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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

September 30, 2009

Career Fire Fighter Injured during Rapid Fire Progression in an Abandoned Structure Dies Six Days Later – Georgia

SUMMARY

On November 23, 2006, a 33-year-old male career fire fighter (the victim) was seriously injured during a fire in a single story abandoned duplex house. The victim was working the interior of the structure fire with other crew members for less than a minute when they were ordered to evacuate the structure because of extreme conditions. At about the same time a flashover or flameover occurred; the victim became disoriented and was unable to exit the burning structure. The victim was rescued approximately 4 minutes later and transported via ambulance to a metropolitan trauma center where he remained in critical condition for several days in the burn unit before succumbing to his injuries on November 29, 2006. Key contributing factors identified in this investigation include an initial size-up not being conducted, a failure to recognize the signs of an impending flashover/flameover as fire fighters entered the structure, inadequate communication on the fire ground and the possibility that ventilation induced the rapid fire progression.

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

- ***Ensure that an initial size-up of the incident scene is conducted before beginning interior fire fighting operations.***
- ***Ensure that the first arriving company officer does not become involved in firefighting efforts when assuming the role of incident commander.***
- ***Ensure that a Rapid Intervention Team (RIT) is established and in position with a backup hoseline prior to initiating an interior attack.***
- ***Ensure that ventilation is closely coordinated with interior fire suppression operations.***

- ***Ensure that crew integrity and accountability are maintained during fire suppression operations.***
- ***Ensure that all fire fighters are equipped with a radio and trained on how to initiate emergency traffic.***
- ***Train fire fighters to recognize the conditions that forewarn of a flashover/flameover and communicate fire conditions to the incident commander as soon as possible.***
- ***Train fire fighters on actions to take if they become trapped or disoriented inside a burning structure.***
- ***Ensure that fire fighters serving as acting officers are adequately trained.***

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 unoccupied, vacant or abandoned structures to improve fire fighter safety.***

INTRODUCTION

On November 23, 2006, a 33-year-old male career fire fighter was seriously injured during a flashover in an abandoned single story duplex; he died as a result of these injuries 6 days later. On November 29, 2006, the U.S. Fire Administration notified the National Institute for Occupational Safety and Health (NIOSH) of this incident. On January 15-19, 2007, two safety and occupational health specialists and a general engineer from the NIOSH Fire Fighter Fatality Investigation and Prevention Program investigated this incident. The NIOSH team met with officials of the fire department, representatives from the International Association of Fire Fighters (IAFF), and the Director of the Georgia State Fire Academy, who served as the chairperson of the committee appointed by the fire chief to review the incident. The team interviewed the officers and fire fighters involved in the incident, examined photographs of the fireground, and reviewed other pertinent documents including the investigative report conducted by an independent review panel commissioned by the fire chief. The NIOSH investigators also reviewed departmental standard operating procedures,[1] dispatch records, radio communication transcripts, the arson investigation report, the victim's training records, self-contained breathing apparatus (SCBA) maintenance records, and floor plans and photographs of the structure. NIOSH investigators visited the fire department's training academy and met with the chief training officer.

FIRE DEPARTMENT

The career fire department involved in this incident has approximately 1,100 employees and serves a metropolitan population of more than 450,000 residents in a geographic area of about 132 square miles. The fire department operates 31 engine companies, 13 truck companies, and one squad company from 36 fire stations.

TRAINING and EXPERIENCE

The 33-year old victim had been with the department for more than 2 months and was working his 6th shift at the time of the fatal injury. He had more than 5 years of fire fighting experience with another career fire department in Georgia where he originally completed 14-weeks of recruit training. The victim had completed more than 600 hours of training in areas such as exterior and interior fire fighting, truck company operations, emergency medical technician (EMT), hazardous materials awareness, vehicle extrication, introduction to high angle rescue, and confined spaces. These courses were sponsored through the fire department, local community technical college and the state fire academy. The victim had also completed live fire training sessions coordinated through the state fire academy.

The victim was a Certified Firefighter and Certified Airport Firefighter in the State of Georgia. The fire department's fire academy provides new fire fighters with 8 months of training. Recruits attend four months of fire fighting training and four months of EMT training. After graduating from the academy, fire fighters complete a 1-year probationary period. Instead of attending his new department's fire academy, the victim had completed the department's "Fast Track" program for experienced fire fighters newly hired by the department. The fast track program is 4 weeks of departmental orientation and training for fire fighters with valid Georgia or national training certifications.

EQUIPMENT and PERSONNEL

There were 7 apparatus and 37 fire fighters on scene during the 1st alarm response at the time the victim was injured. The initial dispatch was at 2002 hours. Responding apparatus included:

Engine 16 (victim, fire fighter/acting officer in charge, and 2 fire fighters)

Truck 16 (officer and 3 fire fighters)

Engine 1 (fire fighter/acting officer and 2 fire fighters)

Truck 1 (officer and 4 fire fighters)

Engine 7 (officer and 3 fire fighters)

Truck 11 (officer and 3 fire fighters)

Battalion Chief 3 Incident Commander and aide (command technician fire fighter) via battalion car

Battalion Chief 2 Incident Safety Officer and aide (command technician fire fighter) via battalion car

Customer Service 5 (1 officer) (*Note: Assists with the public and media on the fire ground*)

Air Truck 7 (1 fire fighter)

Squad 4 (officer and 6 fire fighters)

TIMELINE

Note: This timeline is provided to set out, to the extent possible, the sequence of events. Times are approximate and were obtained from review of the dispatch records, witness interviews, photographs of the scene and other available information. In some cases the times may be rounded to the nearest minute, and some events may not have been included. The timeline is not intended, nor should it be used, as a formal record of events.

The response, listed in order of arrival (time approximate) and events, include:

- **2000 Hours**
  911 received a call from a neighbor reporting the fire

- **2002 Hours**
  911 dispatched the first alarm assignment to the fire
  "Report of structure fire…at an abandoned house"

- **2003 Hours**
  1st Alarm assignment en route

- **2005 Hours**
  Engine 16 (with victim) and Truck 16 on scene
  Engine 16 pulls 2 cross-lay attack lines
  Heavy black smoke; no flame observed

- **2006 Hours**
  Engines 1&7 and Truck 1 on scene

- **2007 Hours**
  Engine 16 stages at front door with hoseline and requests forcible entry
  Squad 4, Battalion 3 on scene
  Battalion 3 assumes command

Engine 16 makes entry with victim on nozzle

- **2008 Hours**
  Battalion 2 on scene
  Battalion 3 requests report and rapid intervention team assignment from Engine 16
  Battalion 3 does not receive report back
  Battalion 3 orders defensive fire attack
  Flameover occurs
  Interior crew backs out

- **2009 Hours**
  Victim seen moving through flames
  Crews on scene aware of fire fighter trapped inside
  Truck 11 on scene; assigned ventilation

- **2010 Hours**
  Fire knocked down
  Squad 4 enters C-side to search for victim using a thermal imaging camera
  Other fire fighter crews enter A-side to search for victim

- **2011 Hours**
  Battalion 3 requests PAR
  Engine 16 incorrectly reports PAR
  Battalion 2 reports Squad 4 making rear entry for victim

- **2012 Hours**
  Engine 7 crew takes Engine 16's hose line in front door and searches for victim
  Victim located and rescued by Squad 4 and Engine 7

PERSONAL PROTECTIVE EQUIPMENT

At the time of the incident, the victim was equipped with the full array of personal protective clothing and equipment, consisting of turnout gear (coat and pants), helmet, Nomex® hood, gloves, boots, and a SCBA with an integrated personal alert safety system (PASS). The structural fire fighting gear was compliant with the 2003 edition of NFPA 1971. The victim was not equipped with a portable radio.

The SCBA worn by the victim was submitted to NIOSH for additional evaluation and testing. A summary of the Status Investigation Report is included in the Appendix of this report. The SCBA suffered serious heat damage but was determined to be in a condition safe for testing. The SCBA failed to meet several certification testing requirements. The SCBA failed to meet the requirements of the positive pressure test, the rated service time test, the static pressure test, the gas flow test (at

full cylinder pressure), and the air flow performance test (see Appendix). These results were consistent with the thermal damage to the second stage regulator that caused a free-flowing condition. The integrated PASS device worn by the victim was reported to have been sounding during the incident. However, during testing the PASS did not operate or activate. Reasons for this could include damage to the PASS after it was heard to alarm or depletion of the batteries powering the PASS. The PASS was assessed as received without changing batteries or performing any other maintenance. The NIOSH SCBA post-incident test results did not suggest any contributing factor to the incident. Due to the extent of the damage, the SCBA could not be returned to service.

STRUCTURE

The incident structure was an abandoned small single story duplex originally built in the 1940s (see Photos 1&2 and Diagram 1). The structure was abandoned and in disrepair at the time of the incident. The exterior doors and windows were boarded-up with plywood. The exterior dimensions of the structure were 36 feet wide and 34 feet in depth. The exterior walls were constructed of brick and the roof had multiple layers of asphalt shingles. The floor was a cement slab over a crawl space, with some carpeting present. The interior walls originally consisted of drywall gypsum/plaster over wood framing, but all the drywall had been removed exposing the wood studs/furring strips and ceiling rafters. This in effect connected all the rooms into one uncompartmentalized space. Most interior furnishings (including doors, plumbing fixtures/piping, and electrical fixtures/wiring) were missing. There were no utilities connected to the structure.

Each duplex of the structure had approximately 500 square feet of living area and each unit was a mirror image of the other. Each duplex had a living room, dining room/kitchen and bathroom. The duplex shared a common front entry door with a small covered porch. Inside a small vestibule there were two entrance doors on the left and right for each unit. *(Note: These doors were missing at the time of the fire)*. There were two small landings with steps leading to a rear door of each unit at the rear of the structure. The duplex sat on an approximately 100 x 100 foot lot that sloped down from the front of the duplex.

WEATHER

At the time of the incident it was dark outside. The temperature was approximately 51 degrees Fahrenheit (°F) with a dew point of 36°F and a relative humidity of 56 percent.[2] The sky was clear with light winds blowing from the northwest with an average wind speed of 3.5 mph.

INVESTIGATION

On November 23, 2006, at 2000 hours a fire was reported in an abandoned house by a neighbor across the street. *(Note: The fire department's coverage area has an unusually high number of*

unoccupied single family and duplex structures, coupled with an unusually high number of homeless citizens. This creates the scenario that unoccupied houses can't be considered as "vacant" and the department typically conducts an interior attack while searching for any potential trapped victims. The department has a history of rescuing homeless citizens from unoccupied residential structures or finding them as fire victims.) The 1st alarm response at 2002 hours included 2 battalion chiefs, 3 engine companies, 3 truck companies, and a squad. Engine 16 and Truck 16 were the first companies on scene at 2005 hours and parked in front of the structure. Engine 1 arrived next, followed by Truck 1 and Engine 7 at 2006 hours.

The engine 16 crew saw smoke about three blocks from the house and when they arrived on scene, they reported a working structure fire in a one story brick house. At 2005 hours, Engine 16 radioed "Engine 16 is on scene…we have a working fire on a one story brick…assuming command and accountability, we're pulling two attack lines." They parked in front of the house and prepared to deploy a 1¾-inch hoseline to the front door. (*Note: The front door was boarded with plywood*). The engine 7 crew established water supply from a hydrant at the end of the block and supplied Engine 16 with a 5-inch supply line. Engine 1 parked in front of Engine 16 and after conferring with the acting engine 16 officer, the crew assumed the role of the Rapid Intervention Team (RIT) and started assembling in the front yard. Trucks 1 and 16 parked on scene and the crews got tools and proceeded to the structure to perform forcible entry and ventilation (see Diagram 2). At this point, as fire fighters had assembled in the front of the structure, dark black smoke was exiting from the eves and from around the boarded windows (no flame was seen).

At 2007 hours, Squad 4 and Battalions 2 & 3 arrived on scene north of the structure. Battalion 3 assumed command and established the command post in a driveway across the street, and Battalion 2 assumed the role of the Incident Safety Officer (ISO). The chief officers conferred after arriving on scene. They had not heard any radio traffic from crews operating in the front of the structure. Battalion 3 radioed Engine 16 for an update, but the crew was staging for a fire attack as the plywood covering the front door was being removed by the crew of Truck 16.

Activities of the Victim and Engine 16

The victim was staged on the nozzle with the Engine 16 crew at the front door. The officer and a fire fighter from Truck 16 removed the plywood from the front door and heavy black smoke started rolling out the front door. The victim advanced the hoseline in through the front door and was backed up by another Engine 16 fire fighter followed by the acting officer. The crew advanced through the front door into the common vestibule and turned right through the entrance to the right duplex (*Note: The doors to the right and left duplexes were missing*). The crew encountered moderate heat, dark smoke and little visibility. The acting officer saw a red glow in the rear B/C corner and he wanted to back the charged hoseline out and reposition through the left duplex entrance. The E16 officer motioned the location of the fire to his crew, at the same time they started hearing other fire fighters behind them yelling "Back Out! Back Out!" The crew experienced a flashover-like event. The intense heat and flame forced the crew to the floor; the interior was fully involved and flames burst out the front door. The crew immediately began to back out. The fire

fighter behind the victim recalled grabbing the victim's foot while moving towards the doorway and colliding with other disoriented fire fighters. Once outside he told the E16 acting officer that the victim was "still in there!" Since several fire fighters were now in front of the structure, the acting E16 officer yelled out the victim's name and someone said "Yea!" At that point other fire fighters outside saw the silhouette of a fire fighter running from left to right through the flames in the front entrance. They start yelling that "someone is still in there!" The E16 acting officer yelled for the victim again and there was no answer. Within 30-60 seconds, fire fighters in the front yard began to hear a PASS device sounding.

Activities of Other Companies A-side

Engine 7 was backing up the Engine 16 crew with another 1¾-inch hoseline that was uncharged. The Engine 7 crews were advancing behind Engine 16. The crew was only a few feet inside when the conditions became untenable. They quickly withdrew and assisted the Engine 16 crew in evacuating. At the same time, truck company crews were removing the plywood covering the windows on the A&B-sides (see Photos 3 and 4).

Fire Command

Battalion 3 was assigned incident command and Battalion 2 was assigned ISO. Both chief officers reported that while en route there was "not a lot" of radio transmissions from the fire ground. They set up the command post across the street and their aides began setting up the command and accountability boards. At 2007 hours, Battalion 3 radioed to dispatch, "Battalion 3 on the scene…we'll be assuming command and accountability." Once on scene, Battalion 3 was not sure who was assigned RIT duties. Battalion 3 radioed Engine 16, "company 16 who you got for RIT?" The Engine 16 acting officer responded that he didn't hear, and to repeat the radio traffic (*Note: Engine 16's crew was already staging to enter the structure*). At 2008 hours, Battalion 3 radioed "command to all units on the scene, let's go defensive for a minute, we got too much fire involved, everybody go defensive, stay out, get some lines in a window…" Battalion 2 had just geared up and was preparing to do a 360 degree walk around when the fire rapidly accelerated.

Fire Fighters Regroup after the Flameover

Fire fighters in the front yard initially disoriented from the flameover regrouped and began a defensive fire attack. The hoseline that the victim originally was nozzle man on was withdrawn from the front entrance by an Engine 7 fire fighter who directed water into the front room of the left duplex. He passed off the nozzle to the Truck 16 officer who directed the water stream to the right which was the location that the victim was last seen. The backup hoseline from Engine 16 was also charged and water was directed through the windows on A and B-sides. Within a minute, the fire was knocked down and fire crews immediately began search and rescue for the victim.

Immediately after the flameover, fire command realized that someone was trapped inside and radioed dispatch for an advanced life support ambulance to respond. However, at this point, it was still

unclear to command that a fire fighter was trapped inside. Truck 1 radioed to command, "Command we need a PAR…definitive PAR immediately." At 2011 hours, Battalion 3 responded "received…command to Engine 16…give me a PAR." The acting Engine 16 officer radioed, "Engine 16 go ahead" and Battalion 3 responded "do you have your whole crew with you?" Engine 16 incorrectly responded, "that is affirmative we have my crew." Battalion 2 still operating in the rear of the structure radioed the IC that "…squad making entry on the C-side, someone down we will advise." At 2012 hours, command realized they did not have accountability when someone radioed "We got a fire fighter down!"

Search for the Victim

At 2010 hours, Squad 4 fire fighters made entry through the rear of the structure. Using a thermal imaging camera during their search, they located the victim in the right duplex along the D-side wall. Simultaneously, a crew from Engine 7 entered the front door and performed a right hand search in the direction the victim had last been seen. Together both search and rescue crews found the victim. The victim was unconscious lying in a prone position facing the rear of the structure. The victim was not wearing his helmet, SCBA mask, Nomex® hood, or right boot when found. (*Note: The victim was wearing all protective gear and was on air when entry was made*.) See diagram 1 for the most probable path the victim took in the structure.

Fire Fighter Activities after Rescue

The victim was carried to a rear door and down the steps to the backyard. Fire fighters began life support as the victim was carried to the front yard to the awaiting advanced life support ambulance. The victim was transported to the emergency room of a metropolitan hospital which was a level one trauma center and was later transferred to the hospital's burn center. The victim's head and neck, lower right leg and foot were severely burned. The victim's airways and lungs were also severely burned. The victim remained in critical condition for several days in the burn center before succumbing to his injuries on November 29, 2006.

FIRE BEHAVIOR and SPREAD

The cause and origin of the fire was ruled accidental by the Fire Marshal, caused from an unattended burning candle used for illumination by a homeless citizen illegally occupying the structure. A foam mattress located in the rear room of the left duplex caught fire from the candle flame. The fire then moved laterally up the adjacent wall into the open attic space. The homeless citizen had evacuated prior to the arrival of fire fighters.

Most fire fighters interviewed described dark black smoke with no flame present on arrival. Other fire fighters reported that the smoke was more dark brown and grayish. Some reported that a "little flame" was showing on the B/C corner within the first minute on scene. Heavy black smoke was forcefully pushing out the doors and windows as soon as they were uncovered. The smoke became

extremely turbulent and fire fighters reported a subsequent flashover. The rapid fire progression lasted about 30-45 seconds. Flames were coming from all the windows, rolling out the front doorway, and showing from under the eves and through the roof in the rear (see Photo 3). Fire fighters in the front yard reported fire "head to toe" inside the structure. As soon as two 1¾-inch hoselines started flowing water through the A-side, the fire was knocked down within 60 seconds. The entire fire progression from arrival on scene to the fire being knocked down was approximately 5 minutes.

Significant factors related to the fire's behavior:

- Foam mattress as the initial fuel
- Large open area within the structure (lack of compartmentalization) created by the removal of interior partitions (drywall)
- Exposed dry lumber in framing and rafters as additional fuel
- Dark black turbulent fuel-rich smoke
- Covered doors and windows initially starved the fire of oxygen
- Possibility of ventilation inducing rapid flame progression when doors and windows were uncovered

The fire department hired an engineering consulting firm to conduct a fire model of the fire.[3] The firm used the Fire Dynamics Simulator software developed by the National Institute of Standards and Technology. The model indicated the rapid flame progression was not a flashover but a flameover. A flameover occurs when the upper hot gas layer in a fire ignites. As fuels in the room burn, superheated soot, smoke, gases, and partially burned pyrolysis products rise to the top of the room. If the fire becomes hot enough, these gases will reach their ignition temperature and ignite. This is also called rollover, due to the physical appearance of flames "rolling" across the ceiling as the gas layer ignites.

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:

- Initial size-up not conducted.
- Failure to recognize the signs of an impending flashover/flameover.
- Inadequate communication on the fireground.
- Possibility of ventilation induced rapid fire progression.

CAUSE OF DEATH

According to the medical examiner's findings, the victim died 6 days after the incident due to complications from thermal injuries.

RECOMMENDATIONS

Recommendation #1: Fire departments should ensure that an initial size-up is conducted before beginning interior fire fighting operations.

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 fire, assists in determining the most effective point of fire 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.[4-8] Retired Chief Alan Brunacini recommends that the arriving IC go partially or completely around the structure whenever possible to get a complete view of the structure.[7] 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 including 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.), and available pre-plan information are all key information which can effect whether an offensive or defensive strategy is employed. The size-up and risk assessment should continue throughout the incident.

In this incident, the initial incident commander concentrated on the A-side of the structure. A complete 360 degree size-up was never conducted. Dark black smoke emitting from under the eves and around the plywood window covering and the deteriorating interior conditions were indicators that could have prompted consideration of switching from offensive to defensive strategies.

Recommendation #2: Fire departments should ensure that the first arriving company officer does not become involved in firefighting efforts when assuming the role of incident commander.

Discussion: Fire fighter safety starts with a strong command presence. According to NFPA 1561, §4.1.1, "the Incident Commander shall be responsible for the overall coordination and direction of all activities at an incident."[9] In addition to conducting an initial size-up, Incident Command (IC) should maintain a command post outside of the structure to assign companies and delegate functions, and continually evaluate the risk versus gain of continued fire fighting efforts. According to the International Fire Service Training Association (IFSTA) publication, *Fire Department Company*

Officer, there are three modes of operation for the first-arriving officer assuming command: nothing showing, fast attack, and command.[10]

"**Nothing-showing mode.** When the problem generating the response is not obvious to the first-in unit, the company officer should assume command of the incident and announce that nothing is showing. He should direct the other responding units to stage at Level I, accompany the crew on an investigation of the situation, and maintain command using a portable radio."

"**Fast-attack mode.** When the company officer's direct involvement is necessary for the crew to take immediate action to save a life or stabilize the situation, the officer should take command and announce that the company is in the fast-attack mode."

"Command mode. Because of the nature of some incidents, immediate and strong overall command is needed. In these incidents, the first-in officer should assume command by naming the incident and designating the command post, give an initial report on conditions, and request the additional resources needed."

In this incident, smoke coming from the roof and inside the building required the "Command mode" of operation. The first arriving officer initiated the "Command mode" by declaring command of the incident over the radio and reporting smoke coming from the roof and inside the building. However, command was never established and the first arriving officer was actually operating in the "Fast-attack mode."

To effectively coordinate and direct fire fighting operations on the scene, it is essential that the IC does not become involved in fire fighting efforts. A delay in establishing an effective command post may result in confusion of assignments, lack of personnel and apparatus coordination which may contribute to rapid fire progression. The involvement of the initial IC in fire fighting also hampers the communication of essential information as command is transferred to later arriving officers.

Recommendation #3: Fire departments should ensure that a Rapid Intervention Team (RIT) is established and in position with a backup hoseline prior to initiating an interior attack.

Discussion: A rapid intervention team (RIT) should respond to every major fire.[11] The team should report directly to the IC and should remain at an area designated by the IC until an intervention is required to rescue a fire fighter. The RIT should have all the tools necessary to complete the task in case a fire fighter needs assistance. These teams can intervene quickly to rescue fire fighters who become disoriented, lost in smoke-filled environments, trapped by fire, involved in structural collapse, or run out of breathing air. A RIT should be established, in position with a backup hoseline and ready for deployment during the initial stages of an incident and before interior fire fighting operations begin. In this incident, the RIT was still staging on the A-side as the flameover occurred.

Recommendation #4: Fire departments should ensure that ventilation is closely coordinated with interior fire suppression operations.

Ventilation decisions should be part of the initial size-up and are necessary to improve the fire environment in order for fire fighters to approach a fire with a hoseline for extinguishment or to allow a quick search for any victims. Ventilation is performed to relieve the products of combustion, allowing fire fighters to advance on the fire. The ventilation needs to be coordinated as fire fighters progress through a structure fire. When venting, the principle is to pull the fire, heat, smoke, and toxic gases away from victims, stairs, and other egress routes.[11] Coordinating ventilation with interior operations ensures that ventilation does not pose risks for fire fighters operating in the interior. By eliminating smoke, heat, and gases from the fire it will help minimize flashover conditions.[4] In this incident, ventilation was not coordinated with interior operations and the removal of the plywood covering the doors and windows may have contributed to the flameover.

Recommendation #5: Fire departments should ensure that crew integrity and accountability are 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 team members knowing who is on their team and who is the team leader; team members staying within visual contact at all times (if visibility is low, teams must stay within touch or voice distance of each other); team members communicating needs and observations to the team leader, and team members rotating together to rehabilitation, staging as a team, and watching out for each other (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 also leave together to ensure that team continuity is maintained.[5] In this incident, the crew entered as a team but with the rapid flame progression, the crew became separated from the victim as they backed out. After exiting the structure, the accounting of team members was done verbally rather than visually, which contributed to confusion about the missing team member.

Recommendation #6: Fire departments should ensure that all fire fighters are equipped with a radio and trained on how to initiate emergency traffic.

Discussion: All fire fighters on the fireground should be equipped with a radio. The radio is an essential tool for the fire fighter to communicate with incident command (IC) and team members. Fire fighters must receive training on the proper operation of portable radios in regards to their operation and the department's standard operating procedures on the fireground, from reporting interior size-up conditions to the IC, as well as, transmitting a distress signal. Radio discipline includes using standard protocol and terminology; using clear, concise text; talking slowly; and listening.[9, 12]

It is vital that each fire fighter be equipped with a radio to inform command of interior conditions and special hazards, and in case of an emergency.[12] Fire fighters must act promptly when they become

lost, disoriented, injured, low on air, or trapped. They must transmit a distress signal for themselves or a partner while they still have the capability. A Mayday should be called using appropriate terminology, i.e. a "Mayday" for a life-threatening situation such as a missing member or an "Urgent" for a potentially serious problem that is not life-threatening.[13, 14] 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. Emergency traffic receives the highest communication priority from the IC, Dispatch, and all fireground personnel. All other radio traffic should stop when this emergency traffic is initiated to clear the channel and allow the message to be heard. The quicker the IC is notified and a RIT team is activated, the greater the chances are of a fire fighter being rescued and surviving. Once a distress signal is transmitted (or not) the distressed fire fighter can and should activate his PASS device and the emergency button on his radio to increase the chances of being located. In this incident, only the victim's acting officer had a radio among the Engine 16 crew. MayDay messages were not radioed to command by fire fighters that saw the victim inside the structure immediately after the flameover.

Recommendation #7: Fire departments should train fire fighters to recognize the conditions that forewarn of a flashover/flameover and communicate fire conditions to the incident commander as soon as possible.

Interior size-up is just as important as exterior size-up.[4] 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 heavy smoke is emitting from the exterior roof system, but fire fighters cannot find any fire in the interior, it is a good possibility that the fire is above them in the roof system. Other warning signs that should be relayed to the IC include dense black smoke, turbulent smoke, smoke puffing around doorframes, discolored glass, and a reverse flow of smoke back inside 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 the initial attack crews observed that the structure was full of thick black smoke when entry was made. This should have been a warning sign of a pending flashover/flameover. Training on fire behavior and smoke reading should be provided to all fire fighters on a regular basis or as needed to ensure that effective recognition skills are maintained.

Recommendation #8: Fire departments should train fire fighters on actions to take 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.[4, 15-18] Disoriented fire fighters must transmit a distress signal while they still have the capability and sufficient air, noting their location if possible. 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, be focused on their situation and avoid unnecessary physical activity. They should survey their surroundings to get their bearings and determine potential escape routes such as windows, doors,

hallways, changes in flooring surfaces, etc.; 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.

In this incident, the victim had gone from a prone position to standing, let go of the nozzle, and was seen running during the flameover. He had at some point removed his helmet, mask and hood during his disorientation. In an emergency situation, fire fighters need to rely on their training so that they take the correct personal safety actions when encountering a flameover. Repetitive skills training can instill knowledge necessary to provide a more self-controlled, composed response to a potentially life-threatening situation.

Recommendation #9: Fire departments should ensure that fire fighters serving as acting officers are adequately trained.

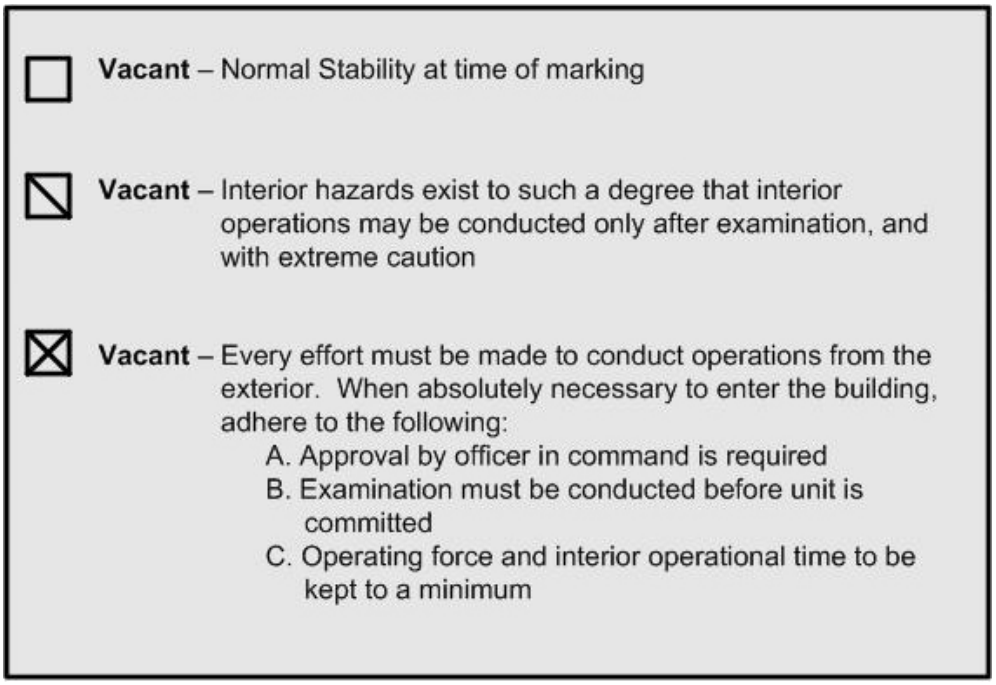
Discussion: The engine company officer that was supervising the victim was not a full time officer but instead an acting officer. Many departments utilize acting officers as staffing needs arise, but a basic responsibility the department must accept is to adequately prepare these acting officers and provide effective company officer training in subjects such as size-up, accountability, communications, hazard recognition, and many other supervisory issues. Using fire fighters as acting company officers is something that many departments must do, but effective and competent training for those members should be required by the department.[19]

Recommendation #10: 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 unoccupied, vacant or abandoned structures to improve fire fighter safety.

Discussion: Information regarding the status of a structure would be invaluable to fire fighters should an incident occur. 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.

Fire departments should consider an exterior marking system on abandoned and vacant structures to inform fire fighters of the structure's status and identify potential hazards.[20, 21] For example, a 12-inch-square warning placard made of a reflective material that glows in the dark and indicates to fire

fighters the occupancy status and any hazards that exist inside the building. Following is an example of three vacant warning placards developed and used by the Fire Department of New York City.[22]



Other jurisdictions may utilize different systems but the objective should be to warn firefighters and other emergency responders that the building poses hazards that are significantly greater than buildings that are maintained and in good repair. A building may be marked either using signs (see Photo 5) or it may be marked by paint on the outside walls of the building. Markings should be readily visible from normal access points of the building.

Municipalities should also consider securely sealing vacant buildings so that they cannot be entered by homeless or other trespassers. Many vacant building fires are started by occupants who should not be in the building. If these buildings were securely sealed, there would be fewer fires in vacant buildings which would reduce the chances of fire fighters becoming involved in the numerous deadly conditions that exist in these structures.[23]

In this incident, the structure had been abandoned for several years and was inhabited by a homeless citizen who started the fire. The interior of the structure had been stripped of all interior furnishings leaving only the framing allowing smoke and products of incomplete combustion to fill the entire structure.

REFERENCES

1. Fire Department [2007]. Standard operating procedures.

2. Weather Underground [2006]. Weather history for incident location in GA, November 23, 2006. [http://www.wunderground.com/history/airport/KPDK/2006/11/23/DailyHistory.html?req_city=NA&req_state=NA&req_statename=NA]. Date accessed September 2009.

3. Fire Department [2008]. An independent review of the incident.

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

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

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

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

8. Dunn, V. [2007]. Strategy of Firefighting. Saddlebrook, NJ: Penn Well Publishing Co. p- 162.

9. NFPA [2007]. NFPA 1561: standard on fire department incident management system. Quincy, MA: National Fire Protection Association.

10. IFSTA [1998]. Fire department company officer, 3rd ed. Stillwater, OK: Oklahoma State University, Fire Protection Publications.

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

12. NFPA [2007]. NFPA 1500: Standard on fire department occupational safety and health program. Quincy, MA: National Fire Protection Association.

13. Clark BA [2004]. Calling a mayday: the drill. [http://cms.firehouse.com/web/online/Firefighter-Safety/Calling-A-MAYDAY--The-Drill/10$32431]. Date accessed: September 2009.

14. DiBernardo JP [2003]. A missing firefighter: Give the mayday. Firehouse, November issue.

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

16. Angulo RA, Clark BA, Auch S [2004]. You called Mayday! Now what? Fire Engineering, Sept 2004, Vol. 157, No. 9, pp. 93-95.

17. Sendelbach TE [2004]. Managing the fireground Mayday: The critical link to firefighter survival. [http://cms.firehouse.com/content/article/article.jsp?sectionId=10&id=10287]. Date accessed: September 2009.

18. Miles J, Tobin J [2004]. Training notebook: Mayday and urgent messages. Fire Engineering, April 2004, Vol. 157, No. 4, pp. 22.

19. NFPA [2009]. NFPA 1021 Standard for fire officer professional qualifications. 2009 ed. Quincy, MA: National Fire Protection Association.

20. Dunn V [2000]. Vacant building fires. Firehouse Magazine. May 2000, pp. 20-26.

21. Terpak MA [2002]. Fireground size-up. Chapter 10 vacant buildings. Tulsa, OK: Fire Engineering Books.

22. IAAI/USFA/FEMA [2006]. Managing vacant and abandoned properties in your community. Appendix G – building marking. Crofton, MD: International Association of Arson Investigators and Emmitsburg, MD: U.S. Fire Administration. [http://www.interfire.org/features/pdfs/Background%20Paper_2006.pdf]. Date accessed: September 2009.

23. USFA/FEMA [2003]. National Arson Prevention Initiative: board up procedures. Emmitsburg, MD: U.S. Fire Administration. [http://www.interfire.org/pdf/USFA%20Board%20Up.pdf]. Date accessed: September 2009.

INVESTIGATOR INFORMATION

This investigation was conducted by CDR Steve Berardinelli and Jay Tarley, Safety and Occupational Health Specialists and Matt Bowyer, a General Engineer with the Fire Fighter Fatality Investigation and Prevention Program, Fatality Investigations Team, Surveillance and Field Investigations Branch, Division of Safety Research, NIOSH located in Morgantown, WV. An expert technical review was provided by Battalion Chief John J. Salka, Jr., Fire Department of New York and www.FireCommandTraining.com.

Photo 1. Front (A-side) of incident structure.
(Placard placed after the fire above the front entrance says "Warning! By order of the Fire Marshall this structure is dangerous and unsafe".)
(NIOSH photo.)

Photo 2. Rear (C-side) of incident structure.
(NIOSH photo.)

Photo 3. Fire conditions during the incident.
(Photo has incorrect date stamp.)
(Photo courtesy of the fire department.)

Photo 4. Fire fighter activities at front entrance during the incident.
(Photo has incorrect date stamp.)
(Photo courtesy of the fire department.)

Photo 5. Warning placard for exterior operations preferable – enter only for a known life hazard. (The sign is 2ft x 2ft and is printed on corrugated plastic sign stock.)
(Photo courtesy of the IAAI/USFA.)

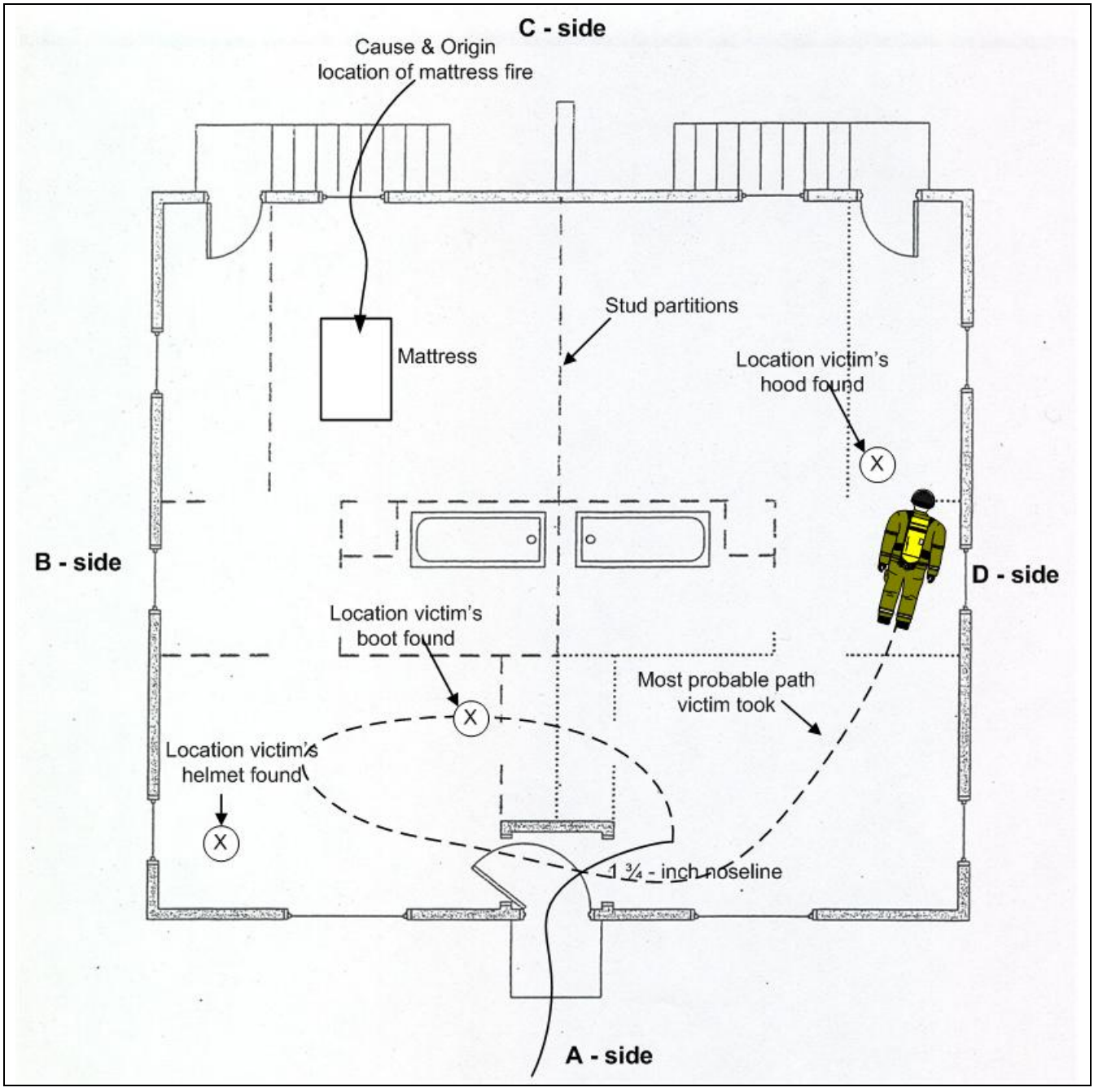


Diagram 1. Layout of the duplex.
(Diagram courtesy of the fire department and annotated by NIOSH.)

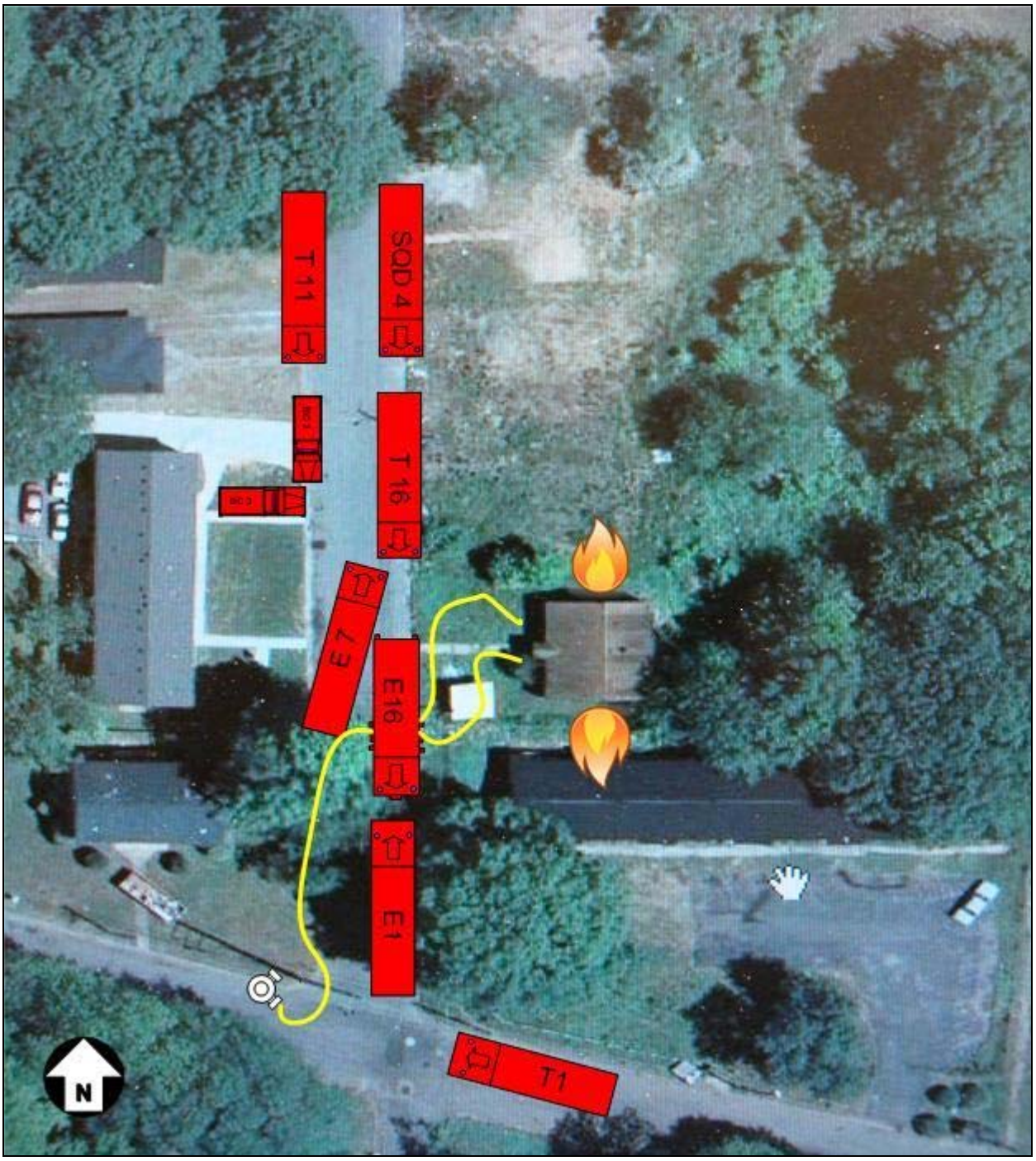


Diagram 2. Aerial view of incident scene.
(Photo courtesy of Google maps and annotated by NIOSH.)

APPENDIX

Status Investigation Report of One Self-Contained Breathing Apparatus NIOSH Task Number 14887

Background

As part of the ***National Institute for Occupational Safety and Health (NIOSH) Fire Fighter Fatality Investigation and Prevention Program***, the Technology Evaluation Branch agreed to examine and evaluate one Scott AIR-PAK NxG2 4500 psi, 30-minute, self-contained breathing apparatus (SCBA).

This SCBA status investigation was assigned NIOSH Task Number 14887. The SCBA, sealed in a corrugated cardboard box, was delivered to the NIOSH facility in Bruceton, Pennsylvania on December 5, 2006. Upon arrival, the sealed package was taken to the Firefighter SCBA Evaluation Lab (building 108) and stored under lock until the time of the evaluation.

SCBA Inspection

The package was opened and the contents inventoried on January 10, 2007, and the box then resealed. The package was re-opened and a complete visual inspection conducted on September 18, 2007. In addition to the SCBA, the box also contained a sealed metal can. The SCBA was examined, component by component, in the condition as received to determine its conformance to the NIOSH-approved configuration. The visual inspection process was videotaped. The SCBA was identified as the Scott Air-Pak model NxG2 4500 psi, 30-minute unit.

The SCBA was overall in poor condition. Much of the unit has suffered serious heat damage. Although the pneumatics appear to remain sealed against the outside atmosphere, the plastic regulator housing is greatly distorted.

Personal Alert Safety System (PASS) Device

A Personal Alert Safety System (PASS) device was attached to the SCBA. During the inspection, the PASS device did not activate or operate. It was not tested against the specific requirements of NFPA 1982, *Standard on Personal Alert Safety Systems (PASS)*, 1998 Edition. Because NIOSH does not certify PASS devices, no further testing or evaluations were conducted on the PASS unit.

SCBA Testing

The purpose of the testing was to determine the SCBA's conformance to the approval performance requirements of Title 42, *Code of Federal Regulations*, Part 84 (42 CFR 84). Further testing was conducted to provide an indication of the SCBA's conformance to the National Fire Protection Association (NFPA) Air Flow Performance requirements of NFPA 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus for the Fire Service*, 2002 Edition.

The following performance tests were conducted on the SCBA:

NIOSH SCBA Certification Tests (in accordance with the performance requirements of 42 CFR 84):

1. Positive Pressure Test [§ 84.70(a)(2)(ii)]
2. Rated Service Time Test (duration) [§ 84.95]
3. Static Pressure Test [§ 84.91(d)]
4. Gas Flow Test [§ 84.93]
5. Exhalation Resistance Test [§ 84.91(c)]
6. Remaining Service Life Indicator Test (low-air alarm) [§ 84.83(f)]

National Fire Protection Association (NFPA) Tests (in accordance with NFPA 1981, 2002 Edition):

7. Air Flow Performance Test [Section 7.1.1]

Testing was conducted on September 20 and 25, 2007. All testing was videotaped with the exception of the Exhalation Resistance Test and Static Pressure Test. The SCBA met the requirements of the Exhalation Resistance Test, the Remaining Service Life Indicator Test, and met the Gas Flow Test requirement at 500 psig supply pressure. The unit failed all other test requirements. It was noted during testing that the regulator free-flowed air, likely due to distortion of the regulator housing cover. In addition, the heads-up display (HUD) did not function at all during testing.

Summary and Conclusions

An SCBA was submitted to NIOSH for evaluation on December 5, 2006 and inspected on September 18, 2007. The unit was identified as a Scott AIR-PAK model NxG2 30-minute, 4500 psi, SCBA (NIOSH approval number TC-13F-517). The SCBA was determined to be in a condition safe for testing.

The unit was subjected to a series of seven performance tests. Testing was conducted on September 20 and 25, 2007. The SCBA failed to meet the requirements of the Positive Pressure Test, Rated Service Time Test, Static Pressure Test, Gas Flow Test (at full cylinder pressure), and the NFPA Air

Flow Performance Test. These results are consistent with those expected for an SCBA with a damaged second-stage regulator that is in a free-flowing state. No maintenance or repair work was performed on the unit at any time.

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

Due to the extent of damage to the unit, it is unlikely that it can be returned to service.