure – Texas

They made it to the door and the victim suggested that they make a left hand search to see if they could find the seat of the fire. The victim took the nozzle and the captain followed him for approximately 30 feet when the victim said call a "Mayday". The captain did with no response. *Note: It is unknown why the victim did not try to call Mayday, nor why the captain was not heard.* At this time the captain realized they did not have the handline. *Note: It is believed that a coupling of the handline got caught on something and got pulled from the victim's hand while he attempted to advance the handline.* They were on their knees looking for the handline in zero visibility. They looked for less than five minutes and their low-air alarms sounded.

The captain attempted to call on his radio, but thought that his lapel microphone was not working possibly due to the heat. He took his radio out of his coat and attempted to use the handheld with the same outcome assuming this was due to the volume of radio traffic. The captain then determined that he knew where they were and told the victim to follow him, which he did. The captain made it to an exterior wall and started hitting it with his flashlight while on his knees. He looked back to the victim for assistance, but the victim was gone. The captain broke through the interior wall covering and ran out of air completely. He unplugged his regulator, dropped to the floor, and attempted to kick out the exterior sheeting while lying on his back. He heard someone and saw a light from the outside. Personnel on the exterior heard his attempts to break through the sheet metal. They were able to get a chain saw and make another opening and extricate him.

The captain told his rescuers that the victim had just been with him and was possibly only 10 to 15 feet away. Crews immediately entered through the opening where they had rescued the captain (see Diagram). A crew made several entries through the opening and made multiple searches following the captain's directions, but was unsuccessful. The fire conditions became untenable and the crew was forced to abandon rescue efforts from this location.

Additional attempts were made from multiple locations to gain entry and locate the victim but none were successful due to the intense heat and fire conditions. All operations went defensive until the fire was extinguished and crews could enter safely. The victim was recovered and removed from the structure the next morning. At the time of recovery, the victim's PASS device was not sounding due to the severe damage caused by the fire.

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:

Contributing Factors

- lack of scene management and risk analysis
- inadequate water supply
- apparatus specifications and equipment

- ineffective tactics
- ineffective communications
- inefficient training concerns
- rapid intervention team (RIT) not established
- structure built with little or no protection against fire growth.

Cause of Death

The death certificate listed the cause of death as thermal injuries and smoke inhalation.

Recommendations

Recommendation #1: Fire departments should ensure that the incident commander conducts an initial size-up and risk assessment of the incident scene as outlined in NFPA 1500 before beginning interior fire fighting operations and continually evaluates the conditions to determine if operations should become defensive.

Discussion: Among the most important duties of the first officer on the scene is conducting an initial size-up of the incident. This information lays the foundation for the entire operation. It determines the number of fire fighters and the amount of apparatus and equipment needed to control the blaze, assists in determining the most effective point of fire extinguishment attack, the most effective method of venting heat and smoke, and whether the attack should be offensive or defensive. A proper size-up begins from the moment the alarm is received and it continues until the fire is under control. The size-up should also include assessments of risk versus gain during incident operations. [1, 2-6]

According to NFPA 1500 §A.8.3.3 [NFPA 2007], "the acceptable level of risk is directly related to the potential to save lives or property. Where there is no potential to save lives, the risk to the fire department members should be evaluated in proportion to the ability to save property of value. When there is no ability to save lives or property, there is no justification to expose fire department members to any avoidable risk, and defensive fire suppression operations are the appropriate strategy." [7] According to statistical analysis by the NFPA of fire fighter fatalities in the United States during the period of 2005 to 2009, 3.8 fire fighters died per 100,000 structure fires compared to 5.6 firefighters per 100,000 manufacturing facility fires. [8]

Retired Chief Alan Brunacini recommends that the arriving Incident Commander (IC) drive partially or completely around the structure whenever possible to get a complete view of the structure. While this may delay the IC's arrival by a few seconds, this drive-by may provide significant details not visible from the command post.[4] The size-up should include an evaluation of factors such as the fire size and location, length of time the fire has been burning, conditions on arrival, occupancy, fuel load and presence of combustible or hazardous materials, exposures, time of day, and weather conditions. Information on the structure itself to include size, construction type, age, condition (evidence of deterioration, weathering, etc), evidence of renovations, lightweight construction, loads on roof and walls (air conditioning units, ventilation ductwork, utility entrances, etc.), is key information which can effect whether an offensive or defensive strategy is employed. The size-up and risk assessment should continue throughout the incident.

Volunteer Captain Runs Low on Air, Becomes Disoriented, and Dies While Attempting to Exit a Large Commercial Structure – Texas

Interior size-up is just as important as exterior size-up. Since the IC is staged at the command post (outside), the interior conditions should be communicated to the IC as soon as possible. Interior conditions could change the IC's strategy or tactics. For example, if extreme heat is encountered by an interior crew in a large area remote from the seat of the fire, it is likely that there is the potential for rapid fire growth. Other warning signs that should be relayed to the IC include dense black smoke, turbulent smoke, smoke puffing around doorframes, and air being sucked into the building. It is important for the IC to immediately obtain this type of information to help make the proper decisions. Departments should ensure that the first officer or fire fighter inside the structure evaluates interior conditions and reports them immediately to the IC.

In this incident, a complete size-up was never conducted nor were geographical divisions assigned to manage the operations on multiple sides of the structures. Pre-planning information was not available on the construction features or any other potential hazards associated with the occupancy of this structure. Fire showing from the roof, the size of the building, limited access to the seat of the fire, lack of water supply, and the rapidly deteriorating conditions were all indicators that could have prompted consideration of defensive strategies.

Recommendation #2: Fire departments should ensure that their apparatus are equipped with the required equipment to conduct suppression operations.

Discussion: Rural or underdeveloped areas typically rely on tender-based water supply operations. Tender operations involve transporting large quantities of water between a fill site and the fireground. Once on the fireground, water is typically off-loaded to a portable tank so that an engine can use a suction hose to draft and supply water to attack the fire.[9]

Suppression operations at this incident were delayed due to the first arriving engines not having a suction hose and not being able to obtain prime to draft water to supply the handlines. NFPA 1901, *Standard for Automotive Fire Apparatus* and NFPA 1911, *Standard for the Inspection, Maintenance, Testing, and Retirement of In-service Automotive Fire Apparatus* call for departments to ensure their apparatus have the necessary equipment, such as hard suction lines, to accomplish water supply operations in their districts.[10,11] NFPA 1901 *Standard for Automotive Fire Apparatus*, requires all apparatus that are equipped with a pump to have 20 feet of suction hose with a strainer.[10] Departments should also regularly practice water shuttle operations to ensure that their members are well versed in utilizing the equipment and apparatus to provide adequate water flow for anticipated fire situations.[9,11,12]

Recommendation #3: Fire departments should ensure that an adequate water supply is established and maintained.

Discussion: Establishing adequate water supply on the fireground is one of the most critical elements of firefighting. It is important in areas with a water distribution system and even more critical in areas where water must be supplied.[9,13] The objective of an offensive fire attack is to apply enough water directly to the burning fuel to achieve extinguishment.[14] Determining the number and size of hose lines

to deploy at a fire can be estimated by first estimating the size of the structure and applying various flowrate calculations such as what is taught at the U.S. National Fire Academy (area divided by 3) or by estimating the size of the fire.[15]

The fire department in this incident did not have a water supply established. The interior crew initially made entry with an uncharged handline, then attempted to locate and extinguish the fire in the 58,000 square foot processing building supplied only by the tank water on the initial engine and without a back-up handline.

Recommendation #4: Fire departments should ensure that fire fighters receive the maximum benefit from their self-contained breathing apparatus (SCBA) through training in air management techniques.

Discussion: SCBA air cylinders contain a finite volume of air, regardless of the size. Air consumption will vary with each individual's physical condition, the level of training, the task performed, and the environment. Depending on the individual's air consumption and the amount of time required to exit an immediately-dangerous-to-life-and-health (IDLH) environment, the low air alarm may not provide adequate time to exit. Working in large structures (high rise buildings, warehouses, and supermarkets) requires that fire fighters be cognizant of the distance traveled and the time required to reach the point of suppression activity from the point of entry. When conditions deteriorate and the visibility becomes limited, fire fighters may find that it takes additional time to exit when compared to the time it took to enter the structure.[16-18] NFPA 1404 *Standard for Fire Service Respiratory Protection Training* Paragraph 5.1.4.2 requires fire departments to train fire fighters on air management techniques so that the individual fire fighter will develop the ability to manage his or her air consumption while wearing an SCBA. NFPA 1404 specifies that the individual air management program should include the following directives:

1. Exit from an IDLH atmosphere should be before consumption of reserve air supply begins.
2. Low air alarm is notification that the individual is consuming the reserve air supply.
3. Activation of the reserve air alarm is an immediate action item for the individual and the team.[19]

Fire departments and fire fighters should regularly conduct training exercises in which fire fighters perform various exercises and work tasks at different work rates until their SCBA cylinder air is exhausted so that fire fighters become familiar with the time they can expect to work before the low air alarm sounds, and how long they have to exit once the low air alarm sounds. In order to comply with NFPA 1404, fire departments and fire fighters should follow the Rule of Air Management which states "*Know how much air you have in your SCBA and manage that air so that you leave the hazardous environment before your low-air alarm activates.*"[19, 20] By being aware of these time parameters, fire fighters can make educated decisions on the time they can safely spend in IDLH atmospheres.

Volunteer Captain Runs Low on Air, Becomes Disoriented, and Dies While Attempting to Exit a Large Commercial Structure – Texas

In this incident, the victim and his partner were on air while working outside breaching the wall prior to making entry. When they entered the 58,000 square foot structure to locate and extinguish the fire, most of their air was exhausted from the work outside.

Recommendation #5: Fire departments should ensure that fire fighters understand the influence of ventilation on fire behavior and coordinate ventilation with interior fire suppression operations.

Discussion: Ventilation is the systematic removal and replacement of heated air, smoke, and gases from inside a structure with cooler air. It is critical that fire fighters understand the influence of ventilation on fire behavior and the fire environment. Increasing ventilation to a ventilation controlled fire will result in an increased heat release rate, and may result in extreme fire behavior such as ventilation induced flashover or backdraft. However, effective tactical ventilation closely coordinated with fire attack can significantly reduce the potential for extreme fire behavior and increase tenability. Close coordination means the hoseline is in place and ready to operate so that when ventilation occurs, the hoseline can overcome the increase in combustion likely to occur. If a ventilation opening is made directly above a fire, fire spread may be reduced, allowing fire fighters the opportunity to extinguish the fire. If the opening is made elsewhere, the chimney effect may actually contribute to the spread of the fire.[1,16]

Venting can be a very effective life safety procedure. When venting for life safety purposes, the principle is to pull the fire, heat, smoke and toxic gases away from victims, stairs, and other egress routes. A vent opening made between the fire fighters and their path of egress could be fatal if the fire is pulled to their location or cuts off their path of egress.[16]

In this incident, improper ventilation occurred. Horizontal ventilation began when crews opened the door on the rear loading dock and a rear wall. It was completed when the front door was opened to make an interior attack. This provided oxygen to the fire and allowed it to progress towards the front of the building. This was not coordinated with the interior fire suppression crew.

Recommendation #6: Fire departments should ensure that fire fighters are trained and retrained on Mayday competencies.

Discussion: Fire fighters need to understand that their personal protective equipment (PPE) and SCBA do not provide unlimited protection. Fire fighters should be trained to stay low when advancing into a fire as extreme temperature differences may occur between the ceiling and floor. When confronted with an emergency situation, the best action to take may be immediate egress from the building or to a place of safe refuge (e.g., behind a closed door in an uninvolved compartment), call a Mayday, and manually activate the PASS device. A charged hoseline should always be available for a tactical withdrawal while continuing water application or as a lifeline to be followed to egress the building. Conditions can become untenable in a matter of seconds. In such cases, delay in egress and/or transmitting a Mayday message reduces the chance for a successful rescue.

The victim had some drill training in Mayday best practices but for an unknown reason he asked his partner to call a Mayday. Firefighters should be 100% confident in their competency to declare a

Volunteer Captain Runs Low on Air, Becomes Disoriented, and Dies While Attempting to Exit a Large Commercial Structure – Texas

Mayday for themselves. Fire departments should ensure that any personnel who may enter an IDLH environment have had training on Mayday competency throughout their active duty service. Presently there are no national Mayday standards for firefighters to be trained to and most states do not have Mayday standards. A Rapid Intervention Team (RIT) will typically not be activated until a Mayday is declared. [7] Any delay in calling the Mayday reduces the window of survivability and also increases the risk to the RIT.[21-25]

The US Fire Administration National Fire Academy has two courses: Q133 "Firefighter Safety: Calling the Mayday" a self study course and H134 "Calling the Mayday: Hands on Training" course; they are both available on one CD free of charge from the National Emergency Training Center publication office [22]. The IAFF also has a course titled, Fire ground Survival.[26]

Any Mayday communication must contain the location of the firefighter in as much detail as possible, and at a minimum should include the division (floor) and quadrant. It is imperative that firefighters know their location when in IDLH environments at all times to effectively be able to give their location in the event of a Mayday. Once in distress firefighters must immediately declare a Mayday. The following example uses LUNAR (Location, Unit, Name, Assignment/Air, Resources needed) as a prompt: "Mayday, Mayday, Mayday, Division 1 Quadrant C, Engine 71, Smith, search/out of air/vomited, can't find exit." When in trouble, a firefighter's first action must be to declare the Mayday as accurately as possible and activate their PASS alarm.

Fire fighters also need to understand the psychological and physiological effects of the extreme level of stress encountered when they become lost, disoriented, injured, run low on air or become trapped during rapid fire progression. Most fire training curricula do not include discussion of the psychological and physiological effects of extreme stress, such as encountered in an imminently life threatening situation, nor do they address key survival skills necessary for effective response. Understanding the psychology and physiology involved in life threatening situations is an essential step in developing appropriate responses. Reaction to the extreme stress of a life threatening situation, such as being trapped, can result in sensory distortions and decreased cognitive processing capability.[22] Fire fighters should never hesitate to declare a Mayday. There is a very narrow window of survivability in a burning, highly toxic building. Any delay declaring a Mayday reduces the chance for a successful rescue. [27]

It is unknown why the Mayday was not heard in this incident. Incident Command must ensure that Mayday transmissions are prioritized and acted upon immediately.

Recommendation #7: Fire departments should train fire fighters to communicate interior and exterior conditions to the incident commander as soon as possible and to provide regular updates.

Discussion: Proper size-up and risk versus gain analysis requires that the incident commander have a number of key pieces of information and keep informed of the constantly changing conditions on the fireground. New decisions must be made and old ones revised based upon increased data and improved information. Decisions can be no better than the information on which they are based. The

Volunteer Captain Runs Low on Air, Becomes Disoriented, and Dies While Attempting to Exit a Large Commercial Structure – Texas

IC must use an evaluation system that considers and accounts for changing fireground conditions in order to stay ahead of the fire. If this is not done, the attack plan will be out of sequence with the phase of the fire and the IC will be constantly surprised by changing conditions [4,5,7,28] Interior size-up is just as important as exterior size-up. Since the IC is staged at the command post (outside), the interior conditions should be communicated by interior crews as soon as possible to the IC. Interior conditions could change the IC's strategy or tactics. Interior crews can aid the IC in this process by providing reports of the interior conditions as soon as they enter the fire building and by providing regular updates.

In this incident, the IC was not advised of the heavy charged smoke and intense heat in the vast interior. Since the interior crew acts as the eyes and ears of the IC, all fire fighters must continuously update the interior conditions to assist with tactical decisions.

Recommendation #8: Fire departments should ensure that a rapid intervention team (RIT) is established and available to immediately respond to emergency rescue incidents.

Discussion: A RIT should be designated and available to respond before interior attack operations begin at all fireground operations. [1,27,28] The team should report to the officer in command and remain in a designated ready position until an intervention is required to rescue a fire fighter(s) or civilians. The RIT should have all tools necessary to complete the task (e.g., a search rope, first-aid kit, and a resuscitator). The RIT's only assignment should be to prepare for a rapid deployment to complete any emergency search or rescue when ordered by the IC. The RIT allows the suppression crews the opportunity to regroup and take a roll call instead of performing rescue operations. A RIT should preplan a rescue operation by finding out fire structure information (i.e., construction materials, layout, entry/egress routes, etc.), crew location and assignments, and monitoring radio traffic. When the RIT enters to perform a search and rescue, they should have full cylinders on their SCBAs and be physically prepared. When a RIT is used in an emergency situation, an additional RIT should be put into place in case an additional emergency situation arises.[28]

A RIT was not established at this incident.

Recommendation #9: Fire departments should conduct pre-incident planning inspections of buildings to facilitate development of safe fireground strategies and tactics.

Discussion: NFPA 1620 *Standard for Pre-Incident Planning*, states "The purpose of this document shall be to develop pre-incident plans to assist responding personnel in effectively managing emergencies for the protection of occupants, responding personnel, property, and the environment." 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.[5,29,30]

Building characteristics including type (or more importantly risk) of construction, materials used, occupancy, water supply, 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. [30] Since fire departments have many structures within their jurisdiction, it is a challenge to establish an effective preplanning system. Priority should be given to those having elevated or unusual fire hazards and life safety considerations.

One tool for fire departments to use in assessing their risks for structures within their jurisdictions is the mnemonic, BECOME SAFE:

- Building
- Evaluation
- Construction/occupancy
- Operational hazards
- Manage time and elements
- Engagement
- Situational awareness
- Assessment and risk analysis
- Fire behavior and effects
- Evaluate and execute [31]

In this incident, the size of the building, the large fuel load, the lack of a fire department connection, and the lack of hydrants presented an elevated life safety consideration in the event of a fire. A thorough building inspection and pre-incident plan for a commercial occupancy in this area could have potentially identified the hazards typically associated with this type of operation such as: larger volume areas, large fuel loads, lack of fire alarms, lack of sprinklers, inadequate fire stopping/separation, inadequate water supply, and exit locations. Evaluating the construction features and layout of the structure allows the fire department the opportunity to determine a response protocol for the specific identified hazards and to develop fireground strategies and tactics (ventilation strategies, avenues of fire spread, proper attack line selection, water shuttle routes, etc.) before an incident occurs. The construction features of occupancy (large open areas), possible commercial fuel loads and access restrictions suggested large volumes of water would be necessary to fight a major fire at this site. A pre-planning process, involving individual fire companies within their response territory, could have noted this information which may have aided the IC in developing a safer and more effective offensive or defensive strategy. In order to facilitate open communication, fire department personnel and state and federal food/sanitation code enforcing agencies should be cross-trained on each-others' duties and responsibilities. Fire fighters should have a basic understanding of what a code violation is and how to report them during a pre-plan, and federal food/sanitation code enforcing agencies should have a basic understanding of fire and life safety issues during their inspections and report to the fire marshal's office or the authority having jurisdiction. The relay of this information could be used to facilitate dynamic risk management and enhanced command and control.

Volunteer Captain Runs Low on Air, Becomes Disoriented, and Dies While Attempting to Exit a Large Commercial Structure – Texas

Recommendation #10: Fire departments should ensure that all fire fighters and officers receive fundamental and annual refresher training according to NFPA 1001 Standard for Fire Fighter Professional Qualifications and NFPA 1021 Standard for Fire Officer Professional Qualifications.

Discussion: Initial and continual training provides an opportunity to ensure that all fire fighters and officers are proficient in their knowledge and skills in recognizing and mitigating hazards. Training on structural fire fighting should include, but not be limited to, departmental standard operating procedures, fire fighter safety, building construction, and fireground tactics. NFPA 1500 *Standard for a Fire Department Occupational Safety and Health Program*, Chapter 5.5.3, requires that the fire department provide an annual skills check to verify minimum professional qualifications of its members.[7] NFPA 1001 *Standard for Fire Fighter Professional Qualifications* was established to facilitate the development of nationally applicable performance standards for uniformed fire service personnel.[32] NFPA 1021 *Standard for Fire Officer Professional Qualifications* was developed in the same way to determine that an individual possesses the skills and knowledge to perform as a fire officer.[33] The intent of these standards is to develop clear and concise job performance requirements (JPRs) that can be used to determine that an individual, when measured to the standard, possesses the skills and knowledge to perform as a fire fighter or a fire officer, and that these JPRs can be used by any fire department in the country.

Recommendation #11: Manufacturers, equipment designers, and researchers should continue to develop and refine durable, easy-to-use radio systems to enhance verbal and radio communication in conjunction with properly worn SCBA.

Discussion: During this incident the victim asked his partner to call for a Mayday. It is unknown why he made the request, but it could have been related to the volume of traffic or a malfunctioning radio. The Mayday was not heard by the IC or dispatch. While it is unclear what caused the radio communication problems, effective radio communication is an important part of safe fireground operations.

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°C to 260°C, with the radios returning to normal function after cooling down. Additional research is needed in this area. [34,35] Fire service radios also need to be waterproof as normal fireground conditions dictate that radios are frequently exposed to excessive amounts of water during routine use through exposure to hose streams, overspray, water dripping from overhead, etc.

The use of PPE and an SCBA make it difficult to communicate, with or without a radio.[35,36] 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.[36,37]

Volunteer Captain Runs Low on Air, Becomes Disoriented, and Dies While Attempting to Exit a Large Commercial Structure – Texas

Recommendation #12: State offices with the responsibilities of enforcing fire protection codes should develop written agreements with state and federal agencies who inspect agriculture facilities for food and sanitation requirements to advise them of fire and life safety hazards that could be reviewed during their inspections.

Discussion: Agricultural occupancies throughout the United States are often located in rural, unincorporated areas which are not required to meet standard building and fire codes because they are outside of a specific jurisdiction. These occupancies have federal oversight from agencies such as the US Department of Agriculture and the Food and Drug Administration but the oversight is limited to food and sanitation requirements. State offices with fire code enforcement responsibilities should develop written agreements and provide adequate training so that these federal agencies can utilize their services when they observe possible violations of the NFPA 101, Life Safety Code during their routine food and sanitation inspections.[38]

References

1. IFSTA [2008]. Essentials of fire fighting, 5th ed. Oklahoma State University. Stillwater, OK: Fire Protection Publications, International Fire Service Training Association.

2. Dunn V [1992]. Safety and Survival on the Fireground. Saddle Brook NJ: Fire Engineering Books and Videos.

3. Dunn V [2000]. Command and Control of Fires and Emergencies. Saddle Brook NJ: Fire Engineering Book and Videos.

4. Brunacini AV [1985]. Fire command. Quincy, MA: National Fire Protection Association.

5. Dunn V [1998]. Risk management and lightweight truss construction. New York: WNYF, Official training publication of the New York City Fire Department, 1st issue.

6. NIOSH [1999]. NIOSH Alert: Request for assistance in preventing injuries and deaths of fire fighters due to structural collapse. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. (NIOSH) Publication No. 99-146.

7. NFPA [2007]. NFPA 1500: Standard on Fire Department Occupational Safety and Health Program, 2007 Edition. Quincy, MA: National Fire Protection Association.

8. Rita F. Fahy, Paul R. LeBlanc, Joseph L. Mollis [2011].Firefighter Fatalities in the United States-2010. Quincy, MA: National Fire Protection Association.

9. Delmar Publishers [2000]. Fire fighter's handbook: essentials of fire fighting and emergency response. New York: Delmar Thomson Learning.

10. NFPA [2009]. NFPA 1901: Standard for Automotive Fire Apparatus, 2009 Edition. National Fire Protection Association, Quincy, MA.

11. NFPA [2007]. NFPA 1911, Standard for the Inspection, Maintenance, Testing, and Retirement of In-service Automotive Fire Apparatus, 2007 Edition. National Fire Protection Association, Quincy, MA.

12. NFPA [2009]. NFPA 1002: Standard for Apparatus Driver/Operator Professional Qualifications, 2009 Edition. National Fire Protection Association, Quincy, MA.

13. NFPA [2007]. NFPA 1142: Standard on Water Supplies for Suburban and Rural Fire Fighting, 2007 Edition. National Fire Protection Association, Quincy, MA.

14. Klaene BJ and Sanders RE [2000]. Structural fire fighting. Quincy, MA: National Fire Protection Association.

15. USFA/FEMA [1999]. Incident Command System Student Manual. ICS-SM. Emmitsburg. MD: United States Fire Administration.

16. International Fire Service Training Association (IFSTA) [2000]. Model Procedures Guide for Structural Firefighting. 2nd Edition. Stillwater, OK: Fire Protection Publications.

17. Hoffman, JJ [2002]. MAYDAY-MAYDAY-MAYDAY. Fire Department Safety Officers Association Health and Safety for Fire and Emergency Service Personnel 13(4):8.

18. NIOSH [2001]. Supermarket Fire Claims the Life of One Career Fire Fighter and Critically Injures Another Career Fire Fighter – Arizona. Morgantown, WV: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, Fatality Assessment and Control Evaluation (FACE) Report F2001-13.

19. NFPA [2006]. NFPA 1404 Standard for Fire Service Respiratory Protection Training, 2006 Edition. Quincy, MA: National Fire Protection Association.

20. Bernocco S, Gagliano M, Phippips C, and Jose P. [2008]. Is your department complying with the NFPA 1404 air management policy? Fire Engineering. Vol 161, No 2. February. pp 103-108.

21. Clark, B.A. [2005]. 500 Mayday called in rookie school. *http://firefighteremsjobs.com/topics/strategy-and-tactics/500-maydays-called-rookie-school*.

22. US Fire Administration [2006]. Mayday CD Q133 Firefighter Safety: Calling the Mayday and H134 Calling the Mayday: Hands on Training. Emmitsburg, MD: U.S. Department of Homeland Security, U.S. Fire Administration, National Fire Academy.

23. Clark BA [2008]. Leadership on the line: Firefighter Mayday Doctrine where are we now? Radio@Firehouse.com http://www.firehouse.com/podcast/leadership-line/leadership-line-firefighter-mayday-doctrine-where-are-we-now.

24. IAFC Safety, Health, and Survival Section [2010]. Rules of Engagement of Structural Firefighting. [http://www.iafcsafety.org/image/ROE_Poster.pdf]. Date Accessed: July 2011.

25. Grossman D & Christensen, L [2008]. *On combat: The psychology and physiology of deadly conflict in war and peace* (3rd ed.). Millstadt, IL: Warrior Science Publications.

26. IAFF [2010]. Fire ground Survival. http://www.iaff.org/hs/fgs/fgsindex.htm. Date Accessed: July 2011.

27. International Association of Fire Chiefs [2009]. Rules of Engagement for Firefighter Survival. http://www.iafc.org/displayindustryarticle.cfm?articlenbr=39522 . Date Accessed: July 2011.

28. NFPA [2008]. NFPA 1561 Standard on Emergency Services Incident Management System, 2008 Edition. Quincy, MA: National Fire Protection Association.

29. NFPA [2010]. NFPA 1620. Standard for pre-incident planning. 2010 Edition. Quincy, MA: National Fire Protection Association.

30. Brannigan FL [1999]. Building construction for the fire service. 3rd ed. Quincy, MA: National Fire Protection Association.

31. CommandSafety.com [2009]. "Building Knowledge = Firefighter Safety", Know Your District and its Risk. http://commandsafety.com/2009/06/fireems-safety-health-and-survival-week-day-two-%e2%80%9cbuilding-knowledge-firefighter-safety%e2%80%9d-know-your-district-and-its-risk/. Date Accessed: July 2011.

32. NFPA [2008]. NFPA 1001: Standard for Firefighter Professional Qualifications. 2008 Edition. Quincy, MA: National Fire Protection Association.

33. NFPA [2008]. NFPA 1021: Standard for Fire Officer Professional Qualifications. 2008 Edition. Quincy, MA: National Fire Protection Association.

34. NIST [2007]. Advanced fire service technologies program. Proceedings of the 2007 NIST Annual Fire Conference. National Institute of Standards and Technology, Building and Fire Research Laboratory. Gaithersburg, MD.

35. Davis WD, Donnelly MK, and Selepak MJ [2006]. Testing of portable radios in a fire fighting environment. NIST Technical Note 1477. National Institute of Standards and Technology. Gaithersburg, MD. Building and Fire Research Laboratory.

36. USFA/FEMA [1999]. Improving firefighter communications. USFA-TR-099. Emmitsburg. MD: United States Fire Administration.

37. TriData Corporation [2003]. Current status, knowledge gaps, and research needs pertaining to fire fighter radio communication systems. Report prepared for NIOSH. Arlington, VA: TriData Corporation.

38. NFPA [2009]. NFPA 101: Life Safety Code. 2009 Edition. Quincy, MA: National Fire Protection Association.

Investigator Information

This incident was investigated by Jay Tarley, Safety and Occupational Health Specialist, and Matt Bowyer, General Engineer, with the Fire Fighter Fatality Investigation and Prevention Program, Fatality Investigations Team, Surveillance and Field Investigations Branch, Division of Safety Research, NIOSH.

A subject matter review was conducted Kevin D Quinn of the National Volunteer Fire Council. A technical review was also provided by the National Fire Protection Association, Public Fire Protection Division.

Additional Information

The Texas State Fire Marshal's Office conducted a separate investigation of this incident. Their investigation report will be available at http://www.tdi.state.tx.us/reports/fire/documents/fmloddaraguz.pdf.

Disclaimer

Mention of any company or product does not constitute endorsement by the National Institute for Occupational Safety and Health (NIOSH). In addition, citations to Web sites external to NIOSH do not constitute NIOSH endorsement of the sponsoring organizations or their programs or products. Furthermore, NIOSH is not responsible for the content of these Web sites.