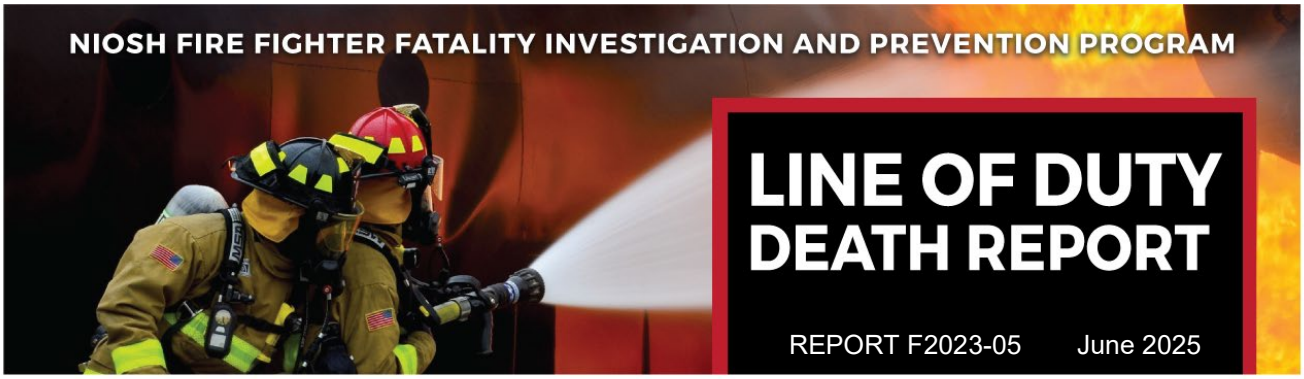


1000 FREDERICK LANE, MORGANTOWN, WV 26508 · 304.285.5916

Firefighter Dies After Becoming Lost in the Attic at a Residential Structure Fire – Illinois

Executive Summary

On April 4, 2023, a 49-year-old firefighter died after becoming lost in the attic of a residential structure. At 03:23 hours, the Office of Emergency Management and Communications (OEMC) transmitted a Still Alarm (first response) for a residential structure fire for Box 142016. Battalion Chief 22 (BC22), Engine 75 (E75), Engine 115 (E115), Tower Ladder 24 (TL24), and Truck 27 (T27) were dispatched. OEMC transmitted a Working Fire Dispatch (confirmed fire, additional resources deployed) for Box 142016 at 03:25 hours with several additional units dispatched. E75 arrived on-scene at 03:26 hours and advised this was a working fire. E75 stretched a horseshoe hose load (100-feet of 2½-inch and 100-feet of 1¾-inch) to the fire building (middle building in **Photo 1**) but there was a delay in getting water due to a lack of water pressure. TL24 and BC22 arrived at 03:29 hours. A member of TL24 forced the door of the fire building for E75. The E75 nozzle and E75 officer were going up the stairs to the 2nd floor where the fire was located. The stairs were compromised, and they were ordered out of the building. The Incident Commander (IC) requested a Still and Box Alarm for Box 142016 at 03:31 hours and the OEMC dispatched several additional units. E75 hydrant (establishes water supply to the engine) (deceased firefighter) was assigned to take the hoseline from E75 nozzle to knock down the fire showing from the Delta 1 exposure (side of the structure shown on the right in photographs) (white building to the right in **Photo 1**). At approximately 03:37 hours, E75 hydrant and E75 officer went into the Delta 1 exposure and worked their way to the attic. The conditions in the attic were hot with heavy smoke, and there

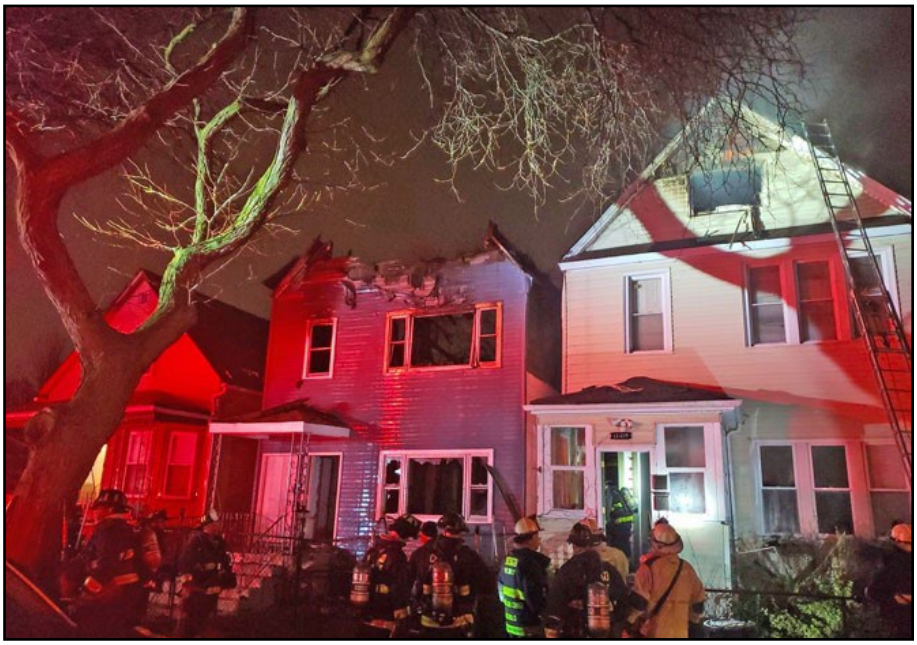


Photo 1: A firefighter was lost in the attic of the white residential structure (Delta 1 exposure).
(Courtesy of the fire department)

was fire in the side Alpha/side Bravo corner of the attic. E75 hydrant was attacking the fire, when E75 officer's low-air alarm or end-of-service-time-indicator (EOSTI) sounded. IC ordered an evacuation of the Delta 1 exposure at 03:55 hours. The E75 officer told E75 hydrant that they were to leave the attic, which E75 hydrant acknowledged. When E75 officer got down to the 1st floor, E75 hydrant was not behind him. He radioed E75 hydrant with no response and also called IC asking the location of E75 hydrant. IC transmitted a Mayday at approximately 04:04 hours. Squad 5 (SQ5) entered the Delta 1 exposure and went to the attic. SQ5 found E75 hydrant in the knee wall of the attic on the side Charlie corner at approximately 04:11 hours. A master stream flowing from TL24 into the attic was shut down. SQ5 and a member of T27 got E75 hydrant out of the attic while his EOSTI was sounding. They brought him down the stairs and out of the building at 04:18 hours. While coming down the stairs, E75 hydrant had his SCBA facepiece on, but it became dislodged. E75 hydrant was transported to a local trauma center at 04:28 hours where he was subsequently pronounced deceased. The medical examiner later reported his cause of death to be carbon monoxide (CO) toxicity from smoke and soot inhalation, with contribution of thermal injuries and hypertensive arteriosclerotic cardiovascular disease. The fire at Box 142016 was declared under control at 06:10 hours.

Contributing Factors

- *Size-up and risk assessment*
- *Crew integrity*
- *Personnel accountability*
- *Rapid intervention team/crew*
- *Simultaneous interior and exterior operations*
- *Occupational medical evaluations*
- *Wellness and fitness program*

Key Recommendations

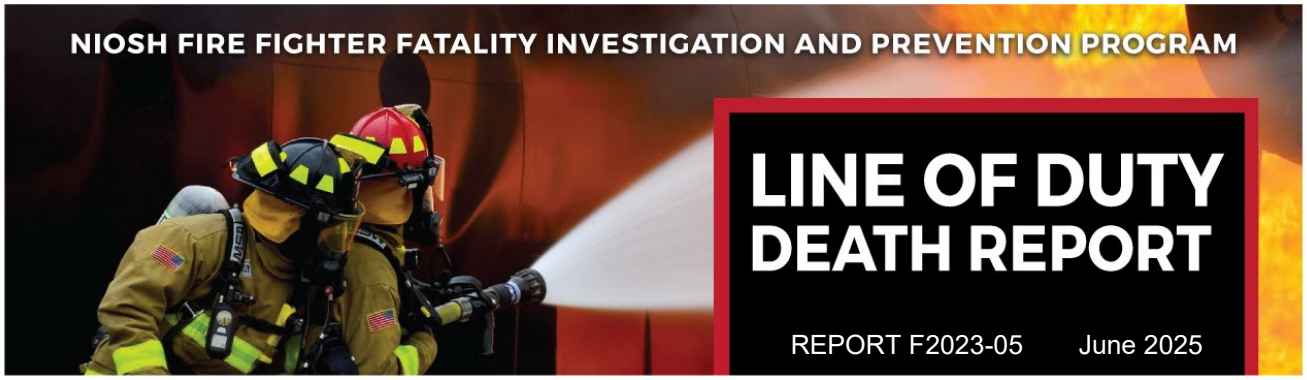
NIOSH offers the following recommendations:

- *Key Recommendation #1: Ensure initial and ongoing size-ups and risk assessments are conducted throughout the incident.*
- *Key Recommendation #2: Company officers and firefighters maintain crew integrity when operating in the hazard zone.*
- *Key Recommendation #3: Ensure ICs immediately establish divisions/groups with a supervisor to communicate conditions and provide accountability.*
- *Key Recommendation #4: Ensure a rapid intervention team/crew is dedicated, assigned, and in place before interior firefighting operations begin and throughout an incident.*
- *Key Recommendation #5: Ensure interior and exterior operations, such as water application, are not conflicting.*
- *Key Recommendation #6: Ensure that firefighters undergo cardiovascular disease screening as recommended in NFPA 1582.*
- *Key Recommendation #7: Implement a mandatory wellness and fitness program for fire department members that is consistent with **NFPA 1583, Standard on Health-Related Fitness Programs for***

Firefighter Dies After Becoming Lost in an Attic at a Residential Structure Fire – Illinois

***Fire Department Members**, and the International Association of Fire Fighters/International Association of Fire Chiefs (IAFF/IAFC) **Wellness-Fitness Initiative**.*

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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Firefighter Dies After Becoming Lost in an Attic at a Residential Structure Fire – Illinois

Introduction

On April 4, 2023, a 49-year-old firefighter died after becoming lost in the attic of a residential structure. The firefighter was transported to a local trauma center where he was pronounced deceased. On April 5, 2023, the U.S. Fire Administration (USFA) announced this fatality through its firefighter fatality email notification service. Three investigators representing the National Institute for Occupational Safety and Health (NIOSH) Fire Fighter Fatality Investigation and Prevention Program traveled to Illinois to investigate this incident onsite from July 9 to July 17, 2023.

During the investigation, NIOSH representatives interviewed the following people:

- Fire commissioner
- Deputy fire commissioners of fire operations and EMS operations
- Chief of safety (district chief)
- Fire department attorney
- Battalion chief of the Office of Fire Investigations (OFI)
- Deputy district chief of Bureau of Logistics
- District chief of training (Chief of Training)
- Vice President and now current President of International Association of Fire Fighters (IAFF) local
- County medical examiner
- Lieutenant with the department's communications division

NIOSH investigators interviewed command officers, company officers, and firefighters assigned to Box 142016 on Still Alarm, Rapid Intervention Team (RIT) Dispatch, the Still and Box Alarm, and 2nd Alarm. The investigators reviewed training records and requirements, standard operating procedures (SOPs), and general orders used by the fire department. A complete record of the fire alarm office radio transmissions was reviewed.

Fire Department

The fire department involved in this incident is a career department. At the time of this incident, the department had 5,143 full-time members. The fire department is led by a fire commissioner and is assisted by a 1st deputy fire commissioner who oversees the four bureaus—Operations, Fire Administrative Services (which oversees the Personnel Division), the Employee Assistance Program

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Unit, and the Training Division. The Personnel Division manages the Medical Section that monitors the health and fitness of all uniformed members of the department.

The Bureau of Operations is the department's largest staffed bureau, consisting of 4,500 uniformed firefighters and paramedics, many of whom are "cross-trained." The Bureau of Operations consists of four divisions: Fire Suppression and Rescue, Emergency Medical Services (EMS), Special Operations, and the Office of Fire Investigation (OFI).

The Fire Suppression and Rescue Division is responsible for the day-to-day operations of all fire suppression companies in the 98 firehouses dispersed throughout the city. When those companies are not fighting fires or responding to EMS incidents, they are responsible for conducting daily training, school inspections, and fire hydrant inspections within their first due district. The division staffs 96 engine companies, 61 truck companies, 4 squads (heavy rescues which are 2-piece companies), 25 battalions (battalion chiefs), 14 deputy district chiefs, and 8 district chiefs, which are divided into 5 districts. The department covers a land area of 228 square miles, 37 miles of rivers and waterways, and serves a population of 2,697,000. Department members assigned to the Operations Division work a 24-on/48-off shift schedule with three platoons or shifts.

Each firehouse is assigned a captain. The captain is responsible for the fireground operations and management, firehouse budget, candidate training and evaluation, firefighter supervision, leave management, training schedules for each shift, apparatus maintenance, facility management and maintenance, public fire education, fire inspections, and serving as acting battalion chief as needed.

Each position on an engine, truck, and squad company has a unique identifier that is used for communication purposes (**see Table 1**). If an engine or truck company operates short (staffing of four instead of five), they operate under a variance. There are four squad companies, which are two-piece companies. Each squad company consists of a heavy rescue and a 55-foot snorkel.

Table 1: Staffing Positions for Each Unit

Unit	Staffing Number	Positions
Engine Company	5	Officer; Engineer; Firefighter Pipeman (Pipe); Firefighter Heelman (Heel); Firefighter Hydrant
Truck Company	5	Officer; Driver; Firefighter Roof; Firefighter Entry; Firefighter Search
Squad Company	5	Squad Officer; Squad Driver; Squad Firefighter Rear; Snorkel Firefighter Search; Snorkel Driver / Search

The EMS Division operates 80 advanced life support ambulances, which are staffed with paramedics and emergency medical technicians. EMS field supervisors are assigned to each battalion to assist with staffing, logistical needs, and patient care.

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The OFI is mandated by state law and municipal ordinance to determine the cause and origin of all fires, within the city. The OFI has five 24-hour response units, as well as a Major Incident Response Unit that is outfitted with tools and supplies to compliment the 24-hour vehicles sent to investigate major incidents.

Training, Education, and Professional Development

Illinois Office of the State Fire Marshal

The Illinois Office of the State Fire Marshal (OSFM) does not mandate minimum training requirements for firefighters. However, the OSFM does maintain and oversee a Division of Personnel Standards and Education (DPSE) which promotes, encourages, and assists local governments in improving the levels of education and training standards for local firefighters. While this program is strictly voluntary, the OSFM and the DPSE highly encourage local governments to adopt and complete firefighter certification programs. This includes offering a reimbursement program for firefighter training costs. Additional information about the DPSE's programs can be found on the Division's website, and the General Assembly's Illinois Administrative Code which includes training facilities, examinations and certifications, and a current list of certifications.

Fire Department

This career fire department enacted requirements that exceeded the state's requirements. The fire department hires candidates through the city's civil service process and gives recruitment tests for both single-role paramedics and firefighter positions. Recruits that pass the exam are placed on an eligibility list and that list is sorted in lottery order. The list is referred to as vacancies become available. Recruits must pass a background check, a physical ability test, and a medical examination that complies with NFPA 1582, *Standard on Comprehensive Occupational Medical Program for Fire Departments*.

The fire department operates its own recruit training academy, which is more than 6 months and exceeds the state fire training requirement. The curriculum includes:

- *NFPA 1001 Basic Operations Fire Fighter*
- *NFPA 1002 Fire Service Vehicle Operator* (FSVO) course
- National Incident Management System: *Introduction to the Incident Command System* (ICS100)
- National Incident Management System: *An Introduction to the National Incident Management System* (ICS-700.B)
- National Fallen Firefighters Foundation, *Courage to Be Safe Course*
  NFPA 1072 Standard for Hazardous Materials/Weapons of Mass Destruction Emergency Response Personnel Professional Qualifications (NFPA, 2017)
- *Farm Machinery Extrication*

The recruit academy consists of over 490 classroom and practical training contact hours; written and practical testing per state protocol; successful completion of a physical training test (a minimum of three times throughout instruction); and completion of flashover simulator training. Also, each recruit must complete instruction in EMS and receive a *National Registry of Emergency Medical Technicians*

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Emergency Medical Technician (EMT) Certification.

Firefighter candidates complete a probationary period of nine months from their date of hire. Then, candidates are further reviewed during the field evaluation period, which is 12 months of post-fire academy assignment on a company (engine or truck). The candidate is assigned to the station captain's shift. During this period, firefighters are required to participate in a minimum of two hours of training per shift, which is documented by the company officer. All firefighters must complete a 30-minute SCBA drill at the beginning of each work shift, including monitoring air management. During the SCBA drill, firefighters must add their identification tag to the apparatus collection ring located on the apparatus they are assigned to for the shift.

The battalion chief position is the highest tested rank in the department. Ranks above a battalion chief are appointed by the fire commissioner. The ranks of assistant deputy chief paramedic, deputy district chief, district chief, assistant deputy fire commissioner, deputy fire commissioner, and 1st deputy fire commissioner are appointed by the fire commissioner. The fire commissioner is appointed by the mayor.

E75 hydrant (deceased firefighter) had completed more than 644 hours of training. He graduated from the department's fire academy in 2005. He held numerous certifications such as NFPA 1001 Fire Fighter I and II; NFPA 1002 Fire Service Vehicle Operator; NFPA 1041 Fire Service Instructor I; and EMT-B.

E75 officer had completed more than 1,098 hours of training. He graduated from the department's fire academy in 1993. He held numerous certifications such as NFPA 1001 Fire Fighter I, II, and III; and advanced technician firefighter.

Firefighter Dies After Becoming Lost in the Attic at a Residential Structure Fire – Illinois

Building Construction

The fire building was a 2½-story multi-family occupancy. The structure was vacant at the time of the fire. Bravo 1 exposure and Delta 1 exposure were also 2½-story multi-family occupancies (see Photo 2). Each of these wood frame structures were approximately 25-feet x 50 feet.

Photo 2. The fire building is the structure behind the tree. Bravo 1 exposure is to the left and Delta 1 exposure is to the right (with the traffic cones in the yard). The entrance and access to the 2nd floor on each structure is the door on the side Alpha/side Bravo corner.
(Courtesy of the fire department)

The Delta 1 exposure had an entrance on side Alpha for the 1st floor apartment. The entrance and stairs to the 2nd floor apartment had separate entrance through the front foyer on side Alpha/side Bravo corner. The 2nd floor entrance door had a lock and deadbolt. The attic ran the length of the house from side Alpha to Side Charlie. There was a knee wall on side Bravo and side Delta. Most of the side Bravo roof burned through during the fire. It was reported that the 2nd floor and attic were cluttered.

Firefighter Dies After Becoming Lost in the Attic at a Residential Structure Fire – Illinois

Apparatus, Staffing, and Communications

A Still Alarm was transmitted for Box 142016 at 03:23 hours for a residential structure fire. At 03:25:53 hours, a RIT Dispatch was transmitted. **Table 2** lists the units initially dispatched for the fire and the units added for the working fire assignment.

Table 2: Box 142016 Units

Apparatus	Staffing	Comments
Engine 75	5 – Lieutenant and 4 firefighters	
Engine 115	5 – Lieutenant and 4 firefighters	
Tower Ladder 24	5 – Captain and 4 firefighters	
Truck 27	4 – Captain and 3 firefighters	Running a staffing variance
Battalion 22	1 – Battalion chief	Incident commander
Truck 45	5 – Lieutenant and 4 firefighters	Assigned as RIT
Squad 5	6 – Lieutenant and 5 firefighters	2-piece company
Ambulance 7	2 – EMT and paramedic	
Battalion 21	1 – Battalion chief	RIT chief
Battalion 19	1 – Battalion chief	Safety chief

Fire Department Communications

The city's OEMC operates the 9-1-1 center and dispatch for both fire and police. OEMC operates two dispatch centers for the fire department in the city, one north and one south. The fire department has two basic responses for the report of a structure fire. The alarms are a Still Alarm or a Still and Box Alarm. The Fire Alarm Office dispatches a Still Alarm assignment to initial reports of structure fire. The Still Alarm dispatch then sends two engine companies, two truck companies, and a battalion chief. If the Fire Alarm Office receives additional reports of a fire or a company arrives on scene and reports a "working fire," then a squad company, a command van, and a RIT complement are also dispatched. If the report of a fire is located in a squad company's first due area (approximately 40 blocks), then the squad company is sent automatically. A Still and Box Alarm is usually requested by a fire officer, though there are situations where the Fire Alarm Office can transmit a Still and Box Alarm. These situations can include a person trapped in the fire building, multiple structures on fire, a large commercial building on fire, a building collapse, train derailment, an airport alert (aircraft in distress), or smoke in a building with a high life hazard (e.g., hospital, nursing home, or theater).

Timeline

The timeline is a summary of events that occurred as the incident evolved. Not all incident events are included in this timeline. This timeline lists the dispatch communications, fire department response, fireground communications, and fireground operations. Times that are approximate are rounded to the closest minute. The times to the second, were taken from the Fire Alarm Office radio transmissions, the Fire Alarm Office communications records, the data log information from E75 hydrant's SCBA data log, and EMS patient reports.

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Time	Fireground Operations, Response, and Details
03:23 Hours	• OEMC transmitted a Still Alarm for a residential structure fire for Box 142016. BC22, E75, E115, TL24, and T27 were dispatched.
03:25 Hours	• OEMC transmitted a Working Fire Dispatch for Box 142016. Truck 45 (T45), SQ5, 2-7-5 (command van), Ambulance 76 (A76), Battalion 21 (BC21 and RIT chief), Battalion 19 (sector chief), and 4-5-6 (field chief) were dispatched.
03:26 Hours	• E75 arrived on-scene, advised this was a working fire, and stretched a horseshoe load to the fire building and made the hydrant connection.
03:29 Hours	• TL24 and BC22 arrived on-scene.
03:31 Hours	• IC requested a Still and Box for Box 142016. OEMC dispatched Engine 62 (E62), Engine 120 (E120), Engine 93 (E93), Truck 62 (T62), Chief 2-2-5, Battalion 23 (BC23), 4-5-6, Battalion 20 (BC20) and 2129 (assistant deputy fire commissioner).
03:37 Hours	• E75 hydrant and E75 officer assigned and went into the Delta 1 exposure and worked their way to the attic. • E75 officer requested the roof be vented upon arrival in the attic.
03:55 hours	• E75 hydrant was attacking the fire, when E75 officer's EOSTI sounded. • IC ordered an evacuation of the Delta 1 exposure.
04:04 Hours	• E75 officer got down to the 1st floor, but E75 hydrant was not with him. • IC transmitted a Mayday for a missing firefighter.
04:05 – 04:10 Hours	• SQ5 then entered the Delta 1 exposure and went to the attic. • BC23 transmitted a Mayday stating companies were on the 2nd floor.
04:11 Hours	• SQ5 found E75 hydrant in the knee wall of the attic on side Bravo near side Charlie. • A master stream flowing from TL24 into the attic was shut down.
04:12 – 04:18 Hours	• SQ5 and a member of T27 got E75 hydrant out of the attic while his EOSTI was sounding. They brought him down the stairs on side Charlie headfirst and companies operating there helped get E75 hydrant out of the structure
04:28 Hours	• E75 hydrant was transported to a local trauma center.

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Time	Fireground Operations, Response, and Details
06:10 Hours	• The fire at Box 142016 was declared under control by IC.

Personal Protective Equipment

At the time of the incident, E75 hydrant was wearing full structural firefighting turnout gear including helmet, protective hood, gloves, and boots. He was also wearing a NIOSH Approved® SCBA with a medium facepiece. The structural firefighting turnout gear and SCBA were not considered a contributing factor to the fatality in this incident.

Weather Conditions

At 02:53 hours, the weather was fair with an approximate temperature of 45°F. The dew point was 48°F and the relative humidity was 90%. The winds were 15 mph from the northeast [Weather Underground 2023].

Investigation

April 4, 2023, a 49-year-old firefighter died after becoming lost in the attic of a residential structure. At 03:23 hours, the OEMC transmitted a Still Alarm for a residential structure fire for Box 142016. BC22, E75, E115, TL24, and T27 were dispatched. OEMC transmitted a Working Fire Dispatch for Box 142016 at 03:25 hours. T45, SQ5, 2-7-5, A76, BC21 and RIT chief, Battalion 19 (sector chief), and 4-5-6 were dispatched.

E75 arrived on-scene at 03:26 hours and advised this was a working fire. The fire originated in a single residential structure. Prior to fire department arrival, it extended to Bravo 1 exposure and Delta 1 exposure. E75 arrived southbound and stretched a horseshoe hose load (100-feet of 2½-inch and 100-feet of 1¾-inch) to the fire building (middle building in **Photo 1**) but there was a delay in getting water due to a lack of water pressure. TL24 and BC22 arrived at 03:29 hours. A member of TL24 forced the door of the fire building for E75 and BC22 assumed the role of IC. E75 nozzle and E75 officer were going up the stairs to the 2nd floor where the fire was located. The stairs were compromised, and they were ordered out of the building. IC requested a Still and Box Alarm for Box 142016 at 03:31 hours. OEMC dispatched E62, E120, E93, T62, Chief 2-2-5, BC23, 4-5-6, BC20, and 2129.

E75 hydrant (deceased firefighter) took the hoseline from E75 nozzle to knock down the fire showing from the Delta 1 exposure (white building to the right in **Photo 1**). At approximately 03:37 hours, E75 hydrant and E75 officer went into the Delta 1 exposure and worked their way to the attic. When they reached the attic, E75 officer requested the roof be vented. The conditions in the attic were hot with heavy smoke, and there was fire in the side Alpha/side Bravo corner of the attic. E75 hydrant was attacking the fire, when E75 officer's EOSTI sounded. E75 was getting ready to leave the attic when IC ordered an evacuation of the Delta 1 exposure at 03:55 hours. The E75 officer told E75 hydrant that they were to leave the attic, which E75 hydrant acknowledged.

E75 officer met BC23 on the 2nd floor and advised him that E75 was leaving the building. When E75 officer got down to the 1st floor, E75 hydrant was not behind him. He radioed E75 hydrant with no

response and also called IC asking the location of E75 hydrant. IC transmitted a Mayday at approximately 04:04 hours. E75 officer met with SQ5 officer and explained that E75 hydrant was missing. SQ5 then entered the Delta 1 exposure and went to the attic. BC23 transmitted an additional Mayday stating companies were on the 2nd floor.

A firefighter came down the stairs to report there was a firefighter down in the attic. SQ5 found E75 hydrant in the knee wall of the attic on the side Charlie corner at approximately 04:11 hours. A master stream flowing from TL24 into the attic was shut down. SQ5 and a member of T27 got E75 hydrant out of the attic while his EOSTI was sounding. They brought him down the stairs on side Charlie headfirst and companies operating there helped get E75 hydrant out of the building at 04:18 hours. While coming down the stairs, E75 hydrant had his SCBA facepiece on, but it became dislodged. The SCBA free flowed until the cylinder was empty at 04:19 hours. E75 hydrant was noted to be pulseless and cardiopulmonary resuscitation was initiated. E75 hydrant was transported to a local trauma center at 04:28 hours where he was subsequently pronounced deceased. The fire at Box 142016 was declared under control by IC at 06:10 hours.

Fire Origin and Cause

The cause and origin of the fire was investigated by the authority having jurisdiction and was determined to be arson.

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. NIOSH investigators identified the following items as key contributing factors in this incident that ultimately led to the fatality:

- *Size-up and risk assessment*
- *Crew integrity*
- *Personnel accountability*
- *Rapid intervention team/crew*
- *Simultaneous interior and exterior operations*
- *Occupational medical evaluations*
- *Wellness and fitness program*

Cause of Death and Medical Findings

The medical examiner noted E75 hydrant's cause of death as carbon monoxide (CO) toxicity from smoke and soot inhalation, with contribution of thermal injuries and hypertensive arteriosclerotic cardiovascular disease. Supporting these diagnoses are autopsy records documenting the physical examination, laboratory blood testing, and microscopic examination of tissue by a pathologist.

At the time of his autopsy on April 5, 2023, E75 hydrant was 5'8" (147 centimeters) tall and weighed 289 pounds (131 kilograms), with a calculated body mass index (BMI) of 43.9 kilograms per square meter (kg/m^2). A BMI greater than or equal to 30 kg/m^2 is considered obese. Examination of his body revealed 4 small burn marks distributed over both the left and right sides of his head. He also had a 3.5-inch (8.89-centimeter) abraded burn to the right side of his neck, and a 2-inch (5.08-centimeter)

abraded burn to the back of his neck. Soot was present in the upper and lower airways, and tissue erythema (redness) and red and brown secretions were noted in the airways extending down to the lungs, a sign of inhalation injury. Closer examination of the lung tissue showed diffuse vascular congestion. In addition to these acute injuries, he also had signs of chronic heart disease, with severe coronary artery atherosclerosis, or arteriosclerosis, as noted in his cause of death. His left anterior descending coronary artery, which supplies blood to a large portion of heart muscle including the left ventricle, showed 75%-90% blockage with atherosclerotic plaque.

Six tissue samples were collected and sent for microscopic examination; they were taken from the left ventricle of the heart, coronary arteries, lungs, trachea, liver, and kidneys. Notably, the lung specimen showed changes consistent with inhalation injury, and the trachea showed damaged respiratory epithelium with focal areas of black soot deposition.

When CO is inhaled, it binds to hemoglobin in the blood and forms carboxyhemoglobin [Hampson et al. 2012]. Laboratory testing of E75 hydrant's blood collected from sample sites in the heart and the inferior vena cava at autopsy revealed a carboxyhemoglobin saturation of 25%-30%. Normal saturation is ≤ 3.5% in nonsmokers and ≤ 8% in smokers, and symptoms of CO toxicity will often start to appear around 10% saturation [NMS Labs 2023].

Prior to his death, E75 hydrant had a medical history significant for prediabetes, mixed hyperlipidemia (high cholesterol), vitamin D deficiency, gout, and several longstanding musculoskeletal diagnoses causing chronic pain. Per his primary care provider, he was not a smoker, and he tried to exercise twice a week. He did not have a known history of heart disease, and though a computerized tomography scan for heart calcium scoring was ordered in 2021, it is unclear if the scan was ever performed.

Discussion of Carbon Monoxide and Cardiovascular Disease

Though the medical examiner concluded E75 hydrant's cause of death was CO toxicity, his underlying cardiovascular disease likely contributed. In most cases, death from untreated CO toxicity occurs at blood carboxyhemoglobin saturations > 40% [NMS Labs 2023]. E75 hydrant's saturation was 25%-30%, certainly high enough to cause symptoms of toxicity but potentially survivable. However, CO exposure can cause exacerbation of underlying heart disease [Atkins 1985].

CO is a colorless, odorless gas produced by incomplete combustion of carbon compounds [Kao and Nañagas 2006; Rose et al. 2017]. The products of combustion will vary from fire to fire and depend on the materials present and the conditions under which they are burning, so firefighters might be exposed to a wide variety of chemical compounds in their work. While identification of the exact atmospheric composition at the scene of a specific fire is not possible, it is known that CO is commonly produced [Lees 1995]. The NIOSH recommended immediately dangerous to life and health (IDLH) concentration for CO is 1,200 parts per million (ppm) [NIOSH 2016]. Researchers have reported levels of 70,000 ppm in the room of origin during a fire and levels over 10,000 ppm in a room that was remote from the fire [Alarie 2002]. CO levels up to 2,500 ppm were reported outside the fire room during fire suppression and victim removal in a realistic modern fire environment [Horn et al. 2013].

When inhaled, CO passes from the lungs into the bloodstream and binds to hemoglobin, the oxygen-

carrying molecule in red blood cells, to form carboxyhemoglobin. CO has an approximately 200-250 times greater affinity for binding to hemoglobin than oxygen has, meaning if CO is present, oxygen will be displaced and not carried to the rest of the body. This mechanism, as well as cellular damage caused directly by exposure to CO, causes the symptoms of CO toxicity [Hampson et al. 2012; Kao and Nañagas 2006; Roderique et al. 2015]. Common symptoms of CO toxicity are headache, fatigue, and nausea, but higher levels of exposure can lead to altered mental status and eventually death [Hampson et al. 2012]. While symptoms are generally worse with more concentrated or prolonged exposure and higher blood carboxyhemoglobin concentrations, degree of symptoms and clinical outcomes do not correlate perfectly with lab values [Benignus et al. 1987; Hampson 2016]. Heavy exertion, as a firefighter might be engaged in during fire suppression activities, can hasten intake of CO as the respiratory rate increases. Underlying medical conditions that increase sensitivity to low blood oxygen saturation, such as E75 hydrant's coronary artery disease, can also predispose to symptom development at lower levels of CO exposure [Atkins and Baker 1985; Kao and Nañagas 2006; Thom and Keim 1989].

Nearly half of all firefighter duty-related deaths are caused by sudden cardiac death. A study of data gathered at autopsy found that approximately 80% of firefighters who suffered duty-related sudden cardiac deaths had atherosclerosis, cardiomegaly (enlarged heart), or both [Smith et al. 2018]. The prevalence of coronary artery disease in firefighters is concerning in its own right, but the potential for CO exposure in firefighting work adds another layer of risk. Firefighters with coronary artery disease are at heightened risk of poor outcomes with CO exposure, as oxygen delivery to their heart is already compromised by obstructed coronary arteries and then will be further reduced through the displacement of oxygen in the blood by CO. The heart muscle has high oxygen demand, which increases further during physical exertion, and restriction of oxygen supply can cause sudden cardiac death through heart attack or arrhythmia [Huzar et al. 2013].

Recommendations

NIOSH offers the following recommendations to reduce the risk of heart attacks and sudden cardiac arrest among firefighters at this and other fire departments across the country.

Recommendation #1: Ensure initial and ongoing size-ups and risk assessments are conducted throughout the incident.

Continuous communication supports effective risk assessments. It also allows the IC and all personnel operating at an incident to be aware of changing conditions and adjust to avoid hazards or mitigate risks. A 360-degree survey is an important component of the scene size-up and can be used in the risk assessment. The International Association of Fire Chiefs' *Rules of Engagement for Structural Firefighting* recommends that the first rule for ICs is to rapidly conduct or obtain a 360-degree survey of the incident. Many incidents contain obstacles that prevent the viewing of all sides of a structure. When 360-degree reconnaissance is achieved, it provides the IC and personnel knowledge of the building layout, construction, access/egress points, fire location and direction of spread, and obstacles or hazards [NIOSH 2017].

A dedicated incident safety officer (ISO) can perform initial and ongoing size-ups throughout the

incident. Expectations and authority for the ISO include determining hazardous incident conditions, advising the IC to modify control zones or tactics to address corresponding hazards, communicating fire behavior and forecasting growth, and estimating building/structural collapse hazards. The ISO also has the authority to stop or suspend incident operations based on imminent threats to firefighter safety [NFPA 1550 2024]. The ISO should be separate from the IC, operations, or accountability positions so they can focus on their responsibilities and the primary objective of continually assessing all on-scene hazards to firefighter life and safety [NIOSH 2025]. This also includes ensuring rehab is set up for firefighters to hydrate and have their vitals checked.

Recommendation #2: Company officers and firefighters maintain crew integrity when operating in the hazard zone.

Crew integrity is essential to fireground accountability. NFPA 1550 *Standard for Emergency Responder Health and Safety* states in Paragraph 10.5.6 that company officers shall maintain an ongoing awareness of the location and condition of all company members. Paragraph 10.5.7 states that, where assigned as a company, members shall be responsible to remain under the supervision of their assigned company officer [NFPA 1550 2024]. It is the responsibility of every firefighter and company officer to always stay in communication or contact with crew members by visual observation, voice, or touch while operating in the hazard zone. All firefighters should maintain the unity of command by operating under the direction of their company officer. The ultimate responsibility for crew integrity and ensuring no members get separated or lost rests with the company officer. A Mayday should be called if any member cannot be accounted for during a personnel accountability report [NIOSH 2024].

The International Association of Fire Chiefs' Safety, Health, and Survival Section redefined the *Rules of Engagement for Structural Fire Fighting*. One objective is for firefighters to enter a burning building as a team of two or more members and another is that no firefighter be alone at any time while operating in or exiting a building. These objectives align with the definition of crew integrity (i.e., staying together as a team of two or more) [IAFC 2012].

Recommendation #3: Ensure ICs immediately establish divisions/groups with a supervisor to communicate conditions and provide accountability.

In this incident, E75 officer and hydrant were assigned and went to the attic of Delta 1 exposure with no division/group supervisor to provide accountability.

Within a division/group, firefighters advise their supervisor of work progress and provide accountability for crew members engaging in task level activities. The IC should assign divisions/groups to a supervisor early. This is especially important when firefighters are operating from tactical positions that the IC has little or no direct control over (e.g., out of sight). All requests for additional resources or assistance within a division/group are directed to the supervisor who is responsible for communicating with the IC. Supervisors can provide ongoing conditions, actions, needs reports to the IC of all four sides and the interior of an incident which may influence tactics and strategy [SKCFTC 2023]. Division/group supervisors can also assist in providing personnel accountability reports when requested by the IC, ISO, or operations. When the IC does not establish divisions/groups with a supervisor, firefighters should follow established fireground operations

reporting procedures while operating in the incident and hazard zone, such as the IDLH environment [NIOSH 2025].

Recommendation #4: Ensure a rapid intervention team/crew is dedicated, assigned, and in place before interior firefighting operations begin and throughout an incident.

Effective RIT operations are dependent on proactive efforts. Upon arrival, the RIT officer, accompanied by one member of the RIT, will get a report from the IC and then should perform an incident scene survey while the remaining RIT members assemble the RIT equipment. During the 360-degree survey, the RIT officer and members should look for ways in and out of the structure, including window configurations, fire escapes, and construction features. The RIT officer should note the feasibility for placement of ground ladders for rescue or escape purposes. The RIT officer has a responsibility to set up and secure a suitable secondary egress for interior crews [Rowett 2018; Toledo Fire & Rescue Department 2012]. After these tasks are completed, the RIT equipment is put in place and the RIT officer informs the IC that a 360-degree survey is complete and the RIT is ready to intervene, if necessary. The entire RIT should stay in an area immediately accessible to the building for rapid deployment and maintain radio contact with the IC. The RIT officer should brief all RIT members with the results of the incident scene survey [Toledo Fire & Rescue Department 2012]. The RIT officer and members coordinate with the IC to formulate rescue plan contingencies and to monitor radio and fireground conditions. RIT protection is not a passive assignment. This is a process of ongoing information gathering and diligent scene monitoring until the unit is released by the IC [NIOSH 2024; NFPA 1407 2020].

Recommendation #5: Ensure interior and exterior operations, such as water application, are not conflicting.

During this incident, firefighters operated in the structure while on-scene apparatus applied water onto the structure from master streams. When SQ5 found E75 hydrant in the attic, they requested the master streams be shut down.

Conflicting interior and exterior operations are a significant safety concern on the fireground. Exterior water application, such as from master streams, should never be used directly on a building where firefighters are operating inside. These devices deliver high volumes of water flow which can compromise the structural stability of the building. The force of water from a master stream can knock over chimneys and walls. Large amounts of water can add thousands of pounds of weight to the already damaged structural components and facilitate a structural collapse. Additionally, the application of large volumes of water can overwhelm firefighters by generating large amounts of steam that obscures visibility and may burn firefighters, and flood areas such as basements where firefighters may be operating [Phoenix Regional 2018; Van der Feyst 2021; Guzzi 2002]. Interior and exterior operations should be coordinated to lessen these potential life safety hazards. The IC, ISO, and operations should monitor this coordination during the continuous size-ups and risk assessments [NIOSH 2025].

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Recommendation #6: Ensure that firefighters undergo cardiovascular disease screening as recommended in NFPA 1582.

Starting at age 40 years of age, all firefighters should have an annual resting electrocardiogram (EKG). Additionally, annual cardiac risk assessment should be performed, using either the 2-year Framingham risk table or the 10-year risk calculator created jointly by the American College of Cardiology and the American Heart Association. Screening with either of these two methods should begin at age 40 for asymptomatic firefighters with no known history of atherosclerotic cardiovascular disease (ASCVD).

If a firefighter has a 2-year 2-4% risk of ASCVD or a 10% to <20% risk of ASCVD over the next 10 years, the firefighter should undergo symptom-limiting exercise stress testing (EST) with imaging [e.g. echocardiography, technetium (^{99m}Tc) sestamibi study] to at least 12 METs*.

If EST with imaging is positive, the firefighter should be referred to a cardiologist for further evaluation. Consult NFPA 1582 2022 version Chapter 9, Table 9.7 to determine restrictions on essential job tasks.

NFPA 1582 also recommends ASCVD risk assessment under other circumstances, including for firefighters under 40 years old with a high risk of ASCVD, insulin-dependent diabetics, etc.

*Note that this is different from the routine EST used to assess firefighters' aerobic fitness.

Recommendation #7: Implement a mandatory wellness and fitness program for fire department members that is consistent with NFPA 1583, Standard on Health-Related Fitness Programs for Fire Department Members, and the International Association of Fire Fighters/International Association of Fire Chiefs (IAFF/IAFC) Wellness-Fitness Initiative.

Guidance for fire department wellness/fitness programs to reduce risk factors for cardiovascular disease and improve cardiovascular capacity is found in *NFPA 1583, Standard on Health-Related Fitness Programs for Fire Fighters* [NFPA 2022b] and *The Fire Service Joint Labor Management Wellness-Fitness Initiative Candidate Physical Ability Test, 2nd Edition* [IAFF 2007]. Worksite health promotion programs have been shown to be cost effective by increasing productivity and reducing absenteeism, work-related injuries, and lost workdays [Aldana 2001; Stein et al. 2000]. Health promotion programs for firefighters have been shown to reduce coronary heart disease risk factors and improve fitness levels, with mandatory programs showing the most benefit [Blevins et al. 2006; Dempsey et al. 2002; Womack et al. 2005].

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Additional Information

NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments
NFPA 1582 contains descriptive requirements for a comprehensive occupational medical program for fire departments. Its purpose is to outline an occupational medical program that, when implemented in a fire department, will reduce the risk and burden of fire service occupational morbidity and mortality while improving the health, and thus the safety and effectiveness, of firefighters operating to protect members of the public's life and property.

Disclaimer

The information in this report is based upon dispatch records, audio recordings, witness statements, and other information that was made available to the National Institute for Occupational Safety and Health (NIOSH). Information gathered from witnesses may be affected by recall bias. The facts, contributing factors, and recommendations contained in this report are based on the totality of the information gathered during the investigation process. This report was prepared after the event occurred, includes information from appropriate subject matter experts, and is not intended to place blame on those involved in the incident. Mention of any company or product does not constitute endorsement by NIOSH, Centers for Disease Control and Prevention (CDC). In addition, citations to websites external to NIOSH do not constitute NIOSH endorsement of the sponsoring organizations or their programs or products. Furthermore, NIOSH is not responsible for the content of these websites. All web addresses referenced in this document were accessible as of the publication date.

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