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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 *December 16, 2005*

Career Fire Captain Dies When Trapped by Partial Roof Collapse in a Vacant House Fire - Texas

SUMMARY

On February 19, 2005, a 39-year-old career fire Captain (the victim) died after being trapped by the partial collapse of the roof of a vacant one-story wood frame dwelling. The house was abandoned and known by residents in the area to be a "crack house" at the time of the incident. The victim was the captain on the first-arriving engine crew which was assigned to perform a "fast attack" – to take a hoseline into the house, locate the seat of the fire, and begin extinguishment. The one-story wooden ranch-style house was built in the 1950s and additional rooms had been added at the rear in at least two phases following the initial construction. Crews arriving on scene could see fire venting through the roof at the rear of the house. The victim and a fire fighter advanced the initial attack line through the front entrance and made their way toward the rear of the house. Visibility was good in the front of the house but conditions quickly changed as they advanced toward the rear. The fast attack crew had just begun to direct water onto the burning ceiling in the kitchen and den areas when the roof at the rear of the structure (over the building additions) collapsed, trapping the captain under burning debris. The collapse pushed fire toward the front of the house which quickly ignited carbon and dust particles suspended in the air along with combustible gases, sending a fireball rolling toward the front of the structure. Prior to the time of the collapse, two other crews had entered through the front entrance. The rapidly deteriorating conditions following the collapse quickly engulfed the other crews with fire and five fire fighters received burns requiring medical attention.

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

- ***ensure that the Incident Commander continuously evaluates the risk versus gain when determining whether the fire suppression operation will be offensive or defensive.***

Incident scene

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/firehome.html** or call toll free **1-800-35-NIOSH**

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- ***train fire fighters to communicate interior conditions to the Incident Commander as soon as possible and to provide regular updates.***
- ***use thermal imaging cameras (TIC) during initial size-up and search phases of a fire.***
- ***ensure fire fighters open ceilings and overhead concealed spaces as hoselines are advanced.***
- ***ensure that team continuity is maintained during fire suppression operations.***
- ***consider using exit locators such as high intensity floodlights or flashing strobe lights to guide lost or disoriented fire fighters to the exit.***
- ***train fire fighters on the actions to take while waiting to be rescued if they become trapped or disoriented inside a burning structure.***

Additionally, fire departments, municipalities and standard-setting bodies (such as the National Fire Protection Association (NFPA)) should:

- ***consider developing and implementing a system to identify and mark dangerous and/or abandoned structures to improve fire fighter safety.***

Also, manufacturers, researchers, and designers as well as standard setting bodies (such as the NFPA) should:

- ***consider ways to improve personal alert safety system (PASS) devices, radios, and other safety equipment to make them more effective in extreme fire conditions.***

INTRODUCTION

On February 19, 2005, a 39-year-old career fire captain died after being trapped by the partial collapse of the roof of a vacant one-story wood frame dwelling. On February 22, 2005, the U.S. Fire Administration (USFA) notified the National Institute for Occupational Safety and Health (NIOSH) of the fatality. On April 4, 2005, two Engineers and an Occupational Safety and Health Specialist 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 and representatives of the fire department management, the International Association of Fire Fighters (IAFF), and the State Fire Marshal's Office. Interviews were conducted with officers and fire fighters who were at the incident scene. The NIOSH investigators reviewed the department's operating guidelines, the victim's training records, and floor plans of the structure. The incident site was visited and photographed. The victim's personal protective equipment (PPE) including self-contained breathing apparatus and protective clothing were also examined. Due to the condition of the SCBA (severely damaged by heat and flames), no further testing or evaluation of the PPE was able to be conducted by NIOSH.

FIRE DEPARTMENT

The fire department involved in this incident is comprised of 3,875 career fire fighters, has 86 fire stations including 4 air rescue stations, 16 rescue boats, and serves a population of approximately 2.5 million in an area of about 612 square miles.

TRAINING and EXPERIENCE

The victim had 11 years and 11 months of fire fighting experience and had completed numerous training courses such as: the State's requirements

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for Fire Fighter Level I and II, driver/operator, advanced fire fighter, intermediate instructor, shipboard fire fighter, industrial fire fighting, and fire fighter safety and survival. The victim was employed part-time as a fire fighter instructor at a local community college. The victim had been a captain for approximately 3 years and had previously worked as a driver/operator in the station located in the district where the incident occurred and was familiar with the area.

EQUIPMENT and PERSONNEL

The initial alarm resulted in five suppression apparatus, a district chief, a squad vehicle and an ambulance being dispatched to the incident site.

Engine 46 [Captain (victim), three fire fighters, driver/operator]
Engine 35 [Acting Captain, two fire fighters, driver/operator]
Engine 55 [Acting Captain, two fire fighters, driver/operator]
Ladder 46 [Captain, two fire fighters, driver/operator]
Ladder 55 [Captain, two fire fighters, driver/operator]
District Chief 46
Squad 46 [two fire fighter/paramedics]
Ambulance 33 [two fire fighter/Emergency Medical Technicians (EMTs)]

The second alarm resulted in five additional fire suppression apparatus, two district chiefs, a rescue vehicle and several support personnel being dispatched to the incident site. The following crews played a significant role in the recovery phase of the incident.

Engine 25 [Captain, four fire fighters, driver/operator]
Ladder 47 [Captain, two fire fighters, driver/operator]
Engine 33 [Captain, two fire fighters, driver/operator]

PERSONAL PROTECTIVE EQUIPMENT

At the time of the incident, each fire fighter entering the structure was wearing their full array of personal protective clothing and equipment, consisting of turnout gear (coats, pants, and Reed Hood (issued by this fire department and constructed of the same material as the turnout coat/pant ensemble)), helmet, gloves, boots, and a self-contained breathing apparatus (SCBA). Each fire fighter's SCBA contained an integrated personal alert safety system (PASS) device. In addition, a redundant system (TPASS) was also in use and worn by each fire fighter at the incident. This stand-alone TPASS (meeting the requirements of NFPA 1982 Standard on Personal Alert Safety Systems (PASS), 1998 Edition) transmits a continuous radio signal to a base receiver that is maintained and monitored in the district chief's vehicle at the command post. This stand-alone TPASS provides the basis for an electronic accountability system on the fireground. The base receiver provides an audible and visual status of each fire fighter on the fireground. If the TPASS is activated, an emergency warning signal is sent to the base receiver indicating the existence of an emergency. This system identifies each crew member by apparatus number and riding position. An evacuation signal can be transmitted from the base receiver to all TPASS devices where a distinct audible alarm alerts fire fighters to exit the building. Fire fighters manually reset their unit, acknowledging to the base receiver that the fire fighter received the evacuation signal. A fire fighter can also manually activate this system, sending the emergency signal to the base receiver.

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This department issues portable hand-held radios to all fire fighters.

STRUCTURE

The structure was a one-story wood frame ranch style house that was originally constructed in the 1950s. The house was stick-built over a pier and beam foundation. The roof was covered with asphalt shingles supported by rafters in a common hip configuration. Additional rooms were added to the rear of the structure in at least two phases. The first phase was built on a two-pour slab foundation while the second addition was built on a block and wood beam foundation. The house measured 28 feet wide by 64 feet long. One addition added a den that spanned the entire width of the house beyond the kitchen. This addition did not include any interior walls thus the roof rafters spanned the width of the house without any support.

The house had been vacant since the owner's death in 2004 and had been vandalized and was known by locals and fire department and police agencies to be used by vagrants for illicit drug activities.

WEATHER

On the day of the incident, the air temperature was approximately 57 degrees Fahrenheit with clear skies and light wind.

INVESTIGATION

On February 19, 2005, at approximately 0559 hours, the local 911 Office of Emergency Communication (OEC) received a call reporting a house fire in a residential area. The caller reported that smoke and flames were visible. At 0601 hours, the first alarm assignment was dispatched. Engine 46 (E46) was the first apparatus to arrive on the scene at 0604 hours immediately followed by District Chief 46 (DC46) and Ladder 46 (L46). The alarm assignment occurred as crew members (including the victim) were arriving for the normal 0630 shift change, resulting in some responding crews consisting of a mixture of both A-shift and B-shift fire fighters.

The Captain on Engine 46 (the victim), as the first arriving officer, reported to the dispatch OEC that fire was showing from a one-story house and stated that he was initiating a "Fast Attack." Seconds later, DC46 arrived on the scene, and reported to OEC that he was assuming incident command. He reported to the OEC that heavy fire was visible in a one-story house and directed the E46 crew to make the "Fast Attack." Ladder 46 (L46) arrived on the scene next. At approximately 0605 hours, the E46 Captain (the victim) and one fire fighter (carrying the nozzle) made entry into the structure while the second fire fighter from E46 flaked the orange 1¾-inch pre-connected hose line at the door. The second E46 fire fighter worked the hose line slack through the front door and then entered by himself and followed the hoseline to where the Captain and nozzleman were searching for the fire in the kitchen area. Visibility was good at the front of the house but decreased as the crew advanced toward the rear of the house. In recent months, vagrants had begun to use the structure and the interior was cluttered with old furniture, household items, and trash which made it difficult to walk through the darkened rooms (see Photo 1). The E46 crew could hear the sound of burning wood but had difficulty locating the seat of the fire in the smoke-filled darkness. DC46 called Engine 35 (E35) and directed them to pull a 4-inch supply line off E46 to a nearby hydrant and establish water supply. DC46 called Engine 55 (E55) and directed them to be the rapid intervention team (RIT). Seconds later, DC46 realized that E55 would be the second due engine so he changed the assignments for E35 and E55. He directed E35

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to be the RIT and directed E55 to pull a second 1¾-inch pre-connect hose line from E46 and to back up the E46 crew. E55 arrived on the scene at 0606 hours.

The DC46 and the Captain of L46 walked around to the C / D corner of the structure to observe conditions (see Figure 1). DC46 told the L46 Captain that roof ventilation was not possible. DC46 directed L46 to do interior search. The L46 Captain told his crew to take the front door off of its hinges because the door was partially obstructing access into the house. The L46 Captain entered by himself. After removing the door and setting it to the right of the entranceway, the L46 crew (2 fire fighters) entered the structure and started a left-hand search through the living room and front bedroom, keeping in contact with the interior walls. The Captain and the L46 crew members never met inside the structure. L46 was equipped with a thermal imaging camera (TIC) but it was not used during the initial search operations. *NOTE: Several fire fighters reported to NIOSH investigators that flames were venting through the roof at the rear of the structure when they arrived on-scene. Some reported that flames could be seen well above the roofline (see Photo 2 taken shortly after crews began arriving on-scene).*

At approximately 0607 hours, DC46 called the OEC and stated interior search was not possible. Seconds later, Ladder 55 (L55) arrived on the scene. DC46 directed L55 to check exposures. DC46 met the Captain of L55 in the front yard and directed L55 to do an assessment of the B-side exposures (wooden fence and house to the south of the burning structure). Water supply was established to E46 by the engineer / operator (E/O). The electronic accountability system was set up and made operational by the engineer / operators from E55 and E35.

At approximately 0608 hours, DC46 called the OEC and reported that electronic accountability had been set up and was operational. *NOTE: Fire Department Electronic Accountability Guidelines recommend that non-committed E/Os be utilized as the accountability officer. The DC46 directed E55's E/O to operate the accountability system. The E/O from E35 assisted the E/O from E55 in operating the system.* The Acting Captain and two fire fighters from E55 advanced the second hose line (blue colored 1¾-inch pre-connected hoseline from E46) through the front entrance into the structure to back up the E46 crew.

At approximately 0609 hours, L55 reported that the B-side exposures were OK. DC46 returned to the D-side to check on the conditions of the fire. He observed that the water (from the interior attack crews) didn't appear to be having much effect on containing the fire.

At approximately 0611 hours, DC46 walked from the D-side back to the front of the house and saw conditions were getting worse. He called E46 on his radio and asked for an interior report just as the roof at the rear of the house collapsed, pushing fire through the structure toward the front, engulfing everyone inside in flames. There was no response from inside the structure. [*Note: At some point prior to this (probably during the initial hose line advance), the E46 Captain had dropped his radio in the front living room. The radio was located after the incident (see Figure 1).*] DC46 then radioed for everyone to back out of the house. He called the OEC and asked for an evacuation tone on the fireground channel to get everyone out of the house. He told the accountability officer (E/O from E55) to get everyone outside. Numerous apparatus air horns were also sounded for an evacuation signal. DC46 then requested a personnel accountability report (PAR) from all companies at the scene. A second alarm was

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requested which dispatched 3 more engines, 2 more ladder trucks, and additional support personnel.

The roof collapse occurred over the den addition at the rear of the structure (see Photo 3, 4 and Figure 1). The E46 crew was operating in the kitchen area and had just located the fire and begun to direct water onto the flames. The E46 captain (the victim) had just taken the nozzle from the nozzleman to direct water toward the rear of the house. The two E46 fire fighters were just reaching to pull more slack when they were knocked down by the force of the collapse. The L46 Captain who was in the dining room behind the two E46 fire fighters reported hearing a rumbling sound just prior to the collapse. The L46 Captain immediately began yelling for everyone to get out. The L46 Captain radioed that fire fighters were trapped, and requested help. Then, while trying to adjust his radio, he dropped it and was not able to retrieve it (see Figure 1). The nozzleman from E46 was disoriented by the collapse but began moving toward the front of the house. At some point, he noticed flashing lights from the apparatus parked on the street and dove headfirst out a living room window on the D-side. The other E46 fire fighter was able to follow the hoseline to the front door. Just prior to the roof collapse, the E55 crew had advanced the second 1¾-inch hoseline to the kitchen near where E46 was operating. They could hear the L46 Captain talking nearby. The E55 crew also were knocked down by the force of the collapse, but were able to follow their hose line toward the front of the house and were assisted to the outside.

The two L46 fire fighters were continuing their search in the hallway between the front bedroom and the front corner of the dining room when they were engulfed in flames following the collapse. They heard their captain yelling for everyone to get out. One of the L46 fire fighters had his facepiece dislodged when something caused a nearby hose line to flip upward and catch his SCBA regulator. The L46 fire fighters reversed their direction and located a hose line which they followed to the front door. The L46 Captain became disoriented after the roof collapse and followed a hose line until he reached the nozzle then turned around and tried to make his way toward the front entrance. High heat and flames impeded his progress, forcing him to the floor on several occasions.

Following the order to evacuate the structure, the DC46 activated the RIT Team at approximately 0612. Initial accountability reports indicated unaccounted-for fire fighters. The electronic accountability system in use at the incident reported an alarm condition for the E46 Captain (i.e. the victim's PASS device went into alarm mode, indicating the victim had been motionless for at least 30 seconds). It was quickly determined that the E46 Captain had not exited with his crew. The RIT Team (acting Captain and two fire fighters) followed the hoselines through the front door and began searching for missing fire fighters.

The acting Captain from E35 (RIT Team) met the Captain of L46 and helped him make his way to the outside. Once the L46 Captain was outside, it was initially thought that the L46 Captain was the E46 Captain. Upon realizing that the E46 Captain was still inside the structure, the DC46 sent the RIT Team back inside along with crew members from L55 followed by E25 and E47 (who had just arrived on scene) to continue the search. Two hose lines were in operation inside the house. While searching for the E46 Captain, the Acting Captain of E35 (RIT), who was operating by himself, ran out of air, and had to jump out a B-side window.

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The E/O from L46 was directed by the L46 Captain to search through rooms to the left of the house. He retrieved the thermal imaging camera from L46 and entered the house by himself. After some time inside the house, the L46 E/O went back to L46 and retrieved an SCBA, then re-entered the house and continued searching. A third hose line was taken to the B-side of the structure by the E55 crew about the time that the Acting Captain of E35 jumped out the B-side window. The Acting Captain of E35 exchanged SCBAs with the Acting Captain of E55, before re-entering through the B-side wall to continue searching for the E46 Captain.

At approximately 0629, the E25 crew located the victim face-down under approximately 2 – 3 feet of debris and rubble from the collapsed roof. The victim was found facing the rear of the structure (see Figure 1). The victim's SCBA cylinder was the only thing showing above the debris. The victim's PASS device was not in alarm mode (no audible alarm and no flashing lights were detected) when the rescuers found the victim. The victim was pronounced dead on the scene by medical examiners. The victim's turnout gear and SCBA were severely damaged by heat and/or flame exposure at the time the victim was located. The SCBA was too badly damaged to be tested by NIOSH for proper performance.

INJURIES

Five fire fighters who were inside the structure at the time of the collapse received thermal burns requiring medical attention.

CAUSE OF DEATH

The medical examiner lists the cause of death as smoke inhalation and thermal injuries. Postmortem carboxyhemoglobin was reported at 26%.

RECOMMENDATIONS/DISCUSSION

Recommendation # 1: Fire departments should ensure that the Incident Commander continuously evaluates the risk versus gain when determining whether the fire suppression operation will be offensive or defensive.

Discussion: The initial size-up conducted by the first arriving officer allows the officer to make an assessment of the conditions and to assist in planning the suppression strategy. The following general factors are important considerations during a size-up: occupancy type involved, potential for civilians in the structure, smoke and fire conditions, type of construction, age of structure, exposures, and time considerations such as the time of the incident, length of time fire was burning before arrival, and time fire was burning after arrival.[1-2] The Incident Commander must perform a risk analysis to determine what hazards are present, what the risks to personnel are, how the risks can be eliminated or reduced, and the benefits to be gained for interior or offensive operations.[3] The initial size-up should include a complete 360º walk-around of the structure if possible.

The size-up must include continued assessment of risk versus gain during incident operations. According to NFPA 1500 §A-6-2.1.1, "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 must 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."[4] Retired New York City Fire Chief Vincent Dunn states "When no other person's

life is in danger, the life of the firefighter has a higher priority than fire containment."[5]

The first-responding officer, as well as the incident commander, needs to make a judgment as to what is at risk – people or property. This will help determine the risk profile for the incident. Many fire fighters stand by the notion that all incidents are "people" events until proven otherwise. Some fire fighters are willing to concede that a fire environment has become too hostile to sustain life and therefore, the only thing left to save is property. Historically, the fire service has a poor history of changing risk-taking based upon the people/property issue.[6]

In this incident, the structure involved was vacant and abandoned. The structure had been vandalized and was known to be frequented by vagrants using the structure for illicit drug-related activities. The initial call to the 911 dispatch center at 0559 hours reported flames and smoke were visible. The first-arriving crew reported fire showing at 0604 hours. The Incident Commander reported heavy fire visible when he arrived on the scene. Additional crews arriving on the first alarm reported flames venting out the back of the structure as high as 20 feet into the air.

Recommendation # 2: Fire departments should train fire fighters to communicate interior 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 Incident Commander 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.[7] 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 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 requested a progress report from the fast attack crew but did not receive a response. The victim had previously lost his radio and had taken over operating the nozzle when the IC called for the status report, and thus was unable to respond. After the incident, the initial attack crews entering the front of the structure reported good visibility and little heat until they reached the kitchen area. Crews also reported difficulty in finding the fire, even though fire was venting from the rear of the structure when the first crews arrived. Thus, the interior conditions (lack of fire) did not match the exterior conditions (rear of structure fully involved). This information could have been used to justify changing from a fast attack mode to a more cautious defensive operation.

Recommendation # 3: Fire departments should use thermal imaging cameras (TICs) during the initial size-up and search phases of a fire.

Discussion: Thermal imaging cameras (TIC) can be a useful tool for initial size up and for locating the seat of a fire. Infrared thermal cameras can assist fire fighters in quickly getting crucial information about the location of the

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source (seat) of the fire from the exterior of the structure, so they can plan an effective and rapid response with the entire emergency team. Knowing the location of the most dangerous and hottest part of the fire may help fire fighters determine a safe approach and avoid structural damage in a building that might have otherwise been undetectable. Ceilings and floors that have become dangerously weakened by fire damage and are threatening to collapse may be spotted with a thermal imaging camera. A fire fighter about to enter a room filled with flames and smoke can use a TIC to assist in judging whether or not it will be safe from falling beams, walls, or other dangers. The use of a thermal imaging camera may provide additional information the Incident Commander can use during the initial size-up. Thermal imaging cameras (TICs) should be used in a timely manner, and fire fighters should be properly trained in their use and be aware of their limitations.[8]

In this incident, members of the three initial attack crews reported that they were able to make entry into the structure standing up and encountered little heat until they reached the dining room area. Yet, they also reported flames venting out the back of the house as the crews arrived on-scene. The use of a TIC during initial size-up and entry into the structure could have confirmed that the fire was already burning in the attic area overhead. This information may have influenced the fire department to use more defensive tactics. The department has an established guideline covering the use of thermal imaging cameras which states "the TIC will be utilized in every structure fire." A TIC was on-site but it was not put into service during the initial attack phase of the incident

Recommendation #4: Fire departments should ensure fire fighters open ceilings and overhead concealed spaces as hoselines are advanced.

Discussion: It is important to pull ceilings and open overhead concealed spaces as fire fighters advance on a fire to be sure the fire is not moving through the concealed spaces, getting behind the advancing fire fighters and cutting off their means of egress.[9] It is also important to consider the time that the fire has been reported to be burning. Fires in concealed spaces usually mean that the building's support structures such as columns, roof and floor joists or trusses, etc., are involved. The longer the fire has to consume these support members, the more likely structural collapse becomes. In this incident, the initial call to the 911 dispatch center reported that fire was visible. Arriving crews reported flames venting out the back of the building. Yet, the crews who entered the structure reported no heat and good visibility at the front. The initial attacking hoseline crew reported hearing the fire but not being able to see it. These are all indications of fire in the concealed space above a ceiling.

Recommendation # 5: Fire departments should ensure that team continuity is maintained during fire suppression operations.

Discussion: Fire fighters should always work and remain in teams whenever they are operating in a hazardous environment.[4] Team continuity means knowing your team members and who is the team leader, staying within visual contact at all times (if visibility is low, teams must stay within touch or voice distance of each other), communicating needs and observations to the team leader, rotating to rehabilitation, staging as a team, and watching out for your team members (practicing a strong buddy system). Following these basic rules helps prevent serious injury or even death by providing personnel with the added safety net of fellow team members. Teams that enter a hazardous environment together should leave together to

ensure that team continuity is maintained.[10] In this incident, there were numerous instances where fire fighters were working independently, increasing risk for themselves, and possibly to others, if they had also become missing.

Recommendation # 6: Fire departments should consider using exit locators such as high intensity floodlights or flashing strobe lights to guide lost or disoriented fire fighters to the exit.

Discussion: The use of high-intensity floodlights, flashing strobe lights, or other high visibility beacons can be set up at the entry portals of burning structures as an aid to assist fire fighters in situations requiring emergency escape.[11] If manpower permits, a fire fighter can be stationed at the doorway to assist with flaking hose through the entrance and to assist exiting fire fighters. During this incident, several fire fighters inside the structure became disoriented following the roof collapse. During the NIOSH interviews, two fire fighters stated they did not know the way to the front door. One fire fighter finally noticed the flashing lights on fire apparatus parked outside the structure and made his escape by jumping through a window on the D-side. Another fire fighter was located by the RIT Team and assisted outside.

Recommendation # 7: Fire departments should train fire fighters on actions to take while waiting to be rescued if they become trapped or disoriented inside a burning structure.

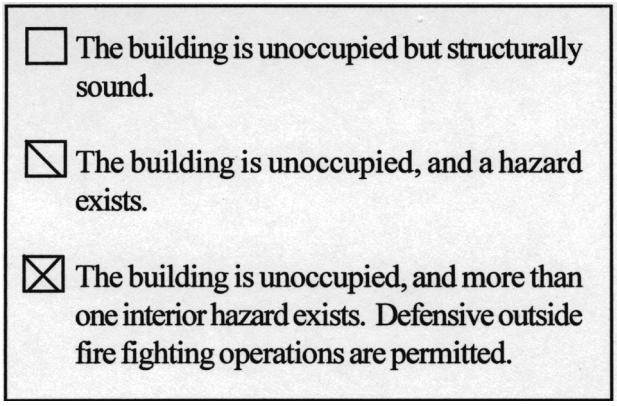
Discussion: Fire fighters must act promptly when they become lost, disoriented, injured, low on air, or trapped.[12-16] First, they must transmit a distress signal while they still have the capability and sufficient air. The next step is to manually activate their PASS device. To conserve air while waiting 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 the IC and other rescuers. Additionally, fire fighters can attract attention by maximizing the sound of their PASS device (e.g. by pointing it in an open direction); pointing their flashlight toward the ceiling or moving it around; and using a tool to make tapping noises on the floor or wall. A crew member who initiates a Mayday call for another person should quickly try to communicate with the missing member via radio and, if unsuccessful, initiate another Mayday providing relevant information on the missing fire fighter's last known location. In this incident, an officer inside the structure radioed that fire fighters were trapped and needed help after the roof collapse, but didn't use the term "Mayday." Broadcasting the Mayday should have triggered the OEC dispatcher to initiate additional measures in response to the emergency. To compound matters, the officer then dropped his radio in the confusion. None of the fire fighters who were inside the structure activated their PASS devices.

Additionally

Recommendation #8: Fire departments, municipalities, and standard setting bodies such as the National Fire Protection Association (NFPA) should consider developing and implementing a system to identify and mark dangerous and/or abandoned structures to improve fire fighter safety.

Discussion: Vacant buildings can and do pose numerous hazards to fire fighters' health and safety. Hazards should be identified and warning placards affixed to entrance doorways or other

openings to warn fire fighters of the potential dangers. Hazards can be structural as the result of building deterioration or damage from previous fires. Structural hazards can occur when building owners or salvage workers remove components of the building such as doors, railings, windows, electric wiring, utility pipes, etc. Abandoned materials such as paper and flammable or hazardous substances and collapse hazards constitute additional dangers fire fighters may encounter. Collapse hazards can include chimney tops, parapet walls, slate and tile roof shingles, metal and wood fire escapes, advertising signs, and entrance canopies. For example, a warning placard may be a 12-inch-square piece of metal painted reflective yellow so that it glows in the dark and indicates to fire fighters that hazards exist inside the building.[17] Following is an example of a warning placard developed and used by the New York City Fire Department.



In this incident, the structure had been abandoned since the time of the owner's death in 2004. The structure was known to be used by vagrants for illicit activities. The structure had also been ransacked resulting in broken furniture, household goods, debris, and litter cluttering the floors.

Recommendation # 9: Manufacturers and researchers as well as standard setting bodies (such as the NFPA) should consider ways to improve personal alert safety system (PASS) devices, radios, and other safety equipment to make them more effective in extreme fire conditions

Discussion: NFPA 1982[18] *Standard on Personnel Alert Safety Systems* describes the performance criteria and test procedures for PASS devices. Among other requirements, this standard states that PASS devices must withstand 160 degrees F (for 4 hours), a temperature well below that to which fire fighters may be exposed during structure fires.[19,20] NIOSH suggests that researchers, manufacturers, and committee members of NFPA 1982 review the temperature resistance testing requirements for PASS devices to ensure that these temperatures are representative of levels encountered under actual fire conditions. In this incident, the base receiver for the electronic accountability system reported an alarm condition for the victim, then the signal was lost. When the victim was located, his PASS device was not sounding. The victim's SCBA and other protective equipment were severely damaged beyond the point where evaluations and testing could be conducted.

In this incident, the victim lost his hand-held radio soon after entering the burning structure. Another officer stated to NIOSH investigators that he attempted to manually activate his PASS device following the roof collapse but could not find the button to do so. He called for help on his radio, then dropped it and was not able to retrieve it. Both issues indicate the need for further refinement of the ergonomic aspects of radios and PASS devices.

Recommendation #10: Manufacturers and researchers should continue to refine existing and develop new technology to track and locate lost fire fighters on the fireground.

Discussion: Fire fighter fatalities often result when fire fighters become disoriented and lost on the fireground. This is particularly problematic if their PASS alarm is inaudible. NIOSH has investigated similar incidents in which PASS alarms were inaudible for undetermined reasons[21,21,23,24]. In this incident, fire fighters wore two separate PASS devices. When the victim was located, neither PASS device was presenting an audible alarm. Acoustic devices that emit sounds above the threshold of human hearing (ultrasonic) have been utilized for locating trapped miners underground.[25] Such devices emit sounds that can be detected by tracking devices and have been investigated in fire fighter training scenarios. Yet another possibility to consider is the use of electro-magnetic systems. Extremely Low Frequency (ELF), Very Low Frequency (VLF) and Low Frequency (LF) electro-magnetic systems that emit signals in the 0 to 300 kHz range have been tested and found useful as location devices for locating trapped miners and in ski patrol rescue.[26] Such devices should be further researched, refined, and hardened for possible use in the fire service.

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INVESTIGATOR INFORMATION

This incident was investigated by Timothy Merinar, Safety Engineer, Mark McFall, Occupational Safety and Health Specialist, and Matt Bowyer, General Engineer with the NIOSH, Division of Safety Research, Fire Fighter Fatality Investigation and Prevention Program. The report was authored by Timothy Merinar.

Photo 1. Note cluttered condition of floor in living room. Photo courtesy of fire department.

Career Fire Captain Dies When Trapped by Parial Roof Collapse in a Vacant House Fire - Texas

Photo 2. Taken just prior to, or near the time, of the collapse. See Photo 3 for the same view after fire extinguishment. Photo courtesy of fire department.

Career Fire Captain Dies When Trapped by Parial Roof Collapse in a Vacant House Fire - Texas

Photo 3. Note roof collapse area at rear of house. Photo courtesy of fire department.

Photo 4. Aerial view of collapse zone. Photo courtesy of fire department.

Career Fire Captain Dies When Trapped by Parial Roof Collapse in a Vacant House Fire - Texas

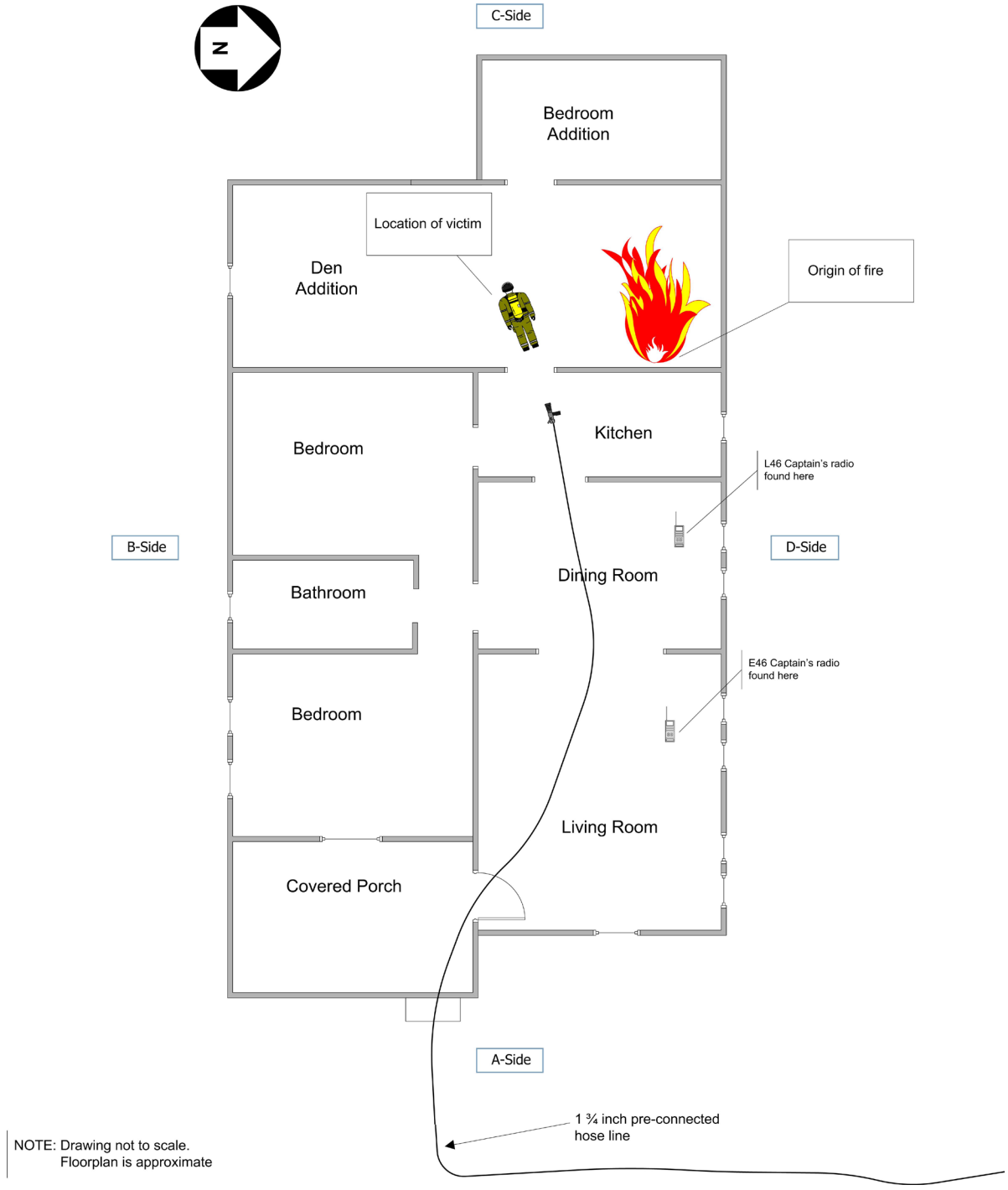

Figure 1. Layout of structure

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