



Death in the line of duty...

NIOSH
Fire Fighter Fatality Investigation
and Prevention Program

A summary of a NIOSH fire fighter fatality investigation

April 25, 2013

Career Fire Fighter Dies during Fire-Fighting Operations at a Multi-family Residential Structure Fire - Massachusetts

Executive Summary

On December 23, 2011, a 42-year-old male career fire fighter died during fire-fighting operations on the 2nd floor of a three-story apartment building. The victim was assigned to Engine 5 (E5) with a lieutenant and driver/pump operator. E5 was the first-due engine company at this fire. The Incident Commander ordered E5 to take a 1 3/4" hoseline and attack the fire in a 2nd floor apartment. The lieutenant stretched the line to the landing of the 2nd floor but did not realize there were two apartments on the 2nd floor. Due to heavy smoke conditions, he went to Apartment 4 instead of the fire apartment (Apartment 3).

Apartment 4 was locked, so he went to get the ladder company, which was operating on the 3rd floor. At this time, the lieutenant lost contact with the victim. The Incident

Commander (Car 2) went to the 2nd floor landing, contacted the lieutenant from E5, advised him the fire was in Apartment 3, and the door was open. The lieutenant then entered the fire apartment, attempted to knock down the fire, and the apartment flashed. The lieutenant, with his helmet on fire, was pulled out of the apartment by members of Engine 3 and Ladder 1. At this time, the location of the victim was unknown. The lieutenant returned to the fire apartment with a thermal imaging camera (TIC) but the image was featureless due to the amount of heat and fire in the apartment. Several fire fighters stated they heard a personal alert safety system (PASS) alarm sounding but were unable to determine the location. The officer of the fourth-due engine company (Engine 7) entered the fire apartment, located the victim, and removed the victim with the help of two other fire fighters. Despite receiving cardiopulmonary resuscitation (CPR) and advanced life support (ALS) outside the structure, in the ambulance, and in the local hospital's emergency department (ED), the victim died. The death certificate and the autopsy listed the immediate cause of death as "probable cardiac dysrhythmia while



View of the fire building from Side "C" during the initial stages of the fire as Engine 5 was entering from Side "A".

(Photo courtesy of fire department)

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fighting fire” with a contributory cause of “hypertensive cardiovascular disease.” NIOSH investigators agreed and concluded that the physical stress of interior structural fire-fighting probably triggered a cardiac arrhythmia leading to his subsequent cardiac death.

Contributing Factors

- *Crew integrity*
- *Delay of initiating fire attack*
- *Inadequate fire stream application (penciling)*
- *Inadequate fireground communications*
- *Lack of a personnel accountability system*
- *Failure to initiate a “Mayday”*
- *Lack of annual medical evaluation.*

Key Recommendations

- *Ensure that crew integrity is properly maintained by voice contact or radio contact when operating in an immediately dangerous to life and health (IDLH) atmosphere*
- *Ensure the Incident Commander communicates the strategy and Incident Action Plan to all members assigned to an incident*
- *Ensure that engine companies initiate a fire attack based upon scene size-up and the Incident Commander’s defined strategy and tactics.*

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

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



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Introduction

On December 23, 2011, a 42-year-old male career fire fighter died during fire-fighting operations on the 2nd floor of a three-story apartment building. On December 27, 2011, the U.S. Fire Administration (USFA) notified the National Institute for Occupational Safety and Health (NIOSH) of this incident. On January 22 – 27, 2012, an investigator and an occupational health and safety specialist from the NIOSH Fire Fighter Fatality Investigation and Prevention Program traveled to Massachusetts to investigate this incident.

The NIOSH investigators met with representatives of the victim's fire department, the local IAFF union, law enforcement, and local, state, and federal investigators. During the investigation, witness statements were reviewed and interviews were conducted with the fire fighters and fire officers involved in the incident, and the victim's widow. NIOSH investigators also reviewed the fire department's standard operating procedures (SOPs), department and state training requirements, and the training records of the victim and the Incident Commander (IC). The victim's turnout gear was inspected and photographed; the incident scene was visited and photographed; and incident scene photographs, videos, fire ground dispatch tapes, and area maps were reviewed.

Fire Department

This career department consists of the fire chief, 4 deputy chiefs, 10 captains, 8 lieutenants, 75 fire fighters, 1 training officer/Incident Safety Officer (captain), 1 fire prevention officer, 2 fire inspectors, 2 fire alarm staff, and 3 administrative personnel. The department operates out of five fire stations staffing four engine companies and one truck company. The department protects an area of 17 square miles with a population of 50,000.

The administrative staff consists of a fire chief and the four deputy chiefs, one assigned to each shift. All members assigned to the Operations Division work a 24-hour duty shift with 72 hours off (42-hour work week). Each shift is assigned 23 personnel with a minimum staffing of 17 personnel on duty per shift. One member of each shift is assigned to the Fire Alarm Office. This position is rotated among the fire fighters assigned to Fire Headquarters. Members assigned to the Services Division work with the Fire Marshal's Office and the Fire Alarm Office. The department is responsible for the maintenance of fire alarm boxes located throughout the city. The police department receives all 911 calls. If the call is for the fire department, the police dispatcher transfers the call to the fire department's Fire Alarm Office. In 2011, the fire department responded to 7,606 alarms and in 2010, the fire department responded to 7872 alarms.

Emergency medical services response and transport in the city is through a contractual agreement with a private ambulance company. The fire department has personnel trained as first responders and as Emergency Medical Technician/Basic. In addition to fire-fighting operations, the department provides

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vehicle extrication. Hazardous materials mitigation is provided in conjunction with state regional hazardous materials teams, and technical rescue in conjunction with the county technical rescue team.

Training and Experience

The Commonwealth of Massachusetts has no mandatory minimum requirements to become a fire fighter. For cities and towns that have adopted the Commonwealth of Massachusetts civil service system, a candidate must pass the state civil service written examination and successfully complete the Candidate Physical Ability Test (CPAT). Once a candidate is hired by this fire department, the candidate may be required to attend a 12-week recruit school at the Massachusetts Firefighting Academy. The decision to send a candidate to the Massachusetts Firefighting Academy for training and certification is the sole responsibility of the local fire department. Also, the candidate must pass a medical examination prior to entry into the Academy program. ^{1,2} Upon completion of the recruit school, the recruit fire fighter will be certified per NFPA 1001, *Standard for Fire Fighter Professional Qualifications*, to the level of Fire Fighter I and Fire Fighter II and per NFPA 472, *Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents*, to the level of Hazardous Materials: Operational Level Responder.

The recruit fire fighter is then assigned as a probationary fire fighter, completing the remainder of the 12-month probationary period assigned to the Operations Division. During this time, the probationary fire fighter must complete National Incident Management System (NIMS) training which includes: ICS 100, *Introduction to ICS*; ICS 200, *Basic ICS*; IS-700.A, *National Incident Management System*; and IS-800.B, *National Response Framework*. After completion of the probationary period, the member becomes a fire fighter per the state civil service requirements. Though the department does not require a member to be an Emergency Medical Technician/Basic (EMT/B), the member can obtain this certification through a local private ambulance company. The department will provide funding for re-certification.

The fire department requires 8 hours of training per month. Additionally, the department provides training in vehicle extrication, “Mayday” procedures, and fireground survival training. The Massachusetts Department of Fire Services operates the Hazardous Materials Response Division. The county in which the fire department resides operates technical rescue response. Special operations training courses are conducted by the Massachusetts Firefighting Academy.

The rank structure for the fire department is lieutenant, captain, and deputy chief. In order to compete for the position of lieutenant, a firefighter must serve in grade at least 3 years. The state civil service commission administers the examination for each position. A candidate for each position must successfully pass a written examination for the position.

All officers in the department must complete ICS 300, *Intermediate ICS*. Though not mandated, the department will provide funding for each officer to complete NFPA 1021, *Standard for Fire Officer Professional Qualifications*, Fire Officer I certification through the Massachusetts Fire Training Council.

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The victim was hired by the fire department in 2001. He successfully completed recruit school at the Massachusetts Firefighting Academy graduating on June 15, 2001 as part of Class 144. Also, the victim had completed courses in driving simulation, driver awareness, emergency vehicle operator, illicit drug labs, hazardous materials training, hazardous materials operations, fire fighter decontamination, and vehicle extrication. Additionally, the victim completed his monthly training requirements. The victim was placed on extended medical leave for approximately 18 months from November 2008 to March 2010. (See the **“Resuscitation Efforts and Medical Findings”** section of this report.) Upon his return to work, the victim went through re-training on personal protective equipment (PPE) and SCBA, engine company operations, ladder company operations, ground ladders, driver/operator duties and responsibilities, fire alarm/watch desk operations, and house duties.

The Incident Commander had 22 years of fire service experience with the fire department. He had served as a deputy chief for the past 18 months plus six months in an acting capacity at this position. Prior to joining the fire department, the deputy chief served in the United States Air Force as a fire fighter for three years. The deputy chief had completed the following training: NFPA 1001, *Professional Qualifications for Fire Fighter*, Fire Fighter I; ICS 200, *Basic ICS*; IS 700, *National Incident Management System*; bomb threat procedures; driver awareness; emergency vehicle operator; driver simulator; emergency vehicle operator; advanced; hazardous materials operations and refresher training; protective breathing search and rescue; basic rope rescue; basic confined space rescue; and vehicle extrication. The deputy chief had maintained his department monthly training requirements.

Equipment and Personnel

The following units responded to the incident on the first alarm, were special called, or responded on the second alarm.

Resource Designation	Staffing	Time Dispatched	Time On-Scene	Alarm
Engine 5	1 Lieutenant 1 Driver/Operator 1 Fire Fighter (Victim)	1325 Hours	1329 Hours	1 st Alarm
Engine 4	1 Acting Officer 1 Driver/Operator 1 Fire Fighter	1325 Hours	1329 Hours	1 st Alarm
Ladder 1	1 Lieutenant 1 Driver/Operator 1 Fire Fighter	1325 Hours	1329 Hours	1 st Alarm
Car 2	Deputy Chief	1325 Hours	1328 Hours	1 st Alarm
Engine 3	1 Driver/Operator 1 Fire Fighter	1327 Hours	1333 Hours	“Working Fire” Dispatch

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Engine 7	1 Captain 1 Driver/Operator 2 Fire Fighters	1332 Hours	1336 Hours	"Special Called"
Ambulance 23	2 Medics	1327 Hours	1351 Hours	"Working Fire" Dispatch
Mutual Aid Engine 2	1 Officer 1 Driver/Operator 1 Fire Fighter	1342 Hours	1354 Hours	"Special Called" RIC Team
Car 1	Chief of the Department	1350 Hours	1358 Hours	"Special Called"
Mutual Aid Engine 7	1 Officer 1 Driver/Operator 2 Fire Fighters	1350 Hours	1355 Hours	Second Alarm
Mutual Aid Engine 1	1 Officer 1 Driver/Operator 1 Fire Fighter	1350 Hours	1359 Hours	Second Alarm

Timeline

This timeline is provided to set out, to the extent possible, the sequence of events according to recorded radio transmissions. Times are approximate and were obtained from review of the dispatch records, witness interviews, and other available information. Times have been rounded to the nearest minute. NIOSH investigators have attempted to include all radio transmissions. This timeline is not intended, nor should it be used, as a formal record of events.

Incident and Fireground Conditions	Time	Response & Fireground Operations
December 23, 2012		
Fire is reported to "911" Center; "911" call transferred to fire department Fire Alarm Office (FAO);	1324 Hours	
Fire Alarm Office dispatched companies for a report of possible building fire;	1325 Hours	Car 2, Engine 5, Engine 4, and Ladder 1 dispatched;
Fire Alarm Office provided hydrant locations to 1 st Alarm companies;	1326 Hours	
Engine 3 "Special Called";	1327 Hours	Car 2 reported "smoke showing"; Car 2 requested an additional engine company;

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Incident and Fireground Conditions	Time	Response & Fireground Operations
Black smoke showing from apartments on the 2 nd floor;	1328 Hours	Car 2 on scene; Car 2 confirmed “working fire”;
	1329 Hours	Engine 5, Engine 4, and Ladder 1 on scene;
	1330 Hours	Car 2 advised Engine 4 to supply Engine 5;
	1330 Hours	Car 2 advised Engine 5 to get a hoseline to the 2 nd floor; Ladder 1 ordered to search the 3 rd floor;
Engine 7 “Special Called”;	1331 Hours	Engine 5 stretched a 1¾ hoseline to the 2 nd floor; Ladder 1 went to the 3 rd floor to search; The lieutenant from E5 went to the 3 rd floor to find the crew from L1; The lieutenant from E5 loses contact with the victim.
	1332 Hours	“Command requested another engine company respond to the scene;
	1332 Hours	The officer from Ladder 1 asks “Command” for assistance with ventilation; “Command” goes to Side “C” and ventilates the window and door of the fire apartment;
The master bedroom in Apartment 3 flashed and the fire extended to the entire apartment;	1334 Hours	“Command” asks Ladder 1 for a progress report and conditions on the 3 rd floor; The driver of Ladder 1 operated a hoseline from Side “C” due to the delay of E5 getting water on the fire;
	1335 Hours	“Command” continued trying to contact the officer on Ladder 1; “Command” goes to the 2 nd floor landing to find E5;
	1336 Hours	Engine 7 arrived on scene;
	1337 Hours	Someone on the fireground radioed for the victim to come out of the building; No response or reply from the victim;

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Incident and Fireground Conditions	Time	Response & Fireground Operations
“Command” requested a mutual aid company respond as the Rapid Intervention Crew (RIC); Heavy heat conditions on the 3rd floor;	1338 Hours	Ladder 1 lieutenant radioed the driver/operator of L1 to have two SCBA cylinders ready; E7 ordered to take 2 ½” hoseline inside and “knock down the fire”;
	1339 Hours	The L1 lieutenant and fire fighter, E5 lieutenant, and fire fighter from E3 are outside the building;
	1341 Hours	
Fire Alarm Office copied the message; “Command” to Fire Alarm Office – “strike a 2nd Alarm”; 3 additional engine companies (mutual aid) dispatched to respond to the incident;	1342 Hours	Mutual Aid Engine 2 dispatched as RIC;
	1344 Hours	Ladder 1 back on the 3 rd floor; Ladder 1 lieutenant advised “Command” of heavy heat conditions on the 3 rd floor;
	1344 Hours	Ladder 1 advised that they need a hoseline to the 3 rd floor;
“Command” requested the EMS unit to the front door of the structure; “Command” requested additional ambulances;	1344 Hours	“Command” to all hands, “we believe that we have a trapped fire fighter on the 2 nd floor”; Engine 7 crew removed the victim from the fire building;
	1345 Hours	
	1346 Hours	“Command” to all hands, “evacuate the building”; Fire Alarm Office sounded evacuation tones;
	1347 Hours	

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Incident and Fireground Conditions	Time	Response & Fireground Operations
“Command” requested an additional 3 engine companies and 1 ladder company;	1348 Hours	“Command” again ordered everyone out of the building via radio communications;
	1349 Hours	
	1350 Hours	Car 1 enroute to the incident; Mutual Aid Engine 7 and Mutual Aid Engine 1 dispatched; (Mutual Aid Engine 2 dispatched at 1342 hours);
	1354 Hours	Mutual Aid Engine 2 on scene;
	1355 Hours	Mutual Aid Engine 7 on scene; “Command” initiates an interior attack of the fire apartment with department companies and mutual aid companies;
	1356 Hours	Ambulance 23 with victim and crew of Engine 5 enroute to the hospital;
“Command” placed fire under control;	1359 Hours	Mutual Aid Engine 1 on scene;
	1436 Hours	
December 24, 2011		
“Command” terminated;	0110 Hours	Last unit cleared the incident scene;

Personal Protective Equipment

At the time of the incident, the victim was wearing turnout pants, turnout coat, hood, helmet, boots and a self-contained breathing apparatus (SCBA) with integrated personal alert safety system (PASS) meeting current NFPA requirements. When the victim was rescued, he was not wearing his SCBA facepiece. The NIOSH investigators inspected the victim’s personal protective equipment at the police station in the city. The SCBA and personal protective equipment suffered heat damage as the result of the room flashing over and were shipped to the NIOSH National Personal Protection Technology Laboratory (NPPTL) in Pittsburgh, Pennsylvania for evaluation.

On March 8, 2012, NPPTL personnel in Pittsburgh evaluated the SCBA and the summary evaluation report is included as *Appendix One* of this report. On March 9, 2012, the NPPTL personnel evaluated the personal protective equipment (PPE) at the NIOSH testing laboratory in Morgantown, West Virginia. The summary evaluation report will be included when completed and included as *Appendix Two* of this report.

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Weather Conditions

At approximately 1255 hours, the weather was reported in the immediate area to be 38 degrees Fahrenheit (F), with a wind chill of 31 degrees F, a dew point of 36 degrees F, and the relative humidity at 93%. Wind conditions were up to 7 miles an hour from the northwest with no wind gusts. The sky was overcast and there had been no precipitation in the past 5 hours. ³

Structure

The structure was originally built in 1830 as a three-story single-family dwelling which was later converted to a two-family dwelling. In 1971, the building occupancy was designated for four families by the city's Building Official's Office. In 1988, city council granted a variance to allow the basement to be used as a living area (seven-family occupancy – basement plus two apartments per floor). After a five-month period in 1988, the variance for the basement was rescinded and the occupancy was converted to a six-family occupancy. The building was wood frame, vinyl-sided, with a full basement, and a stone foundation (**See Photo 1**). Two apartments were on each floor (**See Diagram 1**).

Each apartment had its own gas heating unit. There were six separate gas water heaters in the "A/D" corner of the basement. An overhead service drop located at the "A/D" corner of the building provided the electricity with the meters located in the basement in the same area as the hot water heaters. Each apartment had an electrical sub-panel as over current protection. The primary entrance to the building faced the street in the center of the structure. The stairwell to all three floors was along the center of the front wall. The doorways to the individual apartments were located near the front wall. A metal exterior fire escape was located at the rear of the structure (Side "C"). Facing the front of the structure from the street (Side "A"), the apartments were identified with odd numbered apartments on the right side of the building (Side "D") and the even numbered apartments on the left side (Side "B"). The 1st floor had Apartment 1 and Apartment 2. The 2nd floor had Apartment 3 (fire apartment) and Apartment 4. The 3rd floor had Apartment 5 and Apartment 6.

The fire alarm panel was located on the 1st floor outside of Apartment 2. A fire department "Knox Box" was located outside the front door on the exterior of the structure.

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**Photo 1. The apartment building viewed from the “A/D” corner.
The window above the doorway is the hallway landing on the 2nd floor.**

(Photo courtesy of the fire department)

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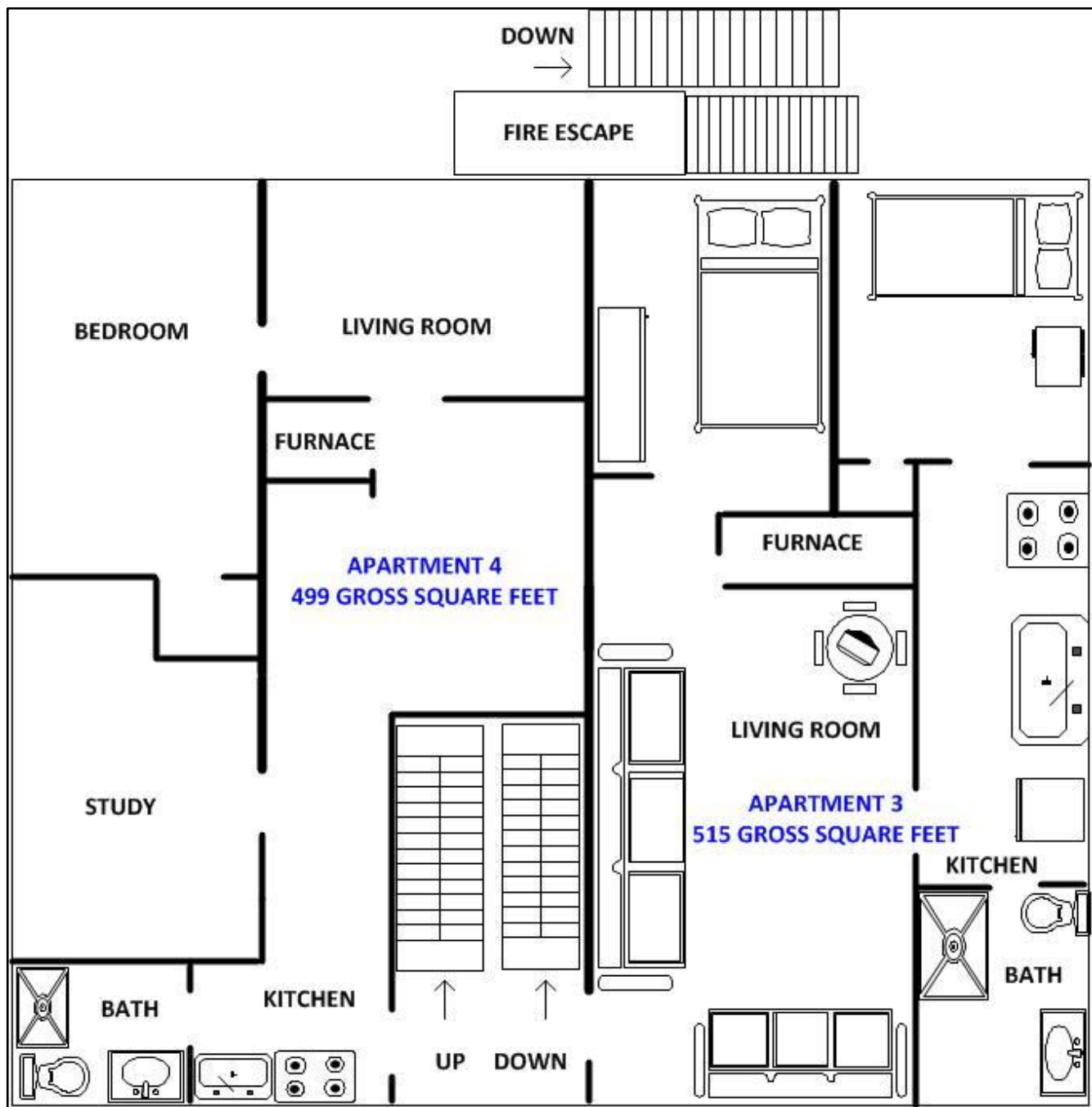


Diagram 1. The floorplan of the 2nd floor of the fire building. The fire occurred in Apartment 3. The floorplan of the 1st floor and 2nd floor of the building are identical.

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Investigation

On Friday, December 23, 2011 at 1324 hours, the fire department Fire Alarm Office received a ‘911’ transfer call from the police department reporting a possible fire in an apartment. At 1325 hours, the fire department Fire Alarm Office dispatched Engine 5, Engine 4, Ladder 1, and Car 2. At 1327 hours, Car 2 (duty deputy chief) reported smoke was showing from the apartment building. At 1328 hours, Car 2 (C2) advised the Fire Alarm Office that this would be a working fire. Car 2 arrived on scene and parked his vehicle off the street and out of the way of responding apparatus. Car 2 assumed “Command” of the incident. As Car 2 got out of his vehicle, he saw a female civilian being treated across the street from the fire building. *Note: This was the occupant of Apartment 3 where the fire started. The female occupant and her son had exited the structure prior to the arrival of the fire department. The female occupant had tried to put the fire out with a pot of water twice (See Photo 2). The fire had started in her bedroom (master bedroom) near an electrical outlet and the mattress of the bed. She and her son left the apartment and knocked on all the doors in the building prior to leaving.*



Photo 2. The pan that the female occupant used to attempt to extinguish the fire in the bedroom. The couch is located on the wall against the stairwell.

(NIOSH photo)

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The Incident Commander (Car 2), who was not wearing any PPE, entered the fire building and went to the 2nd floor. He opened the door to the fire apartment (Apartment 3), looked into the apartment, and observed that the rear (master) bedroom was on fire. Engine 5 (E5) and Ladder 1 (L1) arrived on scene at 1329 hours. Engine 5 pulled just past the front entrance of the apartment building and Ladder 1 parked near the “A/D” corner of the building.

The Incident Commander notified Engine 5 by radio that they needed to stretch a handline to the 2nd floor to Apartment 3 and get water on the fire. The lieutenant and the victim pulled a 150’ 1 $\frac{3}{4}$ ” pre-connect. The Incident Commander returned to the front of the building and met face to face with the officers of Engine 5 and Ladder 1. The Incident Commander told Engine 5 that the fire apartment was located at the top of the stairs on the left on the 2nd Floor. Ladder 1 was ordered to go to the 3rd floor and conduct a primary search. The Incident Commander then went to Side “C” with a police officer. Smoke was pushing out the window and door of the fire apartment on the 2nd floor. The Incident Commander went back to the Side “A” to get an axe off of Engine 5. The Incident Commander noticed the fire fighter (victim) from E5 on the sidewalk preparing to enter the front door. The lieutenant from Engine 5 got to the 2nd floor and realized there were two apartments instead of just one. Due to smoke conditions and confusion, he tried to enter the apartment (Apartment 4) across the hall from the fire apartment (Apartment 3). He could not get the door to the apartment open because it was locked. He took the hoseline and proceeded to the 3rd floor to find the ladder company so they could force open the door to the apartment. The lieutenant lost contact with the victim at this point. The lieutenant met Ladder 1 on the 3rd floor and asked them to force the door to the Apartment 4. The Incident Commander returned to Side “C” as the victim was entering the building. The Incident Commander went up the fire escape and took out the glass from the door of the fire apartment. The Incident Commander waited for the crew of E5 to initiate fire-fighting operations in the fire apartment, but the fire attack did not occur. The Incident Commander went back to Side “A” and to the 2nd floor landing. The Incident Commander did not see or pass the victim. The victim had gone into the fire apartment without contacting the lieutenant or the Incident Commander. The hoseline was stretched to the 3rd floor. The Incident Commander called the lieutenant from E5 and instructed him to get the hoseline to the 2nd floor and into the fire apartment. The lieutenant responded and started to move the hoseline to the 2nd floor. The Incident Commander then left the building. When the Incident Commander got outside, he instructed the driver/operator of Ladder 1 to take a 1 $\frac{3}{4}$ ” hoseline off Engine 5, take the hoseline to Side “C”, and knock down the fire on Side “C”. Engine 4 (E4) arrived on scene at 1329 hours. The Incident Commander advised Engine 4 to go over to the next street (west), go down he wrong way, come over to the street, and bring Engine 5 a supply line. **(See Diagram 2.)**

Engine 3 (E3) arrived on scene at 1333 hours. “Command” advised Engine 3 to abandon their piece and report to “Command”. “Command” assigned the fire fighter from Engine 3 to the hoseline that Engine 5 was operating. The fire fighter on Engine 3 left the driver/operator of Engine 3, went into the building from Side “A”, and went to the 2nd floor. The driver/operator of Engine 3 was delayed due to donning his PPE and SCBA before going into the building.

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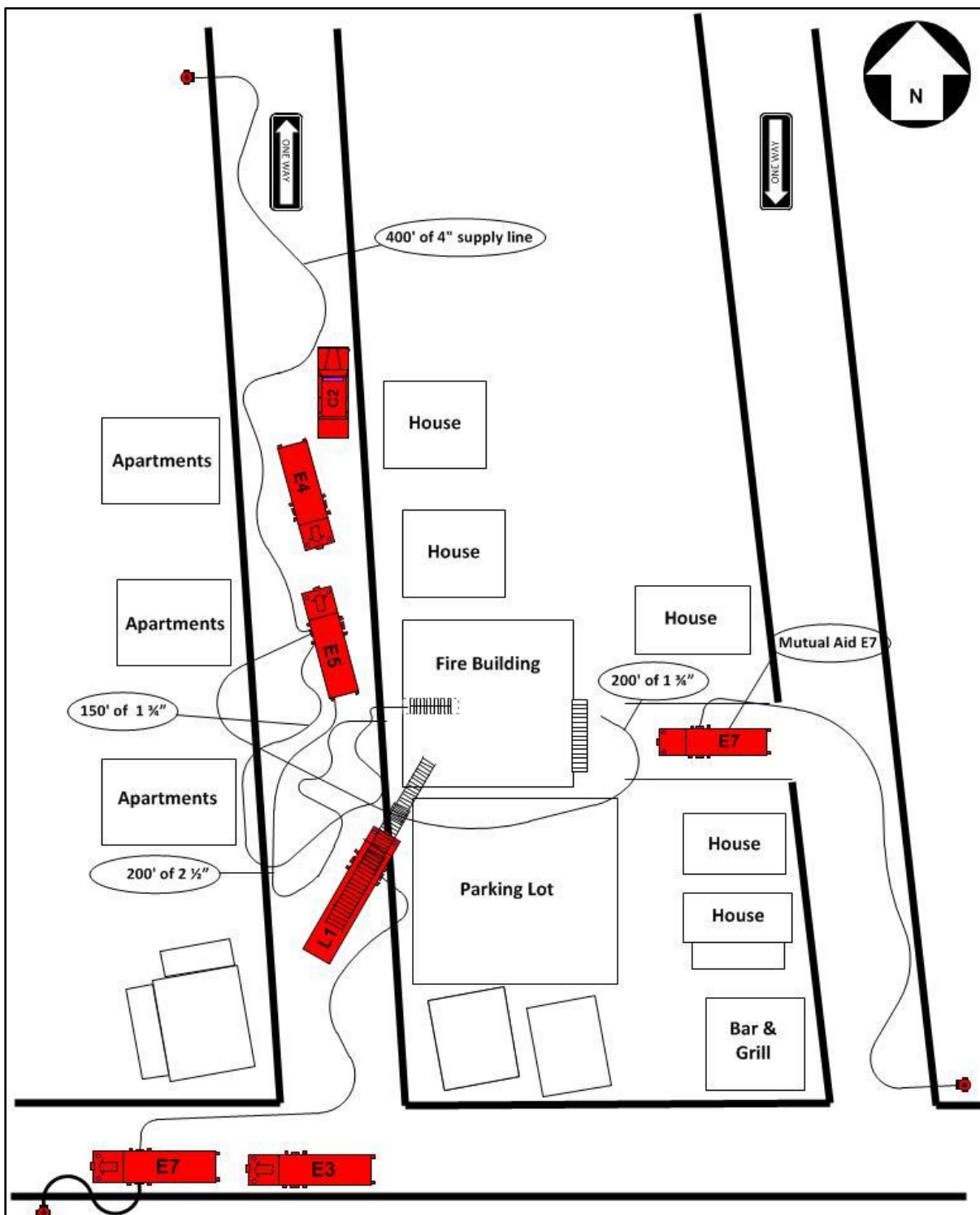


Diagram 2. The view of the fireground which details the apparatus and hoseline placement

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The lieutenant from Engine 5 entered the fire apartment. He opened the nozzle in short bursts at the fire (penciling) to try and knock the fire down. He continued to move further into the apartment and continued to “pencil” the fire. The lieutenant did not make contact with the victim prior to entering the fire apartment. At this point in the incident, neither the lieutenant nor “Command” had made visual or radio contact with the victim since Engine 5 had entered the building. “Command” did conduct a PAR (Personnel Accountability Report) and the lieutenant from Engine 5 reported that the victim was in the stairwell feeding hose. The time was approximately 1334 hours.

The driver/operator of Ladder 1 had pulled a 1¾” handline to Side “C” to knock down the fire which was extending from the 2nd floor bedroom window to the 3rd floor (**See Photo 3**). Ladder 1 went back to search on the 3rd floor and attempted to take out the skylight that was located on the 3rd floor landing. The officer of Ladder 1 reported high heat conditions and very poor visibility on the 3rd floor.

The acting officer and the jumpseat fire fighter from Engine 4 were at the hydrant waiting to supply E5. At 1334 hours, the supply line was charged. The acting officer and the fire fighter walked back to Engine 4 and met the driver/operator from Engine 4. The acting officer and driver/operator from Engine 4 were assigned by the Incident Commander to search the basement of the building due to a report of someone being trapped in the basement. The fire fighter from Engine 4 was assigned as a back-up on the hoseline with Engine 5.

At approximately 1335 hours, the fire apartment bedroom flashed and heavy fire was coming out of the bedroom window on Side “C” and extending into the living room of the fire apartment. The lieutenant from Ladder 1 went into the fire apartment and found the lieutenant from Engine 5, with his helmet was on fire. The fire fighter from E3 was coming into the fire apartment, got the nozzle, and put water on both officers. The fire fighter from E3 knocked down the fire, but his facepiece crazed due to the heat. *Note: Several NIOSH fire fighter fatality investigations have identified SCBA facepiece thermal degradation as a factor in other line of duty deaths. Although the victim’s facepiece showed no thermal degradation, thermal degradation did occur to the SCBA facepiece of the fire fighter of Engine 3, which affected fire-fighting and rescue operations. This required the fire fighter from Engine 3 to leave the building to retrieve another facepiece before his assignment was completed.*

The fire fighter from Ladder 1 had returned to the 2nd floor. The lieutenant and fire fighter from Ladder 1 were low on air and left the building with the fire fighter from Engine 3 and the lieutenant from Engine 5. The fire fighter from Engine 3 got outside and told “Command” that there was a PASS alarm sounding on the 2nd floor.

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Photo 3. The driver/operator of Ladder 1 operating a hoseline from Side “C”. The Incident Commander ordered the driver/operator to knock down the fire which was spreading from the 2nd floor to the 3rd floor. This hoseline, from Engine 5, was operated due to the delay in Engine 5 getting water on the fire. The time was approximately 1334 hours.

(Photo courtesy of the fire department)

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The driver/operator from Engine 3, was now in the fire apartment, took the nozzle, and continued to fight the fire. The fire fighter from Engine 4 was also with him in the fire apartment. The hoseline would only go as far as the couch. *Note: A 150' pre-connect of 1¾" hose was the initial line into the structure. The length of the hoseline was adequate as the lieutenant stretched the line all the way to the 3rd floor. However, an obstruction, such as the coupling, caught on the steps or a doorway which prevented the hoseline from being advanced any further than the couch in the living room.* The lieutenant from Engine 5 got another helmet, changed his SCBA cylinder, got a thermal imaging camera (TIC), and went back to the fire apartment. Due to the heat and fire conditions, the image provided by the TIC was featureless. The driver/ operator from Engine 3 put the nozzle down between the couches (**See Diagram 3**). He could hear a PASS alarm sounding but wasn't sure where the sound was coming from in the apartment. Prior to putting down the nozzle, he had knocked down the fire in the living room and most of the bedroom. He went into the master bedroom still involved with fire. He could see the driver/operator from Ladder 1 outside on the fire escape. The driver/operator from Engine 3 decided to exit out of the room onto the fire escape. He ran through the bedroom that was still involved with fire, through the doorway, and jumped onto the fire escape, landing on his SCBA cylinder. He picked up the hoseline that the driver/operator of Ladder 1 had used, and knocked down the fire in the master bedroom from the fire escape. He then took the hoseline down to the parking lot on Side "C".

Engine 7 (E7) arrived on the scene at 1336 hours. The driver/operator of Engine 7 hooked up to a hydrant to establish a water supply for Ladder 1. "Command" advised the captain of Engine 7 that the victim was in the fire apartment and to try and locate him. As Engine 7 entered the building, the fire fighter of Engine 3 told the captain from Engine 7 that he heard a PASS alarm sounding but was unsure where it was coming from in the apartment. The captain and one fire fighter from Engine 7 entered the building and the other fire fighter from Engine 7 stayed in the street. Engine 7 entered the fire apartment and moved towards the sound of the PASS alarm. The captain from Engine 7 found the victim unresponsive, located between the kitchen and the bedroom lying on his left side facing Side "C". *Note: When the victim was found by the officer from Engine 7 and removed from the structure, the victim was not wearing his facepiece and the SCBA cylinder was out of air. The fire fighter did not declare a "Mayday". It is not known whether the victim removed his facepiece before or after he ran out of air. The SCBA that the fire fighter was using was not equipped with a heads up display (HUD) and the conditions inside the structure would have made it difficult for him to read his remote air gauge. During an examination of the victim's SCBA at the NIOSH NPPTL Laboratory, the end of service time indicator (EOSTI) did function properly. The victim's SCBA by-pass valve was in the closed position.*

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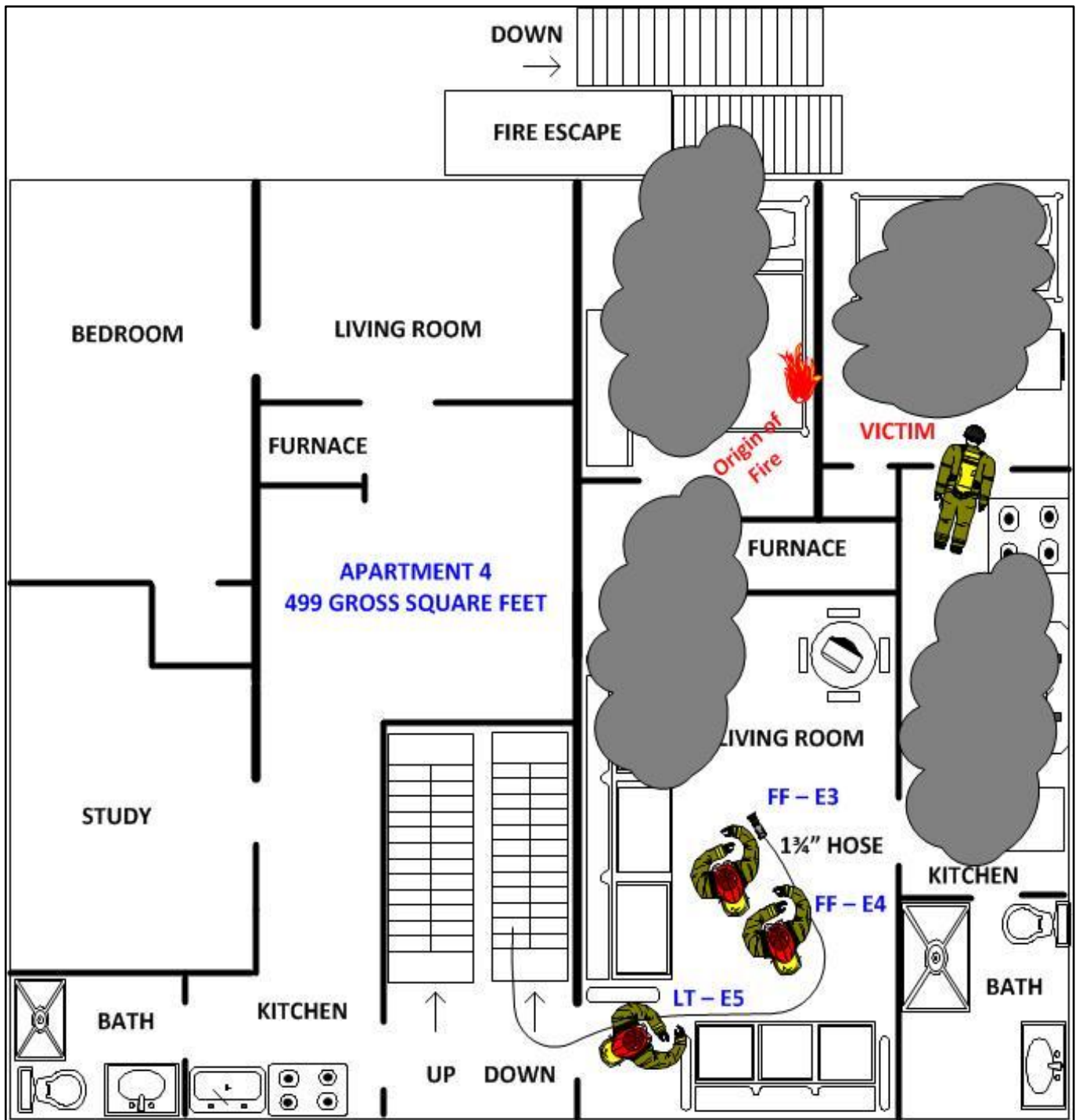


Diagram 3. The location of fire fighters during fire-fighting operations in Apartment 3

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With great effort, the captain pulled the victim towards the doorway of the apartment where fire fighters from E7 and E4 were able to assist. Due to the small size of the apartment, the amount of furniture in the apartment, the narrow stairwell, and the size of the victim, the rescue effort took several minutes (**See Photo 4**).

At 1345 hours, “Command” requested a 2nd Alarm (3 additional engine companies). Mutual Aid Engines 2, 7, and 1 were dispatched and responded. At 1348 hours, “Command” ordered everyone out of the building for a personnel accountability report (PAR).

At approximately 1355 hours, an interior attack was initiated using mutual aid companies. Ladder 1 was ordered to set up on Side “D” and vent the windows of the kitchen and other bedroom. The interior attack extinguished the fire and the fire was placed under control by “Command” at 1436 hours.



Photo 4. A view of the living room of the fire apartment from the doorway. The location of the two couches created ingress and egress problems for fire fighters. The victim was found in the kitchen near the entrance to the 2nd bedroom

(NIOSH photo)

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Fire Cause

According to a joint investigation from the State Fire Marshal's Office with the Massachusetts State Police, the fire department, police department, and the county district attorney, the cause of the fire was accidental and the fire started in the bedroom in Apartment 3.

Resuscitation Efforts and Medical Findings

When the victim was brought out of the building at 1344 hours, he was unresponsive without a heartbeat and with no spontaneous respirations. Cardiopulmonary resuscitation (CPR) and advanced life support (ALS) were initiated, but paramedics were unable to intubate the victim due to "copious amounts of soot in the airway." A King® tube was placed for ventilation as the private ambulance departed the scene for the local hospital's emergency department (ED) at approximately 1356 hours. Enroute to the ED, the victim briefly regained a heart rhythm (sinus tachycardia), but this reverted to asystole prior to arrival in the ED.

Upon arrival in the ED at approximately 1402 hours, the victim was unconscious without a heartbeat or spontaneous respirations. On examination he had sooty material in his airway, thermal burns on his upper extremities and torso, and a laceration on his head. At approximately 1409 hours, the victim regained a heart rhythm for about 10 minutes resulting in a blood pressure of 123/81 millimeters of mercury (mmHg). An electrocardiogram was performed showing no evidence of a heart attack (no ST segment elevations) or ischemia (no ST segment depressions). The carboxyhemoglobin (COHb) level was slightly elevated at 9% suggesting the victim had some carbon monoxide exposure, but not enough to cause his collapse.⁴ A subsequent COHb level performed at 1456 hours was 5.8% (laboratory normal was <5%). Unfortunately, at about 1419 hours, his heart rhythm reverted back to asystole. CPR and ALS resumed which included intubation (proper tube placement confirmed by a CO₂ detector), insertion of a transvenous pacemaker, and administration of a cyanide antidote (intravenous infusion of 2.5 grams of hydroxycobalamin). Despite these measures performed for over 80 minutes in the ED, the victim was unable to be revived. He was pronounced dead at 1521 hours by the attending physician and resuscitation efforts were stopped.

The death certificate and the autopsy completed by a medical examiner in the Commonwealth's Office of the Chief Medical Examiner listed the immediate cause of death as "probable cardiac dysrhythmia while fighting fire" with a contributory cause of "hypertensive cardiovascular disease." Significant finding from the autopsy include an enlarged heart weighing 600 grams (cardiomegaly) with no significant atherosclerotic disease in his coronary arteries⁵. His heart's left ventricle was thickened measuring 1.5 centimeters measured at 1 centimeter below the atrioventricular valve annulus (left ventricular hypertrophy).⁶ He had no pulmonary thromboemboli, negative urine and blood tests for drugs of abuse, and a normal COHb level (<5%) from the medical examiners laboratory. Although the victim had a laceration on his head, there was no internal brain injury accounting for his collapse.

His past medical history showed a weight of 243 pounds with a height of 69 inches for a body mass index of 35.9 kilograms per meter².⁷ In 2008 he was diagnosed with hydrocephalus due to a aqueductal stenosis for which he underwent a successful ventriculostomy and returned to unrestricted work as a fire fighter in March 2010. In 2011, he was diagnosed with type 2 diabetes mellitus

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controlled with oral hyperglycemic agents. Five months prior to his death, his hemoglobin A1C level was tested at 6.0, suggesting good control of his blood sugar, although he was reported to have diabetic complications of retinopathy, peripheral neuropathy, and nephropathy. In 2011 he was also diagnosed with hypertriglyceridemia and treated with diet and a cholesterol lowering medication (statin).

Discussion of the Medical Findings

Cardiomegaly, Left Ventricular Hypertrophy and Sudden Cardiac Death. On autopsy, the victim was found to have an enlarged heart and left ventricular hypertrophy. The most common causes of these cardiac findings are any of the following: chronic ischemia from underlying atherosclerotic CHD, longstanding /untreated hypertension, or valvular heart disease.⁸ Since the victim had none of these conditions (as determined from his autopsy and medical records), it raises the possibility of a less common cardiac condition known as hypertrophic cardiomyopathy.⁸ The medical examiner made no mention of the unusual shape (asymmetric hypertrophy) that typically accompanies this condition, and no microscopic examination of the victim's heart tissue was performed to confirm the diagnosis.⁹ Regardless of the etiology, both cardiomegaly and left ventricular hypertrophy are independent risk factors for sudden cardiac death.^{10, 11}

The victim collapsed during initial attack fire suppression. Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of sudden cardiac death.¹² On-duty fire fighter fatalities due to coronary heart disease have been associated with alarm response, fire suppression, and heavy exertion during training.^{13, 14, 15} The victim was wearing full turnout gear and SCBA weighing over 50 pounds, and had walked at least one flight of stairs with a hoseline into the fire apartment. This would have expended at least 12 metabolic equivalents (METs,) which is considered heavy physical activity. NIOSH investigators conclude that this heavy physical activity probably triggered a cardiac arrhythmia leading to his cardiac death.

Fire Smoke. Fire smoke contains varying amounts of carbon monoxide. If inhaled, carbon monoxide can cause carbon monoxide poisoning, which, in severe cases, can cause sudden death. Given the victim was found in a smoke-filled apartment with soot in his mouth and upper airway, carbon monoxide poisoning was a primary concern of the treating paramedics and ED physicians. Carboxyhemoglobin (COHb) levels in the blood are used to assess CO exposure and CO poisoning. Although the victim's serial COHb levels were slightly elevated (9%, 5.8%, and <5%), they were not at levels known to cause sudden death.⁴ Resuscitation efforts (intubation and administration of 100% oxygen for over an hour) would be expected to accelerate the elimination of COHb and lower COHb levels.¹⁶ Since the victim only regained a heartbeat for less than 10 minutes, these resuscitation measures probably had minimal impact on his COHb levels. In summary, the victim was exposed to carbon monoxide either before or after his collapse. This exposure, however, was not enough to trigger his cardiac arrest and subsequent cardiac death.

Fire smoke frequently contains another chemical asphyxiant gas, hydrogen cyanide.¹⁷⁻²⁵ Although most exposure surveys of fire fighters find the presence of cyanide gas, only two report levels above the "short-term exposure level" (STEL) or above the level "immediately dangerous to life and health" (IDLH).^{19, 23} This should not be surprising given that the generation of cyanide gas depends on the

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material being burned, the rate of pyrolysis, the absolute temperature, and the oxygen supply.²⁶ Given the contents of the fire apartment (e.g. sofa, mattress, and plastics, etc), cyanide was probably generated during this fire. Unfortunately, rapid blood tests to confirm cyanide poisoning are not currently available. Confronted with the signs of smoke inhalation (soot in the upper airway) and clinical signs consistent with cyanide poisoning (cardiac arrest, severe acidosis), the victim was treated with one of the cyanide antidotes (intravenous hydroxocobalamin). Unfortunately, this did not change his clinical status, thus making the diagnosis of cyanide poisoning unlikely.

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:

- Crew integrity
- Delay of initiating fire attack
- Inadequate fire stream application (penciling)
- Inadequate fireground communications
- Lack of a personnel accountability system
- Failure to initiate a “Mayday”
- Lack of annual medical evaluation.

Recommendations

Recommendation #1: Ensure that crew integrity is properly maintained by voice contact or radio contact when operating in an immediately dangerous to life and health (IDLH) atmosphere.

Discussion: When an engine company enters a structure, the members must remain in contact by visual (eye-to-eye contact), verbal (by radio or by person-to-person), or direct (by touch) contact. NFPA 1500 *Standard on Fire Department Occupational Safety and Health Program*, states in Paragraph 8.5.5, “Crew members operating in a hazardous area shall be in communication with each other through visual, audible, or physical means or safety guide rope, in order to coordinate their activities.”²⁷ Additionally, NFPA 1500 Paragraph 8.5.6 states, “Crew members shall be in proximity to each other to provide assistance in case of an emergency.”²⁷

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The International Association of Fire Chiefs, Safety, Health, and Survival Section has redefined the *Rules of Engagement for Structural Fire-Fighting*. One of the objectives is to ensure that fire fighters always enter a burning building as a team of two or more members and no fire fighter is allowed to be alone at any time while entering, operating in, or exiting a building. A critical element for fire fighter survival is crew integrity. Crew integrity means fire fighters stay together as a team of two or more. They must enter a structure together and remain together at all times while in the interior, and **all** members come out together. Crew integrity starts with the company officer ensuring that all members of the company understand their riding assignment, having the proper personal protective equipment, and having the proper tools and equipment. Upon arrival at the incident, the company is given a task to perform by the Incident Commander. The company officer communicates to the members of the company what their assignment is and how they will accomplish their assignment. As the members of a company enter a hazardous environment together, they should leave together to ensure that crew integrity is maintained. If one member has to leave, the whole company leaves together. ²⁸

It is the responsibility of every fire fighter to stay connected with crew members at all times. Freelancing by any member must be strictly prohibited. Additionally, crews or companies must never freelance. All fire fighters must maintain the unity of command by operating under the direction of the Incident Commander, division/group supervisor, or their company officer at all times. The ultimate responsibility for crew integrity and ensuring no members get separated or lost rests with the company officer. They must maintain constant contact with their assigned members by visual observation, voice, or touch while operating in a hazard zone. They must ensure they stay together as a company or crew. If any of these elements are not adhered to, crew integrity is lost and fire fighters are placed at great risk. If a fire fighter becomes separated and cannot get re-connected with his/her crew immediately, the fire fighter must attempt to communicate via portable radio with the company officer. If reconnection is not accomplished after three radio attempts or reconnection does not take place within one minute, a “Mayday” should be declared. If conditions are rapidly deteriorating the “Mayday” must be declared immediately. As part of a “Mayday” declaration, the fire fighter must next activate the radio’s emergency alert button (where provided) followed by manually turning on the PASS alarm. Similarly, if the company officer or the fire fighter’s partner recognizes they have a separated member, they must immediately attempt to locate the member by using their radio or by voice. If contact is not established after three attempts or within one minute a “Mayday” must be declared immediately. ²⁸

In this incident, the lieutenant of Engine 5 took the nozzle and a length of hose up the stairs to attack the fire in Apartment 3. When the lieutenant got to the 2nd floor, two things happened. One, he realized that there were two apartments on the 2nd floor. Second, he went to the wrong apartment (Apartment 4) and the door was locked. He proceeded to the 3rd floor with the hoseline to find the crew of Ladder 1. The lieutenant lost contact with the victim at this point. The victim went into the fire apartment ahead of the lieutenant. The Incident Commander did not pass the victim when he came back in the building and went to the 2nd floor to find out why there was no water on the fire. Once the lieutenant got into the fire apartment, he still did not have contact with the victim. When the lieutenant left the building, he did not pass the victim in the stairwell. The lieutenant didn’t realize that the victim had gone into the fire apartment ahead of him.

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Recommendation #2: Ensure the Incident Commander communicates the strategy and Incident Action Plan to all members assigned to an incident.

Discussion: When establishing “Command” at any incident, one of the most important responsibilities of the Incident Commander is to develop a strategy and create an appropriate Incident Action Plan. Based upon the initial size-up, the Incident Commander has to absorb and process a lot of information in a very short period of time. The Incident Commander develops the strategy, which is defined as the overall plan that will be used to control the incident.²⁹ The development and management of the overall strategy (situation evaluation, operational risk management plan, and evaluation and decision-making process) becomes the basis for the Incident Action Plan (tactics). *Note: For most Type V and Type IV incidents, these incidents most often will not have a formal (written) Incident Action Plan due to the short duration of the incident. In this case, the tactics serve as the Incident Action Plan.* The basic order of development is: **strategy**, first and **Incident Action Plan**, second. Connecting the strategic, tactical, and task levels so they all operate within the same basic strategy is a major goal of the incident management system.

For structural fire-fighting operations, the basis for the development of most tactical priorities is Lloyd Layman’s acronym “*RECEO VS*”. These seven factors: rescue, exposures, confinement, extinguishment, overhaul, ventilation, and salvage that should be considered to assist in the developing the Incident Action Plan. Fire fighters understand what the Incident Commander is trying to accomplish and helps them to understand their role in the process.³⁰

At this incident, Car 2 arrived on scene at this incident prior to the arrival of the first due engine company (Engine 5) and first due ladder company (Ladder 1). Car 2 established “Command” and then was able to develop a strategy and Incident Action Plan based upon his size-up of the incident. “Command” went to the fire apartment and made a quick evaluation and then met the officers of Engine 5 and Ladder 1 in the street. “Command” told the officers they needed to get into the fire apartment, which was on the left at the top of the stairs on the 2nd floor. “Command” then went to Side “C” and climbed the fire escape to the 2nd floor landing and broke out the windows on the fire escape door and the bedroom windows. He kept waiting on the fire escape for water to hit the fire, which did not occur. “Command” went down the fire escape and then went back around to the front of the building (Side “A”) to check on the location of Engine 5. There was minimal communication on the fireground channel regarding the operations of this incident.

Once the Incident Commander had developed his strategy and the Incident Action Plan (tactics), which for this incident were very good, this critical fireground information must be communicated via the radio to all members assigned to the incident including the dispatch center. Everyone has to know the strategy that is being implemented and understand their role. When the information is communicated face-to-face, this excludes the remainder of the assignment plus the dispatch center from receiving critical fireground communications.

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Recommendation #3: Ensure that engine companies initiate a proper fire attack based upon scene size-up and the Incident Commander's defined strategy and tactics.

Discussion: The application of water on a fire is one of the most important benchmarks to accomplish at a structure fire. This process is essential to the successful outcome of the incident. The objectives of structural fire-fighting are life safety, incident stabilization, and property conservation. ²⁹

Selection and implementation of any strategic plan and its supporting tactics is dependent upon an accurate and ongoing *size-up* of the fire situation. Size-up starts with the receipt of the alarm and continues until the fire is under control. The size-up process may be carried out many times and by many different individuals during the course of a fire. The responsibility for size-up initially lies with the first officer on the scene, however all engine company members should make a personal size-up of the fire situation. ³¹

Most fire operations employ an *offensive strategy* which emphasizes the rapid stretching of hoseline (s) for an aggressive interior attack on the seat of the fire. Engine company *tactics* at most structure fires are to stretch a hoseline via the primary means of egress (main entrance to the building), obtain an uninterrupted water supply, and attack the fire. ³¹

Stretching and operating hoselines is the primary function of an engine company. All members must realize the importance of the initial line stretched at a structural fire. More lives are saved at a fire by the proper positioning and operating of hoselines than by all other life saving techniques available to the fire-fighting forces. ³¹ The majority of structural fires are controlled and extinguished by this initial line. The **first line** is placed between the fire and any persons endangered by it. This is accomplished by stretching the hoseline via the primary means of egress, usually the main stairway. This tactic:

- provides a base for confining and controlling the fire;
- allows occupants to evacuate via the stairs;
- allows fire fighters to proceed above the fire for search. ³²

In most cases the first line is stretched via the interior stairs to the location of the fire. The purpose of this line is to protect the primary means of egress for occupants evacuating the building and to confine and extinguish the fire. Prior to opening the door to the fire area for advancement of the line, the engine company officer **must** assure that no fire fighters will be exposed in the hallway or on the stairs above as the fire attack is initiated. This can be done via portable radio or in person. ³²

When the fire attack is being initiated, the engine company officer shall announce via portable radio to "Command" that "water is on the fire". This is a significant incident benchmark being met. If the engine company officer can't get water or there is a delay of getting water on the fire, this must be communicated to "Command" as well. ³³

Advancing a hoseline will cause conditions opposite the hose line and above to worsen as the heat, fire, and steam are pushed in the direction by the force of the stream. Conditions in areas behind,

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adjoining or above the operating hoseline must be monitored for sudden possible deterioration due to the effects of hoseline advancement on the fire. All members must be alert to fireground communications concerning hoseline placement and the commencement of fire-fighting operations so that they may seek refuge if necessary. ³³

Communication during the fire attack may be difficult at times due to the noise created by the stream striking walls, ceilings and furnishings. However, the engine company officer must monitor the portable radio for critical information that may affect the engine company. This includes ventilation delays, water supply difficulties, collapse potential and "mayday" and/or "urgent" transmissions. The engine company officer can provide the Incident Commander with vital information that may affect how the fire operation is handled. Messages such as those listed below should be transmitted to the Incident Commander, other units, or individual members on the scene:

- "Start an 1 3/4-inch line to the 4th floor;"
- "Start water;"
- "We have two rooms knocked down, making progress;"
- "Main body of fire has been extinguished;"
- "Increase/decrease pressure;"
- "We need a back-up line." ³³

At this incident the Incident Commander told Engine 5 that the fire apartment was located at the top of the stairs on the left on the 2nd Floor. The lieutenant from Engine 5 got to the 2nd floor and realized there were two apartments instead of just one. Due to smoke conditions and confusion, he tried to enter the apartment (Apartment 4) across the hall from the fire apartment (Apartment 3). He could not get the door to the apartment open. He took the hoseline and proceeded to the 3rd floor to find the ladder company so they could force open the door to the apartment. The lieutenant lost contact with the victim at this point. The lieutenant met Ladder 1 on the 3rd floor and asked them to force the door to the Apartment 4. The Incident Commander went to the 2nd floor landing and did not see or pass the victim. The hoseline was stretched to the 3rd floor. The Incident Commander called the lieutenant from Engine 5 and instructed him to get the hoseline to the 2nd floor and into the fire apartment. The lieutenant responded and brought the hoseline down to the 2nd floor and into the fire apartment.

It is essential for engine company officers to ensure when an incident objective can't be met or is delayed (e.g. getting water on the fire), the information must be communicated to the Incident Commander.

Recommendation #4: Ensure all personnel are trained in the proper application of fire streams.

Discussion: In order to extinguish a fire, an engine company officer should consider the following when preparing for the primary fire attack: total flow of water needed, length of the stretch of the hoseline, location and access of the fire, and available staffing. At this incident, 150' of 1 3/4" hoseline was deployed and taken through the front door of the apartment building, and then to the 2nd floor uncharged. Once the lieutenant from Engine 5 was in place on the 2nd floor landing, the engineer or driver/pump operator was told to charge the hoseline. Due to the smoke and confusion, the lieutenant

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tried to enter the wrong apartment and the door was locked. The lieutenant then took the charged hoseline to the 3rd floor to find Ladder 1 to have them force the apartment door. The Incident Commander went to the 2nd floor landing, ordered the lieutenant back to the 2nd floor landing, and then the lieutenant entered the fire apartment. The lieutenant was trying to knock down the fire by “penciling.” The lieutenant from Engine 5 stated that he used the “penciling” technique which he had learned in recruit school.

Smoke is a fuel source and has to be cooled to prevent the smoke from igniting which can transition to a rollover, flashover, or smoke explosion at any time.³⁴ The concept of “penciling” is also taught in flashover simulators to prevent a room from flashing over. The key point is that “penciling” can be used to cool a room until the fire is located. The hot gas layer near the ceiling can be cooled by applying short pulses of water fog. The fog nozzle can be set on a 30 – 60 degree fog pattern directed upward toward the gas layer and quickly open and close the nozzle (1 – 2 seconds). When the water starts to come back, this indicates the gases have been cooled. If no water comes back, the process must continue.³⁴ Once the fire is located, the nozzle must be completely opened and the fire stream applied directly or indirectly on the fire until the fire is knocked down. Also, the fire stream must be applied by using a solid or straight stream or at most, a 30 degree fog pattern.

The lieutenant had the nozzle (adjustable fog nozzle), went to the 2nd floor, then the 3rd floor, then back to the 2nd floor, and into the fire apartment. The lieutenant tried to knock down the fire by penciling (1 - 2 second increments) and kept moving further into the apartment. The lieutenant could see fire in the bedroom in front of him when the living room and the bedroom flashed. The lieutenant called for the officer of Ladder 1. The lieutenant from Ladder 1 went into the fire apartment and found the lieutenant from Engine 5. The lieutenant’s helmet was on fire. The fire fighter from Engine 3 was coming into the fire apartment, got the nozzle, and put water on both officers.

When encountering a heavy amount of fire and heat in any scenario, fire fighters need to completely open the nozzle to obtain maximum fire flow and attempt to knock the fire down.

Recommendation #5: Fire departments should ensure that the Incident Commander establishes a stationary command post for effective incident management, which includes the use of a tactical worksheet, effective fireground communications, and a personnel accountability system.

Discussion: When a chief officer (e.g., battalion chief, district chief, deputy chief) arrives on scene, he/she should automatically assume a standard stationary, exterior, and remote command position and immediately assume “Command” and begin functioning as the Incident Commander. Command officers generally establish and continue command and control functions inside their vehicles or at the rear of the vehicle, which has a command board.

NFPA 1561 *Standard on Emergency Services Incident Management System*, §5.3.1 states, “The Incident Commander shall have overall authority for management of the incident.” In addition to conducting an initial size-up, the Incident Commander must establish and 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.³⁵

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In establishing a command post, the Incident Commander shall ensure the following (NFPA 1561, §5.3.7.2):

- The command post is located in or tied to a vehicle to establish presence and visibility.
- The command post includes radio capability to monitor and communicate with assigned tactical, command, and designated emergency traffic channels for that incident.
- The location of the command post is communicated to the communications center.
- The Incident Commander, or his/her designee, is always present at the command post.
- The command post should be located in the incident cold zone.³⁵

The tactical worksheet is a critical resource because it helps the Incident Commander to strategically organize the incident scene and serves as a convenient workspace for tracking companies and apparatus. By documenting the assignments of companies or divisions/groups, the Incident Commander creates a visual reference of the overall fireground organization and deployment.

The advantages of using a tactical worksheet are:

- includes a location to quickly note individual assignments;
- provides prompts for the Incident Commander, such as time, air management and strategy prompts;
- provides tactical benchmarks, such as “primary search complete,” “fire under control” and “loss stopped”;
- facilitates consistent, organized information;
- documents assignments and responsibility;
- expedites passing of “Command” or support for the Incident Commander;
- provides resource status.³⁶

Fire departments should have a “Communications” standard operating procedure (SOP) coupled with an effective training program. These procedures include the use of clear text (specifically, no “10 codes”, or other terms that may be unfamiliar to other responders) and provide a separate radio channel for dispatch and a separate tactical channel to be used during the incident. When a tactical level management unit is implemented (division or group), a fire department should provide a dispatch channel, a command channel, and a tactical channel. A fire department should provide the necessary number of radio channels relating to incidents with multiple tactical channels and the complexity of these incidents. NFPA 1500, section 8.2.2, states “that a standard terminology will be established for transmitting information, strategic modes of operation, situation reports, and emergency notification of imminent hazards. The fire department should have procedures for the announcement of emergency conditions, using the term “emergency traffic” as a designation to clear radio traffic”.³⁵ Emergency traffic should be declared by the Incident Commander, tactical level management unit, or member who identifies a high risk situation on the fireground (e.g. power lines down, signs of impending collapse) and should be used to alert members that the Incident Commander is ordering the evacuation of the building. The term “Mayday” should be reserved for only those situations where a fire fighter or fire fighters is/are in trouble or facing a life threatening emergency.

Another critical element that is essential to the success of the personnel accountability system is effective fireground or incident scene communications. The function of resource accountability should

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be assigned to a member who is responsible for maintaining the location and status of all assigned resources at an incident, such as a chief's aide. This is separate from the role of the Incident Commander. The Incident Commander is responsible for the overall command and control of the incident. Due to the importance of responder safety, this function should be assigned to a Personnel Accountability Officer or Resource Status Officer. A number of members could function in this role including a staff assistant, chief officer, apparatus driver/operator, or other responder. There are many means of accounting for resources. Components can include tactical worksheets, command boards, apparatus riding lists, company responder boards, electronic bar-coding systems, and so forth.

Fire departments should ensure a stationary command post is established at working incidents or any time that "Command" is established. This process includes establishing proper radio communication, initiating the tactical worksheet, and starting the personnel accountability system. The next step of the Incident Commander would be to focus on the development of the strategy and the Incident Action Plan (IAP) which is then communicated to all companies and other personnel operating on the incident scene. Most importantly the communications and personnel accountability process would be initiated from the beginning of the incident.

Recommendation #6: Ensure critical benchmarks are communicated to the Incident Commander.

Discussion: The size-up of interior conditions is just as important as exterior size-up. The Incident Commander monitors exterior conditions while the interior conditions are monitored and communicated to the Incident Commander as soon as possible from company officers. Knowing the location and the size of the fire inside the building lays the foundation for all subsequent operations. Interior conditions could change the Incident Commander's initial strategy.³⁷ Also, when operating inside the structure, company officers should communicate to the Incident Commander when making initial entry, searching and clearing areas, during fire attack, progressing between floors, and exiting the structure.

Proper size-up and risk versus gain analysis requires that the Incident Commander gather a number of key pieces of information and be kept informed of the constantly changing conditions on the fireground. The Incident Commander must develop and utilize a system that captures pertinent incident information to allow continuous situational evaluation, effective decision making, and development of an incident management structure. 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 Incident Action Plan will be out of sequence with the phase of the fire and the Incident Commander will be constantly surprised by changing conditions.^{38,39,40}

Interior size-up is just as important as exterior size-up. Since the Incident Commander is located at the command post (outside), the interior conditions should be communicated by interior crews as soon as possible to the Incident Commander. Interior conditions could change the Incident Commander's strategy. Interior crews can aid the Incident Commander in this process by providing reports of the interior conditions as soon as they enter the fire building and by providing regular updates, especially

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when benchmarks are met (e.g., “primary search complete is all clear” and “the fire has been knocked down”).

Retired Fire Chief Alan Brunacini states that critical fireground factors, including interior and exterior conditions, are among the many items that the Incident Commander must consider when evaluating tactical situations. These items provide a checklist of the major issues involved in size-up, decision making, initiating operations, and review and revision. The Incident Commander deals with these critical factors through a systematic management process that creates a rapid, overall evaluation; sorts out the critical factors in priority order; and then seeks out more information about each factor. The Incident Commander must train and prepare (through practice) to engage in conscious information management. Incident factors and their possible consequences offer the basis for a standard incident management approach. A standard information approach is the launching pad for effective incident decision making and successful operational performance. The Incident Commander must develop the habit of using the critical factors in their order of importance as the basis for assigning the specific assignments that make up the Incident Action Plan. The Incident Commander must create a standard information system and use effective techniques to keep informed at the incident. The Incident Commander can never assume the action-oriented responder engaged in operational activities will stop what they are doing so they can feed the Incident Commander with a continuous supply of top-grade objective information. It is the Incident Commander’s responsibility to do whatever is required to stay effectively informed.³⁹

In this incident, several critical fireground issues should have been communicated by radio to “Command”:

- companies found two apartments on the 2nd floor,
- the apartment door was locked,
- a delay in getting water on the fire due to forcible entry,
- an accountability report from all companies prior to initiating fire attack.

These are all critical fireground tasks that may have impacted the outcome of the incident.

Recommendation #7: A personnel accountability system should be used to account for all fire fighters and first responders assigned to any incident.

Discussion: An important aspect of a personnel accountability system is the personnel accountability report (PAR). A PAR is an organized on-scene roll call in which each supervisor reports the status of their crew when requested by the Incident Commander.²⁷ The use of a personnel accountability system is recommended by NFPA 1500 *Standard on Fire Department Occupational Safety and Health Program*²⁷ and NFPA 1561 *Standard on Emergency Services Incident Management System*.³⁵ A functional personnel accountability system requires the following:

- development of a departmental SOP,
- necessary components and hardware,
- training all personnel on the operation of the system,
- strict enforcement during emergency incidents.

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The control of the personnel accountability system should be assigned to an individual responsible for maintaining the location and status of all assigned resources (resource status) at an incident. This is a separate role from the duties of the Incident Commander. The Incident Commander is responsible for overall command and control of the incident. Due to the importance of responder safety, this function would be assigned to a Personnel Accountability Officer or Resource Status Officer. This function can be staffed by the chief's aide, staff assistant, field incident technician, chief officer, or other responder familiar with the department's accountability system. ³⁵

There are many different methods and tools for accounting of resources. Some examples are:

- tactical worksheets,
- command boards,
- apparatus riding lists,
- electronic bar-coding systems,
- accountability tags or keys (e.g. PASSPORT System). ³⁵

These components can be used in conjunction with one another to facilitate the tracking of responders by both location and function. The components of the personnel accountability system should be modular and expand with the size and complexity of the incident. ³⁵

As the incident escalates, additional staffing and resources may be needed, adding to the burden of tracking personnel. The tactical worksheet or incident command board should be established early with an assigned accountability officer or aide. As a fire escalates and additional fire companies respond, a chief's aide or accountability officer assists the incident commander with accounting for all firefighting companies at the fire, at the staging area, and at the rehabilitation area. With an accountability system in place, the Incident Commander may readily identify the location and time of all fire fighters on the fireground. A properly initiated and enforced personnel accountability system that is consistently integrated into fireground command and control enhances fire fighter safety and survival by helping to ensure a more timely and successful identification.

This department had a standard operating procedure for accountability which details the use of the accountability tags by members. When a member is assigned to a company, the accountability tag is placed on a ring on the apparatus and maintained by the company officer.

At this incident, the victim became separated from his lieutenant once they entered the structure. Engine 5 was ordered to stretch a hoseline into the building and to the 2nd floor fire apartment (Apartment 3). Once the lieutenant got to the 2nd floor, he realized there were two apartments. The lieutenant tried to open the door to the Apartment 4 (apartment across the hall from the fire apartment), but the door was locked. The victim was last seen by the Incident Commander pulling the hoseline up the stairwell to the 2nd floor. The lieutenant from Engine 5 went to the 3rd floor to find Ladder 1 and have them force the door. Once the lieutenant got back to the 2nd floor landing, there was no communications or contact with the victim. The lieutenant went into the fire apartment and attempted to knock down the fire. The victim was located approximately 9 minutes later in the kitchen area of

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the fire apartment by the captain from Engine 7, who pulled the victim out of the building with the assistance of two other fire fighters.

Recommendation #8: Ensure that a rapid intervention team crew (RIC) is established and available to immediately respond to a fire fighter rescue operation.

Discussion: At all fireground operations, at least one rapid intervention crews (RIC) should be designated and available to respond before interior attack operations begin.^{28, 41} The size and complexity of the incident will determine the number of rapid intervention crews to utilize.

The rapid intervention crew should report to the officer in command and remain in a designated ready position until an intervention is required to rescue a fire fighter(s). The rapid intervention crew should have all tools necessary to complete the task. The following is the minimum equipment that should be made available to a rapid intervention crew:

- extra SCBA complete with harness, regulator, and extra masks (consider that mutual aid companies may use a different SCBA system),
- search rope,
- forcible entry hand tools such as axe, sledge, Halligan bar, and bolt-cutters.
- mechanical forcible entry tools such as chain saw, metal cutting saw, and masonry cutting saw;
- hoseline,
- ladder complement,
- thermal imaging camera (TIC),
- high intensity handlight.

The rapid intervention crew's only assignment should be to prepare for a rapid deployment to complete any emergency search or rescue when ordered by the Incident Commander. A rapid intervention crew should pre-plan a rescue operation by finding out fire structure information. Make a size-up of the overall scene, considering the following:

- type of building, roof construction, and age,
- possibility of collapse(s),
- points of ingress and egress,
- overall sizes and condition of building,
- number of floors,
- presence of burglar bars,
- history of previous fires in structure,
- contents and interior finish,
- location of stairwells and elevators,
- presence of a basement,
- water supply,
- any overall hazard or relevant details,
- weather conditions and temperature,
- extent of fire development,

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- location and experience level of interior crews,
- reports that the fire may be suspicious (e.g. multiple area of fire or smoke upon arrival).

When the rapid intervention crew enters to perform a search and rescue, they should have full cylinders on their SCBAs and be physically prepared. When a rapid intervention crew is used in an emergency situation, an additional rapid intervention crew should be put into place in case an additional emergency situation arises.²⁷

During fire fighter rescue operations, the Incident Commander should consider implementing the following:

- requesting additional resources including a medical component,
- utilizing staging for resources,
- committing the rapid intervention crew from stand-by mode to deployment,
- changing from strategic plan to a high-priority rescue operation,
- initiating a personnel accountability report,
- withdrawing companies from the affected area,
- assigning a rescue officer,
- assigning a safety officer,
- assigning a back-up rapid intervention crew(s),
- assigning an advanced life support (ALS) or basic life support (BLS) company,
- requesting additional command level officers,
- requesting specialized equipment as necessary,
- ensuring the dispatch center is monitoring **all** radio channels,
- opening appropriate doors to facilitate ingress and egress,
- requesting additional vertical/horizontal ventilation,
- providing lighting at doorways, especially at points of entry.

Upon receipt of a “Mayday”, rescue crews will have to react to a deteriorating interior condition and will have to do so knowing that a fellow firefighter’s life may depend upon their actions. The Incident Commander must also be mentally prepared to take an even greater responsibility and not allow fellow fire fighters to enter a structure that will likely result in more deaths.

At this incident, no “Mayday” was declared, but fire fighter rescue operations were initiated due to the PASS alarm sounding from the victim’s SCBA.

Recommendation #9: Fire departments should use thermal imaging cameras (TICs) during the fire-fighting operations.

Discussion: Thermal imaging cameras (TIC) provide a technology with potential to enhance fire fighter safety and improve the ability to perform tasks such as size-up, search and rescue, fire attack, and ventilation. TICs should be used in a timely manner, fire fighters should be properly trained in the use of a thermal imaging camera, and be aware of their limitations.^{41, 42}

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The application of thermal imaging on the fire ground may help fire departments accomplish their primary mission, which is saving lives. This mission can be accomplished in many ways. First and foremost, in near zero visibility conditions, primary searches may be completed quickly and with an added degree of safety. The use of thermal imaging technology may also be invaluable when a fire department is confronted with larger floor areas or unusual floor plans.⁴² Searching for trapped civilians is part of a fire department's primary mission. At times the search may be for a member who has become separated from the company or crew. TICs may also provide a method for fire fighters to track and locate other fire fighters in very limited visibility conditions. The TIC may provide invaluable **assistance** in locating a missing member of the company or crew. This process can enhance fire fighter accountability before an issue arises.⁴³

At a structure fire, the TIC may help identify the location of the fire or the extent of fire involvement prior to fire fighters being deployed into a structure. Knowing the location of the fire may help fire fighters determine the best approach to the fire. The TIC may provide additional information for a crew(s) making the fire attack that they would not previously have due to poor visibility and building construction. Using this information, fire fighters may be able to locate the fire more quickly and may also ensure that the water application is effective. One of the most important aspects of the TIC is that when used properly and understood it may provide the potential to detect a fire that is isolated or hidden within parts of structure.⁴⁴ While the use of a TIC is important, research by Underwriters Laboratories has shown that there are significant limitations in the ability of these devices to detect temperature differences behind structural materials, such as the exterior finish of a building or outside compartment linings (i.e., walls, ceilings, and floors).⁴⁵

Of all the operations in which the TIC can improve a fire fighter's efforts, this technology has the most dramatic impact on search and rescue. Fire fighters using thermal imagers can see the room, which enables them to quickly navigate and identify victims. Without a TIC, fire fighters search burning buildings by crawling through smoke to try and locate possible victims.

From a ventilation perspective, fire fighters can use the TIC to identify areas of heat accumulation, possible ventilation points, and significant building construction features. This helps ensure proper and effective ventilation that successfully removes smoke and heat from a building.

The fire department in this incident carried a TIC on each engine company and the ladder company. Also, two TICs were assigned to the deputy chief's vehicle. At this incident, none of the crews entered the structure with a TIC. The crew from Ladder 1 could have taken a TIC to the 3rd floor to assist with the search and rescue. The crew from Ladder 1 could have checked the fire apartment with the TIC on the way to the 3rd floor, which would have accomplished several tasks. Ladder 1 could have opened the apartment door for Engine 5 and they could have quickly searched the apartment to ensure that the primary search was "all clear" before moving to search the 3rd floor.

If a fire department is considering the purchase of a thermal imaging camera, please refer to most current edition of NFPA 1801, *Standard on Thermal Imagers for the Fire Service*.

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Recommendation #10: Fire departments should ensure that fire fighters are properly trained in “out of air SCBA emergencies” and SCBA repetitive skills training.

Discussion: Repetitive skills training with self-contained breathing apparatus (SCBA) is a vital skill necessary for fire fighters working in an immediately dangerous to life and health (IDLH) atmosphere. Repetitive skills training can also provide the user with an increased ability to operate these functions and controls in a high anxiety moment or an emergency. Many times these skills will be necessary with gloved hands and limited vision and reduced ability to hear commands or information from other fire fighters or fire officers. Repetitive skills training allows fire fighters to engage buttons such as the don/doff button, bypass, cylinder wheel or main line valve, and buddy breathing connection in training conditions that are non-IDLH. This will help build the fire fighters muscle memory skills so their hands will be able to activate the controls with gloves on and the operation will be a second nature response.

Fire fighters need to be trained to use their equipment and the repetitive skills training reinforces the muscle memory to properly activate the correct controls. Overcoming out of air emergencies is an important goal of repetitive skills training. Fire fighters also need to understand the psychological and physiological effects of the extreme level of stress encountered when they run low on air, become lost, disoriented, injured, run low on air, or become trapped during rapid fire progression. Most fire training curricula does not include discussion of the psychological and physiological effects of extreme stress, such as encountered in an imminently life threatening situation, nor do they address key survival skills necessary for effective response. Understanding the psychology and physiology involved is an essential step in developing appropriate responses to life threatening situations. Reaction to the extreme stress of a life threatening situation, such as being trapped, can result in sensory distortions and decreased cognitive processing capability⁴⁶. In the book *Stress and Performance in Diving*⁴⁷ the author notes that while all training is important, “we know that under conditions of stress, particularly when rapid problem-solving is crucial, over-learning responses is essential. The properly trained individual should have learned coping behavior so well that responses become virtually automatic requiring less stop and think performance.” Fire fighters should never hesitate to declare a “Mayday”. There is a very narrow window of survivability in a burning, highly toxic building. Any delay declaring a “Mayday” reduces the chance for a successful rescue.⁴¹

In this incident the victim ran out of air and removed his facepiece. The fire fighter did not declare a “Mayday” possibly because he was medically incapacitated. It is not known whether he removed his facepiece before or after he ran out of air. The SCBA that the fire fighter was using was not equipped with a heads up display (HUD) and the conditions inside the structure would have made it difficult for him to read his remote air gauge. During the investigation, NIOSH investigators examined the SCBA and found the by-pass valve in the closed position.

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Recommendation #11: All engine companies, ladder companies, rescue companies, squad companies or multi-functional companies should be staffed with an officer.

Discussion: The company officer is responsible for organization, management, leadership, accountability, and safety of the fire fighters assigned to the company. The duties and responsibilities of the company officer focus on the operations of the company during emergency incidents and non-emergency activities.

NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program* defines a “company” as a group of members (1) under the direct supervision of an officer; (2) trained and equipped to perform assigned tasks; (3) usually organized and identified as engine companies, ladder (truck) companies, rescue companies, squad companies, or multi-functional companies (quint); (4) operating with one piece of fire apparatus (pumper, aerial fire apparatus, elevating platform, quint, rescue, squad, ambulance) except where multiple fire apparatus are assigned that are dispatched and arrive together (task force), continuously operate together, and are managed by a single company officer; (5) arriving at the incident scene on fire apparatus.²⁷ NFPA 1710, *Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments* defines a company officer as a supervisor of a crew/company of personnel. Moreover, each company shall be led by an officer who shall be considered a part of the company.⁴⁸ The person can be appointed in an acting capacity. The rank structure could be either sergeant, lieutenant, or captain.

The company officer is responsible for the direct supervision of the members of the company especially during emergency operations. From an incident management standpoint, the company officer provides the chain of command, unity of command, and provides span of control. When a company arrives at an incident, the fire fighters assigned to the company report directly to the company officer (unity of command) which clarifies reporting protocol. This eliminates the confusion caused by conflicting or multiple orders. Additionally, this reduces the span of control of fire fighters reporting to “Command”.²⁹ Most importantly, the company officer can maintain accountability of the fire fighters assigned to the company. The company officer also serves as the focal point for communications for the company. Though each fire fighter should or has a portable radio, the company officer is the contact for company communications on the fireground unless otherwise specified.

Company officers determine, based upon conditions, the priority of the task level functions for their company unless otherwise ordered by “Command”. The assignment of these task level functions represents a standard strategy for tactical operations designed to improve the effectiveness and safety of all companies working together. Splitting companies into individual fire fighters without a company officer creates an issue with span of control, personnel accountability (freelancing), and unity of command. This is particularly difficult during the early stages of an incident. Without an assigned or designated company officer, it is much more difficult for the Incident Commander or tactical level management to account for the location and function of individual fire fighters.

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At this incident, Engine 3 arrived on scene with a driver/pump operator and a fire fighter. Upon arrival, the fire fighter of Engine 3 went directly to the incident scene without waiting for the driver/pump operator. The driver/pump operator had to don his personal protective equipment and SCBA before going to the incident scene. The fire fighter was assigned to the attack hose line on the 2nd floor by the Incident Commander (C2) and stayed there until he came out with the lieutenant from Engine 5. The driver/pump operator was initially assigned to the back-up hoseline by "Command". When the driver/pump operator got inside the fire apartment, the fire fighter from Engine 3 and the lieutenant from E5 were leaving the building.

Recommendation #12: Provide chief officers with a staff assistant or chief's aide to help manage information and communication.

Discussion: A chief's aide, staff assistant or field incident technician are positions designed to assist an Incident Commander with various operational duties during emergency incidents. The chief's aide is an essential element for effective incident management. At an emergency incident, the staff assistant can assist with key functions, such as managing the tactical worksheet; maintaining personnel accountability of all members operating at the incident (resource status and deployment location); monitoring radio communications on the dispatch, command, and fireground channels; controlling information flow by computer, fax, or telephone; and accessing reference material and pre-incident plans.

One of the essential functions or responsibilities of a chief's aide is to manage the personnel accountability system, a vital component of the fire fighter safety process. Accountability on the fireground can be maintained in a variety of methods. The intent is to have a functional system that is designed to account and track personnel as they perform their fireground tasks. In the event of an emergency or "Mayday", the chief's aide uses this system to provide a rapid accounting of all responders at the incident.

Chief officers are required to respond quickly to emergency incidents. In their response, they have to be fully aware of heavy traffic conditions, construction detours, traffic signals, and other conditions. More importantly, the chief officer must also monitor and comprehend radio traffic to assess which companies are responding, develop a strategy for the incident based upon input from first-arriving officers, and develop and communicate an incident action plan that defines the strategy of the incident. A chief's aide can assist the battalion chief or chief officer in processing information without distraction and can complete the necessary tasks en route to the scene.⁴⁹

Departments should consider the chief's aide to be an individual who has the experience and authority to conduct the required tasks. Other potential roles for the chief's aide include assisting with the initial size-up, completing a 360-degree size-up, coordinating progress reports from sector/division officers, and many others. The aide position can be used as a training position to help facilitate officer development. There also are non-emergency functions for the chief's aide that is vital to the daily operations of the department. Some jurisdictions assign a chief's aide to command officers to perform daily administration functions (such as position staffing and leave management).

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At this incident, a chief's aide could have helped establish the command post. As the Incident Commander develops the strategy and Incident Action Plan, a chief's aide could have established the personnel accountability process of all members operating at the incident (resource status and deployment location). In addition, a chief's aide could assist with maintaining the tactical worksheet.

Recommendation #13: Provide pre-placement and annual medical evaluations to all fire fighters consistent with NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Department.

Discussion: To reduce the risk of sudden cardiac arrest or other incapacitating medical conditions among fire fighters, the National Fire Protection Association Technical Committee on Fire Service Occupational Safety and Health developed NFPA1582, *Standard on Comprehensive Occupational Medical Program for Fire Departments*.⁵⁰ This voluntary industry standard provides the components of a pre-placement and annual medical evaluation and medical fitness for duty criteria.

The victim was 42 years old and was not known to have coronary heart disease prior to the autopsy. Screening tests to detect coronary heart disease are not recommended until age 45; therefore, even if the fire department was following NFPA 1582, it is unlikely an annual medical evaluation would have prevented his sudden cardiac death.^{50, 51}

Recommendation #14: Phase-in a mandatory comprehensive wellness and fitness program for fire fighters.

Discussion: Worksite health promotion programs have been shown to be cost effective by increasing productivity, reducing absenteeism, and reducing the number of work-related injuries and lost work days.^{52,53, 54} Fire service health promotion programs have been shown to reduce coronary heart disease risk factors and improve fitness levels, with mandatory programs showing the most benefit.^{55, 56, 57} A study conducted by the Oregon Health and Science University reported a savings of more than \$1,000,000.00 for each of four large fire departments implementing the International Association of Fire Fighters/International Association of Fire Chiefs *Wellness/Fitness Program* compared to four large fire departments not implementing a program. These savings were primarily due to a reduction of occupational injury/illness claims with additional savings expected from reduced future non-occupational healthcare costs.⁵⁸ The fire department currently has a voluntary wellness/fitness program. NIOSH recommends a formal, mandatory wellness/fitness program to ensure all members receive the benefits of a health promotion program.⁵⁰

Recommendation #15: Phase-in an annual physical performance (physical ability) evaluation for all members.

Discussion: NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, requires that a fire department develop physical performance requirements for both candidates and members who engage in emergency operations.²⁷ Members who engage in emergency operations

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must be annually qualified (physical ability test) as meeting these physical performance standards for structural fire fighters.²⁷

This evaluation could be incorporated into the fire department's annual training.

Recommendation #16: Ensure fire fighters are cleared for return to duty by a physician knowledgeable about the physical demands of fire-fighting operations, the personal protective equipment used by fire fighters, and the various components of NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments.

Discussion: NFPA 1582 *Standard on Comprehensive Occupational Medical Program for Fire Departments* contains criteria for medical fitness for duty.

The victim had two known conditions relevant for medical clearance: hydrocephalus, and diabetes mellitus. The hydrocephalus was treated with surgery and after a long rehabilitation period, he was able to resume full duty. The victim also had type 2 diabetes mellitus that did not require insulin. He had good control of his sugars (glucose) and did not have any hypoglycemic episodes. However the victim was reported to have a number of diabetic complications (e.g., retinopathy, peripheral neuropathy, and nephropathy). According to NFPA 1582 *Standard on Comprehensive Occupational Medical Program for Fire Departments* these complications should have triggered work restrictions.⁵⁰

Additionally,

Recommendation #17: The fire department should consider upgrading their self-contained breathing apparatus (SCBA) to the most current edition of NFPA 1981, Standard on Open Circuit Self-Contained Breathing Apparatus (SCBA) for Emergency Services.⁵⁹

Discussion: Many improvements have been made to self-contained breathing apparatus (SCBA) in the 2002 and 2007 editions of NFPA 1981 *Standard on Open Circuit Self-Contained Breathing Apparatus (SCBA) for Emergency Services* since 1997. The SCBA that the victim was using was certified to the 1997 edition of NFPA 1981.

One of the most important improvements is the addition of a remote air display inside the user's SCBA facepiece. This remote display, known as a heads-up display (HUD), allows the fire fighter to see how much air they have remaining in a low visibility, immediately dangerous to life and health (IDLH) atmosphere. This allows the fire fighter to adjust operations so they can exit with their reserve air intact. If a fire fighter does not have a HUD, they may not know that they are low on breathable air until their "end of service time indicator" (EOSTI) sounds. Fire fighters should be trained in air management skills so they exit before their EOSTI sounds and thereby retain their emergency reserve air for overcoming an out of air emergency.⁶⁰ The HUD is an important tool in the later editions of NFPA 1981, which allows fire departments and fire fighters to better use air management techniques on the fireground. Another important upgrade to the 2002 edition of NFPA 1981⁵⁹ is the addition of the rapid intervention crew/universal air connection (RIC/UAC) connection which gives the fire fighters a means to have a rapid intervention crew (RIC) refill a cylinder while they are still in an

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IDLH atmosphere. Other improvements to the SCBA include better electronics protection from heat and moisture, the addition of nose cups to reduce the CO₂ levels inside the SCBA facepiece, lighter and higher volume cylinders and protection against CBRN agents.

Additionally, some of the changes to the 2007 edition of NFPA 1982 *Standard on Personal Alert Safety System (PASS)* ⁶¹ include the following:

- The PASS is exposed to 350° F for 15 minutes and then submerged in 1.5 meters (4.9 ft) of water, also for 15 minutes, for each of 6 cycles. The PASS is then examined to determine no water ingress. All PASS signals must function properly, and electronic data logging functions must operate properly. Following this, the PASS is re-immersed in the test water for an additional 5 minutes with the power source compartment(s) open; after 5 minutes, the PASS is removed from the water and wiped dry, and then the electronics compartment is opened and examined to determine no water ingress.
- Revised high-temperature resistance requirements and added new high temperature functional requirements and testing procedures where the PASS is mounted in a circulating hot-air oven at 500°F for 5 minutes. The PASS alarm signal must function at or above the required 95 dBA sound level, electronic data logging functions must operate properly, and no part of the PASS can show evidence of melting, dripping, or igniting.
- New tumble-vibration requirements and testing in which the PASS is "tumbled" in a rotating drum for 3 hours. The PASS alarm signal must function at the required 95-dBA sound level and electronic data logging functions must operate properly.
- New "muffling" of the alarm signal requirements and testing in which the PASS is mounted on a test subject and evaluated in five positions (face down with arms extended, supine left, supine right, fetal right with knees drawn to chest, fetal left with knees drawn to chest), and the alarm signal must function at or above the required 95-dBA sound level.⁶¹

Contact the department's PASS device manufacturers, ask them about any reported problems with the devices, and what upgrades they may be offering, if any, that may be made to allow current devices to meet the 2007 edition of NFPA 1982.

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Investigator Information

This incident was investigated by Murrey E. Loflin, Investigator and Stephen T. Miles, Safety, Occupational Health Specialist, with the Fire Fighter Fatality Investigation and Prevention Program, Surveillance and Field Investigations Branch, Division of Safety Research, NIOSH located in Morgantown, WV. Dr. Thomas Hales (MD, MPH) Division of Surveillance, Hazard Evaluations, and Field Studies (DSHEFS) in Cincinnati, OH conducted the medical investigation and co-authored the investigation report. Dr. Hales is a member of the NFPA Technical Committee on Fire Service Occupational Safety and Health and Vice-Chair of the Public Safety Medicine Section of the American College of Occupational and Environmental Medicine (ACOEM). An expert technical review was provided by Stephen Raynis, Chief of Safety, Fire Department of New York (FDNY). A technical review was also provided by the National Fire Protection Association, Public Fire Protection Division.

Additional Information

IAFF Fireground Survival Program. The purpose of the Fire Ground Survival program is to ensure that training for Mayday prevention and Mayday operations are consistent between all fire fighters, company officers and chief officers. Fire fighters must be trained to perform potentially life-saving actions if they become lost, disoriented, injured, low on air or trapped. Funded by the IAFF and assisted by a grant from the U.S. Department of Homeland Security (DHS) through the Assistance to Firefighters (FIRE Act) grant program, this comprehensive Fire Ground Survival training program applies the lessons learned from fire fighter fatality investigations conducted by the National Institute for Occupational Safety and Health (NIOSH) and has been developed by a committee of subject matter experts from the IAFF, the International Association of Fire Chiefs (IAFC) and NIOSH.

<http://www.iaff.org/HS/FGS/FGSIndex.htm>.

IAFC Rules of Engagement for Firefighter Survival. The International Association of Fire Chiefs (IAFC) is committed to reducing firefighter fatalities and injuries. As part of that effort the nearly 1,000 member Safety, Health and Survival Section of the IAFC has developed DRAFT “Rules of Engagement for Structural Firefighting” to provide guidance to individual firefighters, and incident commanders, regarding risk and safety issues when operating on the fireground. The intent is to provide a set of “model procedures” for Rules of Engagement for Structural Firefighting to be made available by the IAFC to fire departments as a guide for their own standard operating procedure development. http://www.iafcsafety.org/downloads/Rules_of_Engagement.pdf.

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Appendix One

**Summary of Personal Protective Equipment Evaluation
Status Investigation Report of One
Self-Contained Breathing Apparatus
Submitted By the
Fire Department
NIOSH Task Number 17077
(Note: Full report is available upon request)**

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 a SCBA identified as Scott Health and Safety model AirPak, 4.5, 4500 psig, 30-minute, self-contained breathing apparatus (SCBA).

This SCBA status investigation was assigned NIOSH Task Number 18361. The NIOSH Division of Safety Research (NIOSH/DSR) was advised that NIOSH/NPPTL/TEB would provide a written report of the inspections and any applicable test results.

The SCBA unit, contained within a carrying case manufactured by the Pelican Company, was delivered to the NIOSH facility in Bruceton, Pennsylvania, on February 24, 2012. After the arrival, the package was taken to Building 20 and stored under lock until the time of the evaluation.

SCBA Inspection Report

The package was opened initially in the General Inspection Area (Building 20) on February 28, 2012 and a visual inspection was conducted by Tom Pouchot, General Engineer at the National Personal Protective Technology Laboratory (NPPTL), Technology Evaluation Branch (TEB). The SCBA contained within the carrying case was labeled by NPPTL as SCBA Unit #1. The unit was identified as the Scott Health and Safety Company model AirPak, 4.5, 30-minute, 4500 psig unit, NIOSH approval number TC-13F-0076. The SCBA unit was examined, component by component, in the condition received to determine the conformance of the unit to the NIOSH approved configuration. The visual inspection process was documented photographically.

It was judged that Unit #1 could be safely pressurized and tested, using a replacement cylinder supplied by the fire department.

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SCBA Testing

The purpose of the testing was to determine the conformance of the SCBA 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 conformance of each SCBA 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*, 1997 Edition.

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, 1997 Edition):

7. Air Flow Performance Test [Chapter 5, 5-1.1]

Unit #1 was tested on March 8 and 12, 2011. The March 8, 2012 testing was observed by representatives of the fire department.

Summary and Conclusions

A SCBA unit was submitted to NIOSH by the NIOSH Division of Safety Research (NIOSH/DSR) for evaluation. The SCBA unit was delivered to NIOSH on February 24, 2012, and inspected on February 28, 2012. The unit was identified as a Scott Health and Safety model AirPak 4.5, 4500 psig, 30-minute, SCBA (NIOSH approval number TC-13F-0076). The unit suffered minimal heat damage, exhibited other signs of wear and tear, and the unit was covered slightly with dirt. The cylinder was within certification as the recertification label was dated 04/2011. The cylinder had sufficient damage present that a replacement cylinder supplied by the fire department was utilized for testing. The regulator and facepiece mating and sealing areas on the unit were relatively clean and there was some debris on the inside of the facepiece. The rubber face seal was in fair shape but dirty. The harness webbing on the unit was in good condition with no fraying or tears but the webbing was slightly dirty. The PASS device on the unit did not function. The batteries were replaced and the PASS device functioned normally. The SCBA NFPA approval label on the unit was present and readable. Visibility through the lens of the unit facepiece was fair as the lens had light scratches and dirt present.

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The cylinder was within the hydro certification when last used as the test date of 04/2011 was marked.

A replacement cylinder was utilized for testing the SCBA Unit #1. No other maintenance or repair work was performed on that unit at any time. SCBA Unit #1 met the requirements of the NIOSH Positive Pressure Test, with a minimum pressure of 0.2 inches of water. Unit #1 **did** meet all the requirements of all the other tests. In light of the information obtained during this investigation, NIOSH has proposed no further action on its part at this time. Following inspection and testing, the SCBA was returned to storage pending return to fire department. If the unit is to be placed back in service, the SCBA must be repaired, tested, and inspected by a qualified service technician, including such testing and other maintenance activities as prescribed by the schedule from the SCBA manufacturer. Typically a flow test is required on at least an annual basis.

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Appendix Two

Personal Protective Equipment Evaluation

The NIOSH NPPTL SCBA evaluation report will be appended when it is finalized.