1000 FREDERICK LANE, MORGANTOWN, WV 26508 • 304.285.5916

Firefighter Dies After Falling into the Basement due to Floor Collapse at a Modular Home Structure Fire – Missouri

Executive Summary

The deceased firefighter was operating a hoseline in the kitchen when the kitchen floor collapsed into the basement. The red arrow indicates the kitchen area.
(Photo courtesy of the fire department.)

On January 5, 2020, a 30-year-old career firefighter died after falling into the basement due to a floor collapse at a residential structure fire. The occupants tried to fight the fire before calling 9-1-1, which caused an estimated 6 to 9-minute delay in notifying the fire department. At 11:04:49 hours, fire dispatch transmitted a 1st Alarm assignment for a residential structure fire. Engine 51, Engine 52, Medic 52, and Chief 51 from the fire protection district (FPD) were dispatched. An automatic aid tanker – Tanker 1 was dispatched from a different public safety answering point (PSAP) in a different county. At 11:06:33 hours, Chief 41 and Pumper 43 from Fire Station 41 were dispatched by their PSAP to respond to the residential structure fire. At11:06:33 hours. Pumper 27 was dispatched at 1110 hours. Engine 51 arrived on-scene at 11:12:33 hours. At 11:13:02 hours, Engine 51 advised there was smoke showing from a single-family residence. The captain of Engine 51 advised the fire dispatcher that smoke was showing from the open basement door, which was located on the Side Bravo/Side Charlie corner. The winds were blowing at 24 mph and gusting to 33 mph from the NNW (Side Bravo to Side Delta). The chauffeur of Engine 51 stretched a 1¾-inch hoseline to the front door and then stretched a 1¾-inch hoseline to the top of the basement steps. The captain and firefighter from Engine 51 made entry into the basement with light gray smoke showing at 1115 hours. Engine 51 was only able to proceed a few feet into the basement due to the excessive clutter of the occupants' possessions. There was smoke in the basement but no visible fire or heat. Chief 51 arrived on-scene and assumed Command at 1117 hours. Engine 51 exited the basement and moved to the front yard. They met Chief 51 and advised him of the conditions in the basement. Command advised the case comments stated the occupants said the fire was in the laundry room behind the dryer. Command

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ordered Engine 51 to take the hoseline at the front door and make their way to the laundry room area. Engine 51 made entry through the front door at 1118 hours. Chief 41 and Pumper 43 arrived on-scene at 1119 hours. Battalion Chief 82, Engine 81, Tanker 81, and Squad 82 were dispatched at 1119 hours. Chief 41 conducted a 360-degree walk around. Pumper 43 was assigned to the basement. Pumper 43 took the hoseline at the bottom of the basement steps and stretched it into the basement. Engine 51 and the firefighter from Engine 52 entered the front door and went inside the house. The firefighter from Engine 51 remained at the front door. As they moved into the kitchen area, the captain from Engine 51 called Command and asked to have the roof vented. The time was approximately 1122 hours. They found fire in the kitchen area and were attempting to knock down the fire. The firefighter at the front door stated he heard glass breaking and a lot of noise. At 1126 hours, the captain of Engine 51 exited the structure without the firefighter from Engine 52. At 1129 hours, the captain advised Command that the firefighter from Engine 52 was still in the kitchen. The captain of Engine 51 advised the firefighter was possibly trapped by a ceiling collapse. Pumper 43 was reassigned from the basement to the front door in an attempt to locate the missing Engine 52 firefighter. The smoke changed from gray smoke to black smoke under pressure. Pumper 43 began to advance into the kitchen beyond the hoseline a short distance when the ceiling began to come down. The interior conditions began to deteriorate rapidly. The officer of Pumper 43 called a Mayday at 11:31:25 hours. Pumper 43 was out of the structure at approximately 1132 hours. The Mayday for Pumper 43 was cleared. Pumper 27 arrived on-scene at 1135 hours. Battalion 82, Engine 81, Tanker 81, and Squad 82 arrived on-scene at 1136 hours. Command changed the strategy to defensive at this point. At 11:42:19 hours, Command contacted the fire dispatcher and requested a box alarm assignment from a metropolitan fire department. At 1143 hours, Command advised the strategy was changed to defensive operations. Firefighters on-scene continued to fight the fire defensively plus tried to locate the missing firefighter from Engine 52. At 11:49:48 hours, the metro dispatched a box alarm sending 4 engines, 2 trucks, 2 heavy rescues, a district chief and a deputy chief to respond to this incident. At 1209 hours, the 1st Alarm assignment from the metro fire department started to arrive on-scene. At 1222 hours, Pumper 45 took a 1¾-inch hoseline into the basement with Truck 15. Pumper 45 and Truck 15 found the firefighter submerged under water and covered with debris. The missing firefighter was located near the wall on Side Alpha directly under the double windows in the kitchen/dining room. He was partially under a workbench and a table. At 1241 hours, Rescue 9 and Rescue 31 entered the basement via the ground ladder in a window on Side Alpha. Rescue 9 had a hoseline with them. The water was approximately 20-24 inches deep in the basement, and extremely hot. Rescue 9 had to move a considerable amount of debris to get the firefighter from underneath the workbench and table. The visibility was good but there was some steam. A carabineer was hooked to the firefighter's SCBA strap, and the members of Rescue 9 were able to pull the firefighter to the doorway of the basement. The firefighter was out of the basement at 1305 hours. The firefighter was moved to a medic unit and transported to a regional medical center at 1308 hours. The firefighter was pronounced deceased at 1328 hours. The fire was declared out at 1705 hours.

Contributing Factors

- *Delayed notification of the fire to the 9-1-1 center*
- *Lack of continuous scene size-up and risk assessment*
- *Lack of crew integrity*
- *Building construction – modular home*
- *Basement fire*

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- *Wind-impacted fire*
- *Lack of incident management, including management of a Mayday*
- *Lack of personnel accountability*
- *Lack of a rapid intervention crew(s)*
- *Inadequate fireground communications*
- *Portable radio operational issues*
- *Inadequate staffing*
- *Initial lack of a secured water supply*
- *Lack of proficiency training.*

Key Recommendations

- *Fire departments should ensure the first arriving resource conducts a scene size-up and risk assessment, determines the incident's strategy, and incident action plan, and assumes command. This information is communicated in the initial radio report.*
- *Fire departments should ensure that company officers and firefighters maintain crew integrity when operating in the hazard zone*
- *Fire departments should ensure that all companies are operating based upon the assignment given by the incident commander. The Task-Location-Objective assignments should be communicated over the radio, which eliminates freelancing and ensures that tactical priorities are met*
- *Fire departments need to ensure that critical incident benchmarks are communicated to the incident commander throughout the incident*
- *Fire departments should use NFPA 1700, Guide for Structural Fire Fighting to develop and revise fireground operational procedures*
- *Fire departments should develop and implement a standard operating procedure (SOP)/standard operating guideline (SOG) for tactical operations involving modular homes*
- *Fire departments should review and update their SOP/SOG for tactical operations involving below-grade fires*
- *Fire departments should develop and implement SOPs/SOGs, training programs, and tactics for wind-impacted fires*
- *Fire departments should ensure incident commanders establish a stationary command post that is tied to a vehicle for effective incident management, which includes the use of a tactical worksheet*
- *Fire departments should incorporate the principles of command safety into the incident management system. This ensures that the strategic-level safety responsibilities are incorporated into the command functions throughout the incident*
- *Fire departments should ensure that all firefighters and fire officers are trained for Mayday operations*
- *Fire departments should provide a Mayday tactical worksheet for incident commanders in the event of a Mayday*
- *Fire departments should ensure all members and dispatchers are trained on the safety features of their portable radio, particularly the features useful during a Mayday*
- *Fire departments should ensure all firefighter portable radio volume-power knobs cannot be accidentally turned down or off when in use*

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- *Fire departments should use a functional personnel accountability system, requiring a designated accountability officer or resource status officer*
- *Fire departments should regularly review and revise their SOP/SOG on the deployment of rapid intervention crew(s)*
- *Fire departments should review and/or develop SOG/SOP to ensure that water supply is established and maintained during initial fireground operations, particularly in areas with limited or no hydrants*
- *Fire departments should ensure that all members engaged in emergency operations receive annual proficiency training and evaluation on fireground operations, including live fire training. This training should be conducted with automatic aid fire departments.*

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 January 5, 2020, a 30-year-old career firefighter died after falling into the basement due to a floor collapse at a residential modular home structure fire. The firefighter was operating a hoseline with a captain in the kitchen when the floor collapsed. The firefighter fell into the basement. On January 6, 2020, the U.S. Fire Administration notified the National Institute for Occupational Safety and Health (NIOSH) of this incident. On January 19 – 26, 2020, a safety and occupational health specialist, an investigator, and a general engineer from the NIOSH Fire Fighter Fatality Investigation and Prevention Program traveled to Missouri to investigate this incident. The NIOSH investigators met with the fire chief of the fire protection district fire, the assistant chief, a captain, and firefighters that responded to this incident. Additionally, NIOSH investigators met with and interviewed members of the mutual aid fire protection district and the metropolitan fire department that responded to this incident. NIOSH investigators also met with a forensic pathologist that conducted the autopsy. NIOSH investigators obtained and reviewed fire department training records, SOPs, incident scene photographs, drawings and videos, and training records of the deceased firefighter.

Fire Department

This fire department is designated as a fire protection district (FPD), which is a geographical area of a town or county that receives contract fire protection. An administrative board can create a FPD, consolidate adjoining FPDs, alter the boundaries of a FPD, or dissolve a FPD on its own motion or by petition. A Missouri FPD is a political subdivision of the state [University of Missouri Extension 2020].

The fire protection district serves a population of 8,990 residents in 43.1 square miles. In 2020, the FPD answered 1013 alarms for service, which included:

- Fire 90
- EMS 664
- Other (e.g., Automatic Fire Alarms, etc.) 259

The FPD operates two fire stations, providing basic life support (BLS), advanced life support (ALS), and transport capabilities. Fire Station 51 houses one engine, one medic unit, and one brush/forestry truck. Fire Station 51 houses the administrative officers and has facilities to conduct classroom training. Fire Station 52 houses one engine and one medic unit.

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The FPD has 13 career members and 17 part-paid members. The FPD has a paid fire chief, paid assistant fire chief, and a paid administrative assistant. There are three shifts, and each shift works a 48-hours on/96-hours off schedule.

The fire department provides electronic policy and procedures manuals to each member at each fire station.

Training, Education, and Professional Development

The Missouri Division of Fire Safety's *Training and Certification Unit* develops, provides and oversees the training curriculum used regionally for firefighters, fire investigators, fire inspectors, fire officers, fire service instructors, as well as emergency responders dealing with hazardous materials. Although certification is not mandatory in the state of Missouri, the Division of Fire Safety has issued more than 95,000 certifications at various levels to more than 36,000 individuals [Missouri Division of Fire Safety].

In April 1996, the division received accreditation for certification programs from the International Fire Service Accreditation Congress (IFSAC). IFSAC is a peer-driven, self-governing system of both fire service certification programs and higher education degree programs. Accreditation is accomplished through the review of certification programs of member entities to ensure they meet nationally recognized professional qualification standards in their administration of skills and knowledge exams. Because of this accreditation, Missouri shares certification reciprocity with many states and entities internationally.

In October 2011, the division received accreditation for certification programs from the National Board on Fire Service Professional Qualifications (Pro Board). Pro Board was organized to establish an internationally recognized means of acknowledging professional achievement in the fire service and related fields. Pro Board's primary goal is to accredit organizations that certify uniform members of public fire departments, both career and volunteer. However, other organizations with fire protection interests may also be considered for participation. Accreditation is provided at the state level to the empowered certifying authority of that jurisdiction.

Currently, the Division of Fire Safety is accredited at the levels of NFPA 1001, *Standard for Fire Fighter Professional Qualifications*, Fire Fighter I and II; NFPA 1021, *Standard for Fire Officer Professional Qualifications*, Fire Officer I and II; NFPA 1521, *Standard for Fire Department Safety Officer*, Incident Safety Officer; NFPA 1031, *Standard for Professional Qualifications for Fire Inspector and Plan Examiner*, Fire Inspector I and II; NFPA 1033*, Standard for Professional Qualifications for Fire Investigator*, Fire Investigator; NFPA 1041, *Standard for Fire Service Instructor Professional Qualifications,* Fire Service Instructor I and II, Live Fire Instructor; NFPA 1002, *Standard for Fire Apparatus Driver/Operator Professional Qualifications*, Driver Operator; NFPA 1006, *Standard for Technical Rescue Personnel Professional Qualifications,* Technical Rescuer; and NFPA 472, *Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents*, Hazardous Materials Awareness, Hazardous Materials Operations, and Hazardous Materials Technician. For more information, see: Firefighter Training and Certification | Fire Safety | Missouri Department of Public Safety (mo.gov).

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The firefighter from Engine 52 had been a member of the fire protection district since November 2019. The firefighter had completed the following certifications: NFPA 1001, *Standard for Fire Fighter Professional Qualifications*, Fire Fighter I (Pro Board) and II (Pro Board); NFPA 472, *Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents*, Hazardous Materials Awareness (Pro Board), Hazardous Materials Operations (Pro Board) and Hazardous Materials Technician (Pro Board). These certifications were issued by the Georgia Firefighter Standards and Training Council when the firefighter was employed by a fire department in the state of Georgia. Additional certifications included: IS-00100.b. – *Introduction to Incident Management System (ICS-100)*, IS-00200.b – *ICS for Single Resources and Initial Action Incident* (ICS-200), IS-00700.a – *National Incident Management System (NIMS) an Introduction*, *an Introduction*, IS-00800.b – *National Response Framework, An Introduction*, Interior Search and Rescue (16 hours), and Structural Fire Control (16 hours).The Pro Board® accredits those public sector organizations (generally governmental or educational) internationally that certify emergency services responders against the requirements of the National Professional Qualifications System Standards. Those standards are promulgated by the National Fire Protection Association (NFPA). The firefighter was certified as an *EMT-Paramedic* by the Missouri Department of Health and Senior Services, the Bureau of EMS.

The company officer of Engine 51 had nine years of service with the fire protection district and had worked as a paramedic for an EMS organization. He had completed the following certifications: NFPA 1001, *Standard for Fire Fighter Professional Qualifications*, Fire Fighter I and II; NFPA 472, *Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents*, Hazardous Materials Awareness and Hazardous Materials Operations.

The fire chief (incident commander) had 26 years of fire service experience. At the time of this incident, he had been fire chief of the fire protection district for nine months. The fire chief had the following certifications: NFPA 1001, *Standard for Fire Fighter Professional Qualifications*, Fire Fighter I and II; NFPA 472, *Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents*, Hazardous Materials Awareness and Hazardous Materials Operations; NFPA 1021, *Standard for Fire Officer Professional Qualifications*, Fire Officer I and II; NFPA 1031, *Standard for Professional Qualifications for Fire Inspector and Plan Examiner*, Fire Inspector I; and NFPA 1033*, Standard for Professional Qualifications for Fire Investigator*, Fire Investigator I.

Building Construction

The structure involved in this incident was a modular home. Modular homes are usually fabricated in sections in a factory. Each section is built separately before being shipped to the site for final assembly. They are also called “prefab homes” short for prefabricated homes. Manufactured and modular dwellings are built off-site, may not have the same fire resistance as site-built structures, and may propagate fire rapidly due to the geometry of the building. These structures may be susceptible to early failure due to numerous lightweight building construction materials [NFPA 1700 2021].

Modular homes are legally considered permanent constructions required to be attached to a permanent foundation. Basements are permanent structures that in most cases act as foundations, sustaining and

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distributing the weight of the building, as well as keeping the moisture out [Perry, K 2022]. Basements are usually built of concrete, although the materials and construction techniques utilized will depend on the location and specific requirements. There are different types of basements, some are built as fully underground structures with no windows, while others are partially underground spaces with windows or even doors looking outdoors. The basement possibilities available for modular homes are just the same as those available for any other type of construction. Even if modular homes are built off-site, foundations and basements are constructed on-site following the same building process they would if built under a traditional construction (**See Photo 1**). The only access to the full basement at this incident was a standard door on the Side Bravo/Side Charlie corner, which is a walkout basement.

The dimensions of the modular home involved in this incident were 52-feet, 4 inches long and 26-feet, one inch wide. The square footage of the modular home was approximately 1352 square feet.

Photo 1. An example of a modular home being placed on the foundation with a basement.
(Photo courtesy of the kelseybassranch.com)

Regarding the construction of the modular home involved in this incident:

- Built on a poured masonry foundation with no windows
- 12 -14 8-inch steel I-beams ran west to east (Side Alpha to Side Charlie)
- A 10-inch steel I-beam ran from Side Bravo to Side Delta which was part of the modular home
- An unknown number of 2-inch x 6-inch wooden joists were on top of the 8-inch I-beams
- The flooring was made of a single layer of 1-inch particle board placed on top of the wood joists (**See Diagram 1**). The floor was covered with linoleum over the particle board

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- The exterior walls were covered with a light colored vinyl siding
- The gable roof was covered with composite asphalt shingles.

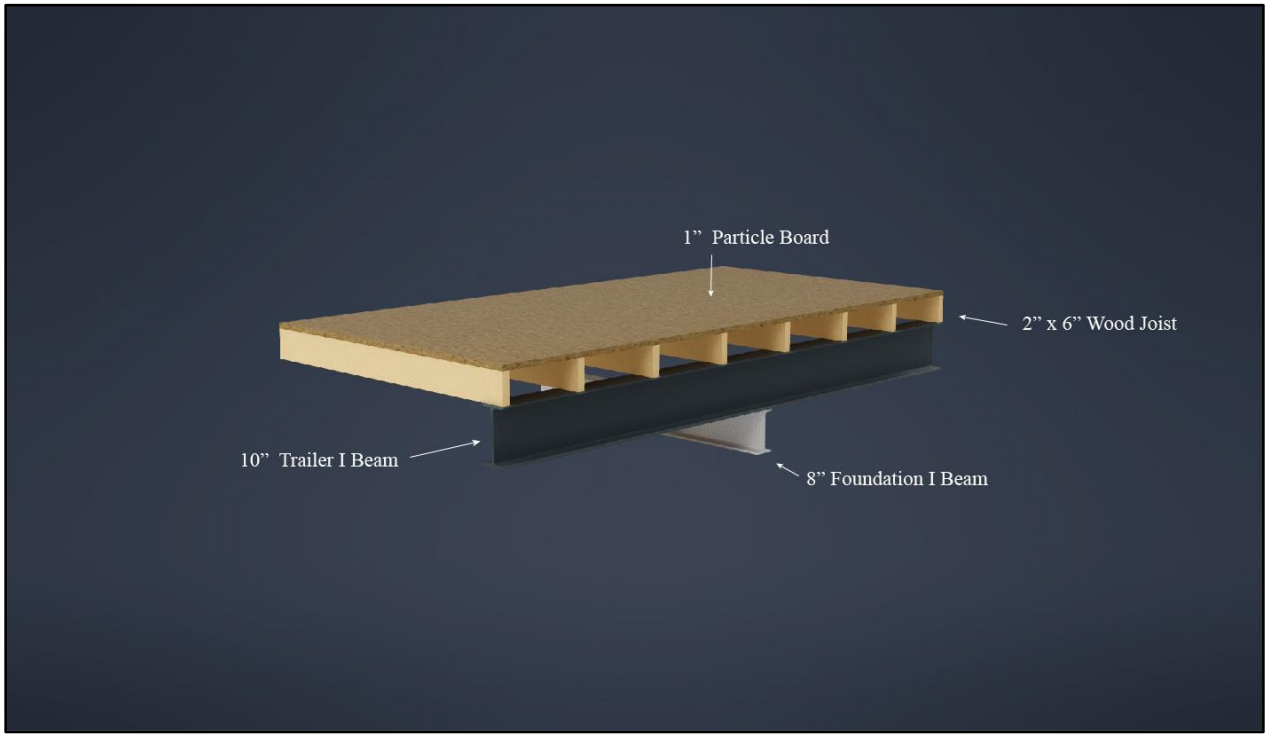

Diagram 1. The flooring construction of the modular home.
(Photo courtesy of the UL Fire Safety Research Institute)

The truss roof in this this modular home was made with 2-inch x 2-inch finger jointed trusses. Finger jointed wood trusses are an engineered wood product designed for residential/light commercial application (**See Photo 2**). The trusses had charred only an 1/2-inch and were badly bowed and failing. The flooring was made of a single layer of medium-density fiberboard (MDF), in its untreated state, fiberboard fairs poorly, swelling or even fracturing when exposed to even a negligible amount of water, plus deteriorates due to heat and with age. The fire was between the joists and the MDF flooring in the laundry room and was not in the basement.

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Photo 2. An example of finger joists that are precut into the chords and web members
(Photo courtesy https://www.fireengineering.com/fire-prevention-protection/firefighters-and-construction-finger-jointed-wood-truss/ by Salvatore Ancona)

A concrete stairwell that went to the basement was located on the north end of the structure and was the only access to the basement. A wood deck with a wooden gazebo was attached to the front on the house (west – Side Alpha). Electricity and LP gas were the utilities in service at the time of the fire.

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The 1st floor consisted of 3 bedrooms, two bathrooms, a combination living room and kitchen, a utility room with a washer & dryer, a covered porch, and several closets (**See Diagram 2**).

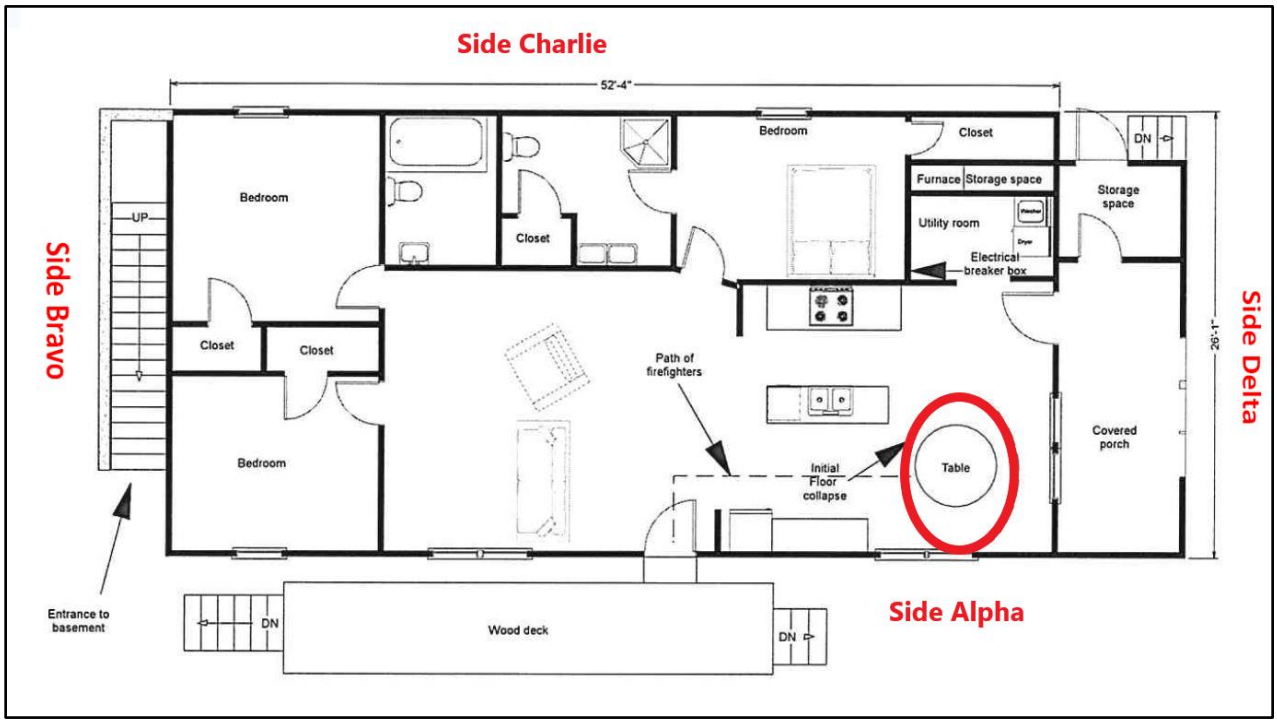

Diagram 2. The floor plan of the 1st floor. The area where the floor collapsed is denoted by the red circle in the kitchen.
(Diagram courtesy of the Missouri Office of the State Fire Marshal.)

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The floor plan of the utility room where the fire was initially reported. The utility room was located off the kitchen towards the rear of the house. (**See Diagram 3**).

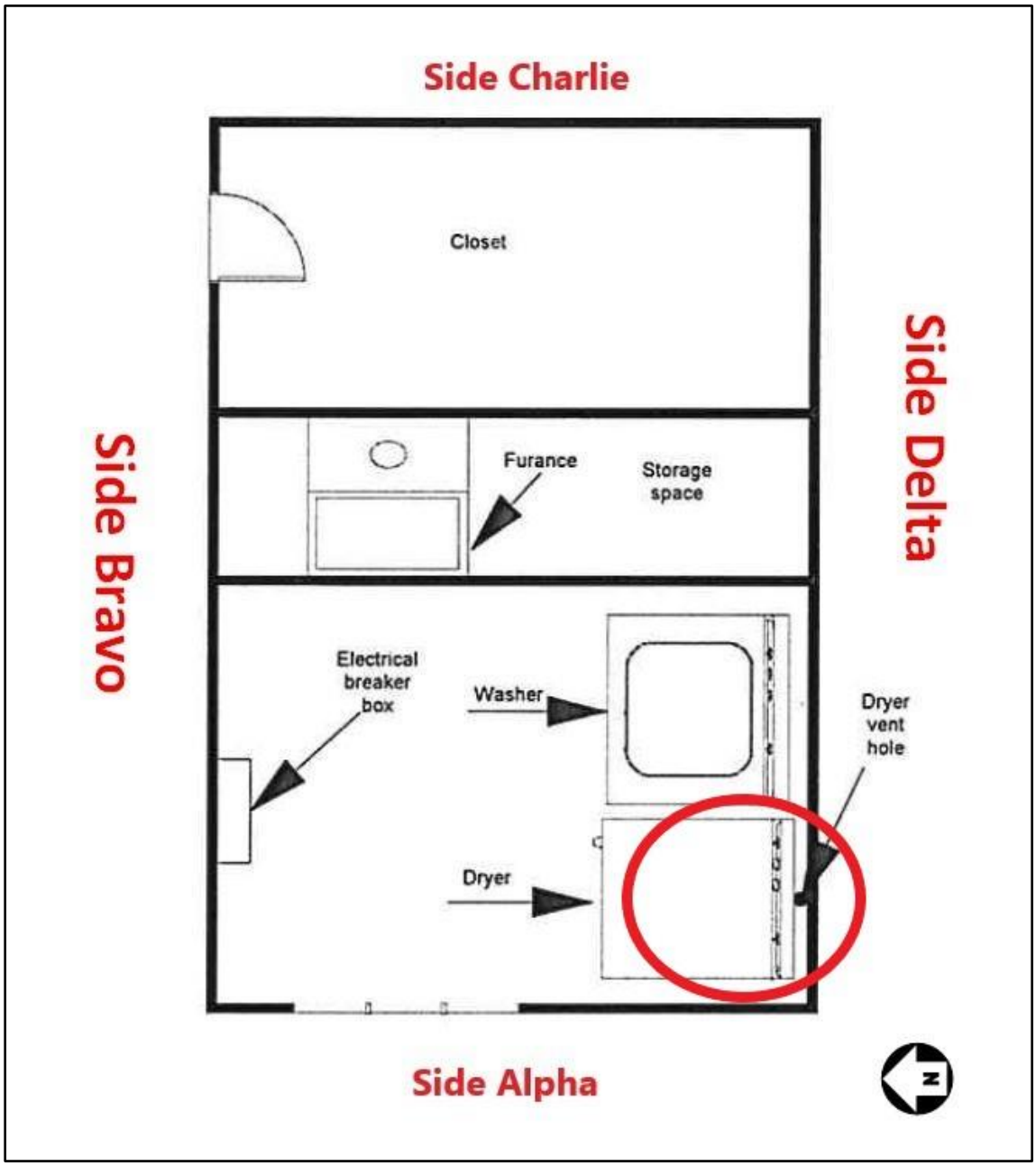

Diagram 3. The utility room which was located on Side Delta of the house next to a storage room. The occupants reported the fire started in the vicinity of the dryer, indicated by the red circle.
(Diagram courtesy of the Missouri Office of the State Fire Marshal.)

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The basement of this structure consisted of a living area/bedroom with a full bath (**See Diagram 4**). When the floor collapse occurred, the firefighter from Engine 52 fell into the basement and landed on the floor near a workbench.

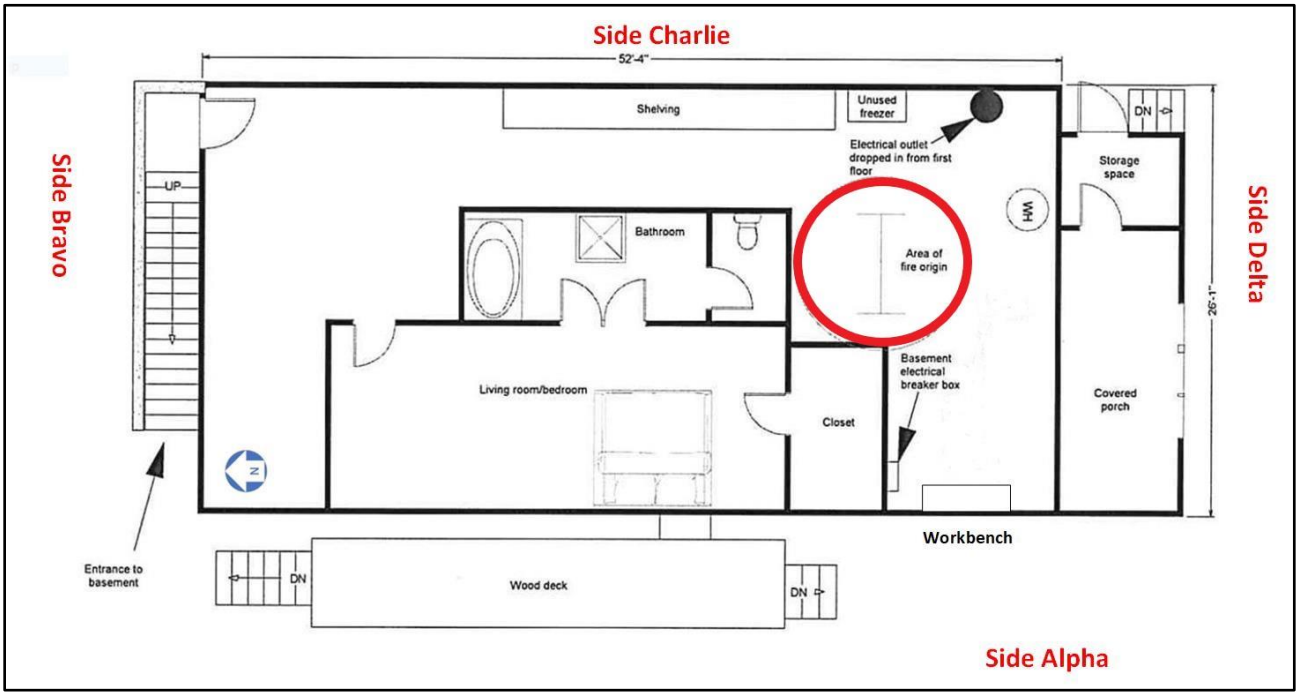

Diagram 4. The floor plan of the basement. The area of fire origin is denoted by the red circle. The fire was between the 1st floor and the ceiling of the basement. ***(Diagram courtesy of the Missouri Office of the State Fire Marshal.)***

Apparatus, Staffing, and Communications

The FPD operates 2 fire stations. The fire protection district has three paid fire fighters per shift, one of which is a company officer (captain). There are three shifts, and each shift works a 48-hours on/96-hours off schedule. The FPD has a paid fire chief, a paid assistant fire chief, and a paid administrative assistant, and has 13 career members and 17 part-paid members.

The staffing on the day of the fire on Engine 51 was an officer, a chauffeur, and a firefighter. The staffing on Engine 52 was a chauffeur and a firefighter. Medic 52 was staffed with 2 EMTs.

The fire apparatus that responded prior or after the floor collapse are listed in the table below (**See Table 1**).

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Table 1. The fire department resources that responded to this residential structure fire prior to the collapse of the kitchen floor.

Fire Department	Apparatus	Staffing
Fire Protection District	Engine 51	3
	Engine 52	2
	Tanker 51	1
	Medic 52	2
	Chief 51	1
Fire Protection District	Pumper 43	4
	Battalion 41	1
Fire Department 27	Pumper 27	2
Fire Department 82	Engine 81	3
	Tanker 81	1
	Squad 82	2
	Battalion 82	1

There are five public safety answering points (PSAPs) for 9-1-1 in the county. One of the PSAPs is the communication division of a municipal police department. This communication division dispatches for the municipal fire and police departments and two fire protection districts, which includes this fire protection district.

Timeline

Not all incident events are included in this timeline. The times were determined by reviewing the dispatch records, audio recordings, witness statements, National Fire Incident Reporting System (NFIRS) incident reports, and other available information. This timeline also lists the dispatch communications and fire department response. The timeline lists critical fireground communications and fireground operations.

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Dispatch Communications & Fire Department Response	Time	Fireground Communications & Fireground Operations
A municipal police dispatch center received a 9-1-1 call from a homeowner, who advised his house was on fire. The fire was reported to be behind the dryer in the laundry room. The caller stated everyone was out of the house.	**11:04:07 Hours**	
The fire dispatch alerted Engine 51, Engine 52, Medic 52, and Chief 51 from the fire protection district (FPD) of a residential structure fire. A mutual aid tanker – Tanker 1, from another county was dispatched by another PSAP.	**11:04:48 Hours**	
Pumper 43 (personnel accountability report)(PAR4) and Chief 41 (PAR 1) were dispatched from Fire Station 41 (automatic aid) from their PSAP.	**11:06:33 Hours**	
Engine 51 responded (PAR 3).	**11:07:13 Hours**	
Engine 52 responded (PAR 2).	**11:09:09 Hours**	
Pumper 43 responded (PAR 4).	**11:09:17 Hours**	
Pumper 27 dispatched on automatic aid.	**1110 Hours**	
Pumper 27 responded (PAR 2).	**1111 Hours**	
Engine 51 (E51) arrived on-scene.	**11:12:33 Hours**	

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Dispatch Communications & Fire Department Response	Time	Fireground Communications & Fireground Operations
E51 officer advised the county fire dispatcher there was light smoke showing from the basement. E51 was investigating.	**11:13:02 Hours**	
E51 advised the fire dispatcher this was a single-family home and assumed Command.	**11:13:09 Hours**	
	1115 Hours	The chauffeur of E51 stretched a 1¾-inch hoseline to the front door. Then he stretched another 1¾-inch hoseline to the top of the steps of the basement. The officer and firefighter from E51 took the hoseline and went down the steps into the basement with gray smoke showing. The basement door was open and there was a gray smoke in the basement. The officer of E51 said nothing showed on this thermal imager. They proceeded only about 10 – 12 feet into the basement due to excessive clutter in the basement. E51 then left the basement.
Engine 52 and Medic 52 arrived on-scene.	**11:16:52 Hours**	
Chief 51 arrived on-scene and assumed Command.	**11:17:36 Hours**	
	1145 Hours	Chief 51 started to conduct a 360-degree walkaround of the structure.
Chief 51 requested a tanker respond from an automatic aid fire department.	**11:17:54 Hours**	

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Dispatch Communications & Fire Department Response	Time	Fireground Communications & Fireground Operations
	1118 Hours	The officer of E51 and a firefighter from Engine 52 (E52) made entry into the house through the front door (Side Alpha). They advanced the 1¾-inch hoseline into the house that was at the front door. The E51 officer and E52 firefighter turned left after entering the house. They went towards the front bedroom. There was light gray smoke showing from the front door.
Battalion Chief 82, Engine 81, Tanker 81, and Squad 82 dispatched to the working fire.	**1119 Hours**	The officer from E51 and firefighter from E52 move into the kitchen. The smoke from the front door was increasing in intensity to medium gray and was banked completely to the floor at this time. The E52 firefighter was flowing water.
Chief 41 and Pumper 43 arrived on-scene. Automatic Aid Tanker 1 on-scene.	**11:19:49 Hours**	
	1120 Hours	Tanker 1 supplied E51 with water.

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Dispatch Communications & Fire Department Response	Time	Fireground Communications & Fireground Operations
	1122 Hours	Pumper 43 (P43) was assigned to fire attack in the basement. P43 took the hoseline at the basement door and made entry. P43 got approximately 6 – 8 feet into the basement. Their thermal imager showed a lot of heat at ceiling level and P43 tried to cool the ceiling Chief 41 conducted a 360-degree size-up and risk assessment. Chief 41 reported to Command that gray smoke was showing on all sides of the structure. Chief 41 reported the utilities were electric and a propane tank.
	1125 – 1126 Hours	The firefighter from E52 fell into the basement due to the collapse of the 1st floor in the kitchen. (**See Diagram 2**). Prior to the collapse, the E51 firefighter at the front door heard glass breaking and a lot of noise.
	1126 Hours	E51 out of the structure (PAR 2 – captain and E51 firefighter). The firefighter from E52 was still inside the structure possibly in the kitchen. Command was not advised that the E52 firefighter was still inside the house. The smoke conditions changed from gray smoke to black smoke under pressure.
On-scene operating time was 15 minutes.	**1127 Hours**	The firefighter and captain from E51 changed SCBA cylinders.

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Dispatch Communications & Fire Department Response	Time	Fireground Communications & Fireground Operations
	1129 Hours	E51 captain advised Command that the firefighter from Engine 52 was still inside the house. E51 was out of water from flowing the 1¾-inch hoselines used by E51 and P43. Chief 41 ordered P43 to Side Alpha and to make entry due to a missing firefighter.
Chief 41 requested Command have Chief 2 from Station 41 dispatched.	**1130 Hours**	Chief 41 assigned as Operations Section Chief (Operations). A mutual aid firefighter found a fire hydrant approximately 400 feet from E51. A mutual aid fire fighter drove E52 to the hydrant. He laid a 5-inch supply line from E51 to the hydrant and made the connection. P43 was assigned as the rapid intervention crew (RIC). P43 made entry through the front door into the kitchen to search for the firefighter from E52. P43 entered with the hoseline and E43 move into the kitchen. P43 reported the hoseline had no water and was limp. Members of P43 reported they could hear a PASS sounding in full alarm. Conditions deteriorated with an increase in heat. The kitchen ceiling started to come down.

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Dispatch Communications & Fire Department Response	Time	Fireground Communications & Fireground Operations
Command advised the fire dispatcher that a Mayday was transmitted at this incident.	**11:31:25 Hours**	P43 called a Mayday due to a ceiling (drywall) collapse in the entrance and kitchen area. The officer of P43 called a Mayday stating, "extreme heat, structural collapse, and trapped". P43 self-rescued (PAR 4) and left the structure.
	1132 Hours	All companies are out of the structure except for the firefighter from E52, who was trapped in the basement.
Command requested a medic unit from an automatic aid fire department.	**11:34:32 Hours**	
Pumper 27 (P27)arrived on-scene.	**1135 Hours**	
Battalion 82, Engine 81, Tanker 81, and Squad 82 arrived on-scene to the working fire.	**1136 Hours**	Structure was well involved with fire.
Command requested the county fire dispatcher issue a fire recall for the fire protection district.	**11:36:42 Hours**	
	1137 Hours	P27 made an attempt to enter the house through the front door and locate the E52 firefighter. They were unsuccessful due to deteriorating conditions.

Firefighter Dies After Falling into the Basement due to Floor Collapse at a Modular Home Structure Fire – Missouri

Dispatch Communications & Fire Department Response	Time	Fireground Communications & Fireground Operations
	1138 Hours	Three (3) 1¾-inch hoselines were operating from the exterior. Two hoselines operating on Side Alpha and one hoseline operating on Side Delta. Battalion 82 (BC82) was assigned as rapid intervention group supervisor. He assigned Squad 82 (SQ82) to the roof for vertical ventilation. Engine 81 (E81) removed the kitchen bay windows and cut the wall under the bay windows down to the floor level. Upon removing the windows, E81 discovered that a portion of the kitchen floor had collapsed. This confirmed the firefighter from E52 had fallen into the basement. A roof ladder was lowered into the basement from the bay window area through the collapsed area. Firefighters tried to go down ladder to conduct a search. The firefighters were unable to make it to the basement do to the intense heat conditions.
On-scene operating time was 30 minutes.	**1142 Hours**	
Command requested the fire dispatcher contact the metropolitan fire department. Command requested a full box alarm assignment from the metro fire department. Command also requested another alarm for this incident, including an air cascade unit, and the fire marshal.	**11:42:19 Hours**	

Firefighter Dies After Falling into the Basement due to Floor Collapse at a Modular Home Structure Fire – Missouri

Dispatch Communications & Fire Department Response	Time	Fireground Communications & Fireground Operations
Command advised all companies the strategy was being changed to defensive operations.	**1143 Hours**	
The fire dispatcher contacted the metro fire department dispatcher. A request was made for a full box alarm assignment for this incident. The strategy was changed to defensive operations.	**11:43:41 Hours**	
The metro fire department dispatched a 1st Alarm assignment to assist the FPD. Pumper 45, Pumper 42, Pumper 41, Pumper 36, Truck 15, Truck 11, Rescue 9, Rescue 31, Car 107, and Car 101 were dispatched.	**11:49:48 Hours**	
Pumper 36 was cancelled enroute.	**11:50:13 Hours**	
	1155 Hours	Fireground operations are in a defensive strategy.
On-scene operating time was 45 minutes.	**1157 Hours**	
Chief 2 from Fire Station 41 responded.	**12:04:41 Hours**	
Car 107 (District Chief and District Safety Officer) arrived on-scene.	**12:09:32 Hours**	
	1210 Hours	Car 107 met with Command to develop a strategy and incident action plan to recover the missing firefighter.

Firefighter Dies After Falling into the Basement due to Floor Collapse at a Modular Home Structure Fire – Missouri

Dispatch Communications & Fire Department Response	Time	Fireground Communications & Fireground Operations
On-scene operating time was 60 minutes.	**1212 Hours**	
Pumper 41 on-scene.	**12:13:40 Hours**	
Pumper 45 on-scene.	**12:13:45 Hours**	
Pumper 42 on-scene.	**12:14:08 Hours**	
Chief 2 on-scene.	**12:14:45 Hours**	
Truck 15 on-scene.	**12:16:26 Hours**	
Truck 11 on-scene.	**12:20:00 Hours**	
Car 101 on-scene.	**12:20:17 Hours**	
Rescue 9 on-scene.	**12:20:31 Hours**	
Car 101 assumed Command. The incident action plan changed from rescue to recovery. Car 107 was assigned as the recovery group supervisor.	**1222 Hours**	Command communicated the incident action plan for the recovery process of the firefighter from Engine 52. Pumper 45 (P45) took a 1¾-inch hoseline into the basement with Truck 15 (T15). Pumper 42 (P42) was operating a hoseline on Side Charlie. Truck 11 (T11) was assigned as RIC.
On-scene operating time was 75 minutes.	**1227 Hours**	

Firefighter Dies After Falling into the Basement due to Floor Collapse at a Modular Home Structure Fire – Missouri

Dispatch Communications & Fire Department Response	Time	Fireground Communications & Fireground Operations
	12:34:13 Hours	P45 heard a PASS alarm in the basement. Due to excessive debris in the basement, P45 has trouble locating the missing firefighter. P45 located the missing firefighter who was underneath a pile of debris, a workbench, and a table on Side Alpha.
	1236 Hours	P45 and T15 were out of the basement without being able to remove the firefighter from E52.
	1239 Hours	Command ordered all companies out of the structure for a PAR.
	1241 Hours	Rescue 9 (R9) and Rescue 31 (R31) entered the basement to recover the firefighter from E52. Companies operating in the basement reported there was at least 2+ feet of standing water.
On-scene operating time was 90 minutes.	**1242 Hours**	
	1243 Hours	R9 and R31 were having trouble moving the firefighter. He was submerged underneath the water, underneath a workbench, and covered with debris.
Command advised the fire dispatcher that the power to the structure was secured.	**1252 Hours**	Command advised all companies operating on the fireground, the power to the structure was secured.
On-scene operating time was 105 minutes.	**1257 Hours**	

Firefighter Dies After Falling into the Basement due to Floor Collapse at a Modular Home Structure Fire – Missouri

Dispatch Communications & Fire Department Response	Time	Fireground Communications & Fireground Operations
	12:59:49 Hours	R9 and R31 have packaged the firefighter from Engine 52 in a Stokes basket for removal.
	13:05:30 Hours	R9 and R31 were out of the structure with the firefighter from E52.
Medic 82 transported the firefighter from Engine 52 to regional medical center.	**1308 Hours**	Command conducts a PAR of all members on the fireground.
	13:09:41 Hours	Command advised all companies have PAR.
On-scene operating time was 120 minutes (2 hours).	**1312 Hours**	
The firefighter from Engine 52 is pronounced deceased at a local trauma hospital.	**1328 Hours**	
Command advised the fire dispatcher the fire was under control.	**13:43:19 Hours**	
Command advised the fire dispatcher that the fire was out.	**1705 Hours**	
Per Command all units were clear from this incident.	**19:32:04 Hours**	

Firefighter Dies After Falling into the Basement due to Floor Collapse at a Modular Home Structure Fire – Missouri

Personal Protective Equipment

NIOSH investigators inspected and photographed the turnout gear and SCBA worn by the deceased firefighter at Fire Station 51. At the time of the fire, the firefighter was wearing a station work uniform, full turnout gear, and SCBA with facepiece. All the personal protective equipment (PPE) were compliant with NFPA 1971, *Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting* and were in good condition. The turnout coat and pants were cut by EMS personnel during patient care. The only PPE not inspected was the right structural firefighting glove and the firefighting protective hood.

The SCBA was a SCOTT® AP50 4.5 which complied with the 2002 edition of NFPA 1981, *Standard for Open Circuit Self-Contained Breathing Apparatus for Fire and Emergency Services* with a 30-minute cylinder. The cylinder valve was in the "open" position and the gauge read empty. The by-pass valve was closed and the 2nd stage regulator did not show any signs of damage. The facepiece was still connected to the 2nd stage regulator. The integrated PASS could be manually operated and sounded when checked.

Because the turnout gear was not considered a contributing factor to the fatality in this incident, NIOSH investigators conducted no further evaluation or testing of the turnout gear. No evidence was found to suggest that the SCBA contributed to this fatality. A flow test was conducted on January 27, 2020, on the SCBA used by the firefighter from Engine 52. The flow test results are shown in Appendix One (**See Appendix One**).

Weather Conditions

The temperature at 1053 hours on January 5, 2020, was 50 degrees F (Fahrenheit), the dew point was 27 degrees F, the humidity was 41%, the winds were out of the north northwest (NNW) at 24 miles an hour (MPH) gusting to 33 MPH, the barometric pressure was 29.11 inches, there had been no precipitation in the past 24 hours, and the conditions were fair/windy [Weather Underground 2020].

Investigation

On January 5, 2020, a 30-year-old career firefighter died after falling into the basement due to floor collapse at a residential structure fire. At 11:04:48 hours, the fire protection district was dispatched to a report of a dryer fire. The occupants tried to fight the fire before calling 9-1-1, which caused an estimated 6 – 9-minute delay in notifying the fire department. Companies dispatched from the FPD were Engine 51, Engine 52, Medic 52, and Chief 51. The automatic aid tanker – Tanker 1, was dispatched from a different PSAP in a different county. At 11:06:33 hours, Chief 41 and Pumper 43 were dispatched from Fire Station 41 by their PSAP to respond to a residential structure fire. Pumper 27 was dispatched at 1110 hours and responded at 1111 hours. At 11:12:33 hours, Engine 51 (PAR 3) arrived on-scene. At 11:13:02, Engine 51 advised there was light smoke showing from a single-family residence and Engine 51 was investigating. The winds were out of the north northwest (NNW) (from Side Bravo to Side Delta) at 24 miles an hour (MPH) gusting to 33 MPH. The wind did not impact the fire until after the floor collapse and the roof and all windows were vented (**See Diagram 4**).

Firefighter Dies After Falling into the Basement due to Floor Collapse at a Modular Home Structure Fire – Missouri

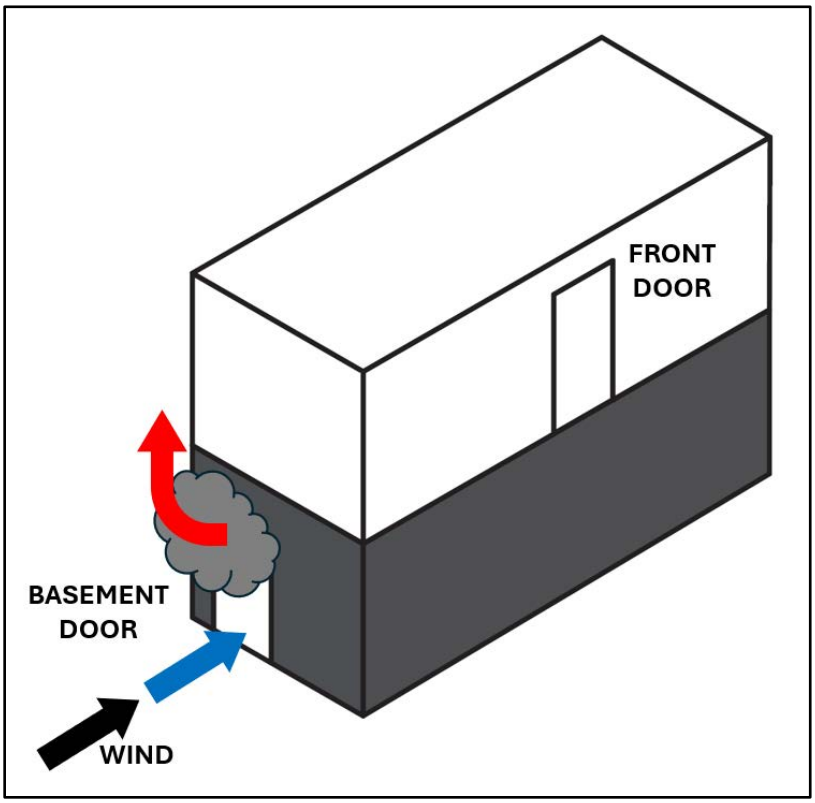

Diagram 5. Light gray smoke was showing from the basement door. The time was approximately 1115 hours.
Diagram courtesy of UL FSRI.

The captain of Engine 51 started a 360-degree walk around. The captain could not get to Side Delta due to a fence in the backyard. The Engine 51 officer advised that smoke was showing from the basement door, which was located on the Side Bravo/Side Charlie corner. The chauffeur from Engine 51 stretched a 1¾-inch hoseline to the basement steps and then stretched a 1¾-inch hoseline to the front door of the structure on Side Alpha (**See Diagram 6**). The captain and firefighter from Engine 51 took the hoseline at the top of the basement steps, went down the steps, and then made entry into the basement. The basement door was open. There was light gray smoke showing from the basement door. The time was approximately 1115 hours. Engine 51 was only able to proceed a few feet into the basement due to the excessive clutter conditions. The captain had a thermal imager, which showed nothing. There was smoke in the basement, but no heat or fire. Engine 51 did not flow water. Engine 51 left the basement. Engine 51 left the nozzle at the basement door.

Engine 52 (PAR 2) and Medic 52 (PAR 2) arrived on-scene at 11:16:52 hours. Engine 52 parked behind Engine 51. The chauffeur from Engine 51 connected a 3-inch supply line to Engine 52 for water. Chief 51 arrived on-scene and assumed Command at 1117 hours. Engine 51 exited the basement, left the hoseline at the basement door, and moved to the front yard. Engine 51 met Chief 51

Firefighter Dies After Falling into the Basement due to Floor Collapse at a Modular Home Structure Fire – Missouri

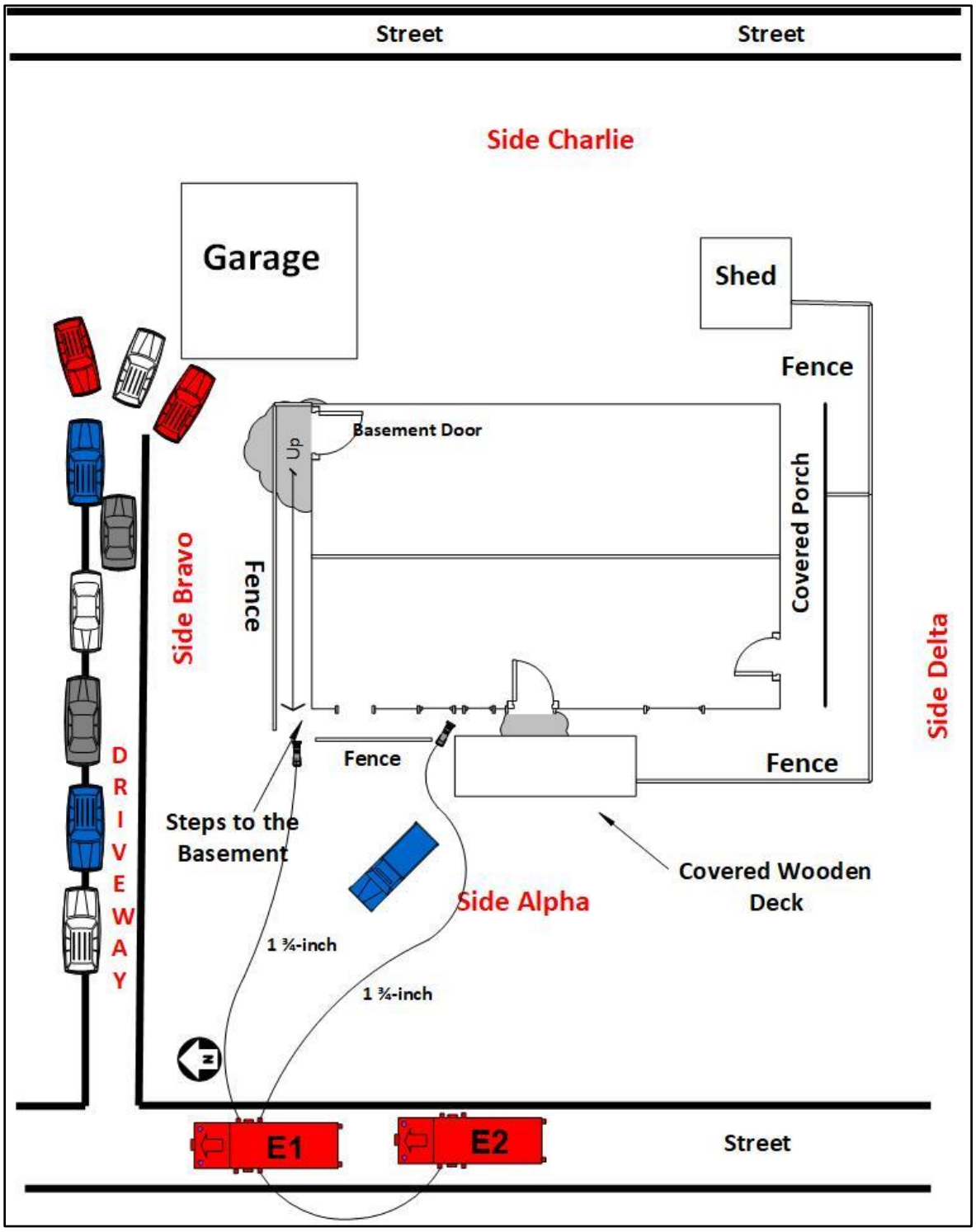

Diagram 6. One hoseline has been stretched to the basement steps and one hoseline to the front door. Light gray smoke was showing from the basement door. The time was approximately 1115 hours.

and advised him of the conditions in the basement. Command advised Engine 51 the case comments stated the occupants said the fire was in the laundry room behind the dryer. Command ordered Engine 51 to take the hoseline at the front door and make their way to the laundry room area.

Engine 51 made entry through the front door at approximately 1118 hours. The firefighter from Engine 52 met Engine 51 at the front door. The captain from Engine 51 and the firefighter from Engine 52 made entry into the house. The firefighter from Engine 51 remained at the front door to hold the screen door open and to feed hose into the building. The firefighter from Engine 52 entered the front door, turned left, and went into the front bedroom by himself. Then he turned and moved towards the kitchen. The captain followed the hoseline in the front door. The captain was behind the firefighter from Engine 52 as he entered the kitchen area. The firefighter from Engine 52 was flowing water.

At 1119 hours, Battalion 82, Engine 81, Tanker 81, and Squad 82 were dispatched to this incident. At 11:19:49 hours, Chief 41 and Pumper 43 arrived on-scene. Upon arrival Chief 41 conducted a 360-degree size-up and risk assessment. Pumper 43 (PAR 4) was assigned to the hoseline at the bottom of the basement steps. Pumper 43 assignment was to knock down any fire in the basement from the doorway. Pumper 43 used a thermal imager in an effort to identify any fire in the basement. High heat was indicated at the ceiling in the basement above the doorway. Pumper 43 backed outside the doorway and began to apply water on the ceiling immediately inside the door. This was to evaluate if entry into the basement was acceptable. The officer of Pumper 43 requested a pike pole to pull the ceiling in the basement. Chief 41 reported to Command that heavy smoke was showing from all sides of the structure. The utilities were electric and propane. The time was approximately 1122 hours.

The Engine 51 firefighter at the front door stated the captain from Engine 51 was inside the doorway. The firefighter and the officer both heard a PASS alarm sounding and heard a lot of glass breaking. The officer went into the kitchen approximately 8 – 10 feet. The Engine 51 officer was getting low on air, the interior was getting hot, and there was no visibility. The officer heard no radio traffic and tried to call Command. The officer wanted the roof vented, but his portable radio was turned off. The noise increased and there was a crashing sound. The officer of Engine 51 said he felt he was being hit by something and his facepiece came off. The officer called the firefighter from Engine 52 several times by name. There was no response. The firefighter from Engine 52 fell into the basement due to the collapse of the 1st floor in the kitchen area between 1125 – 1126 hours. The officer called the Engine 51 firefighter at the front door to help him get out of the house. The Engine 51 officer called a Mayday over the radio but the message didn't transmit. The officer heard a PASS alarm and then the sound went away. The firefighter from Engine 51 went to Engine 51 and got two SCBA cylinders. The captain and the firefighter changed each other's cylinder. The time was approximately 1127 hours (**See Diagram 7**).

At 1129 hours, the chauffeur of Engine 51 advised Command that Engine 51 was out of water. Mutual aid tankers were starting to arrive on-scene. A mutual aid firefighter found a fire hydrant approximately 300 – 400 feet north of the structure. The firefighter drove Engine 52 to the hydrant. He had laid a 5-inch supply line from Engine 51 to the hydrant, made the connection, charged the supply line, and secured a water supply for Engine 51.

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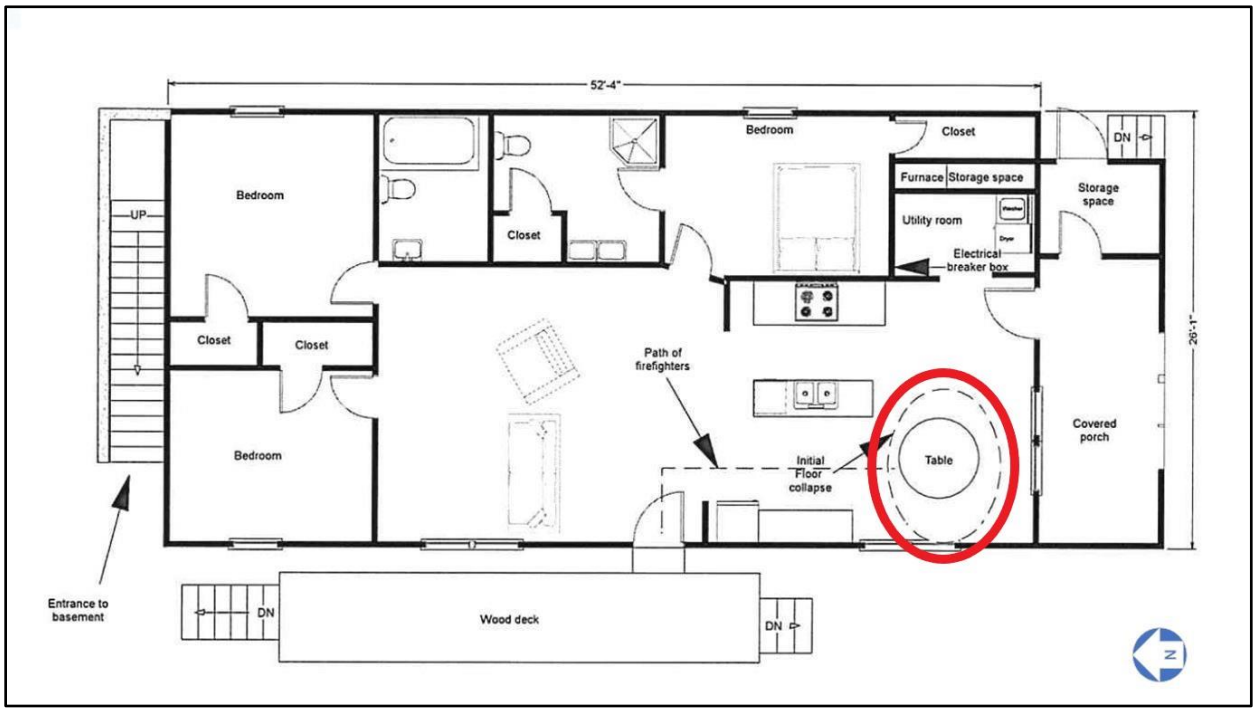

Diagram 7. 1st Floor. The red circle indicates the location of the firefighter from Engine 52, when he fell through the kitchen floor into the basement. The time was approximately 1125 - 1126 hours.

At 1129 hours, the captain of Engine 51 advised Command that the firefighter from Engine 52 was still in the house in the kitchen, possibly trapped by a ceiling collapse. Pumper 43 was reassigned from the basement to the front door in an attempt to locate the firefighter from Engine 52. Pumper 43 repositioned to the front door for search operations. Pumper 43 followed the hoseline advanced by the initial entry crew until it doubled back, possibly due to a loop placed in the hoseline inside the structure. One of the firefighters from Pumper 43 grabbed the hoseline but it was uncharged. Pumper 43 moved towards the kitchen. Members of Pumper 43 stated they could hear a PASS alarm sounding when they entered the front door. Using a thermal imager, the officer of Pump 43 began to advance into the kitchen a short distance beyond the hoseline when the ceiling began to come down. This started to block their egress. The interior conditions began to deteriorate rapidly. The smoke turned from gray to black smoke under pressure (**See Diagram 8**). A layer of soot covered their facepieces and the lens of the thermal imager causing zero visibility and the heat intensified. The officer of Pumper 43 called a Mayday at 11:31:25 hours. The officer of Pumper 43 called a Mayday stating, "extreme heat, structural collapse, and trapped". The front door closed temporarily trapping members of Pumper 43 inside the house. A member of Pumper 43 had gone outside but quickly opened the front door. It took about 45 seconds to get the other three members of Pumper 43 out of the structure safely. Pumper 43 was out of the structure at 1132 hours and the Mayday was cleared.

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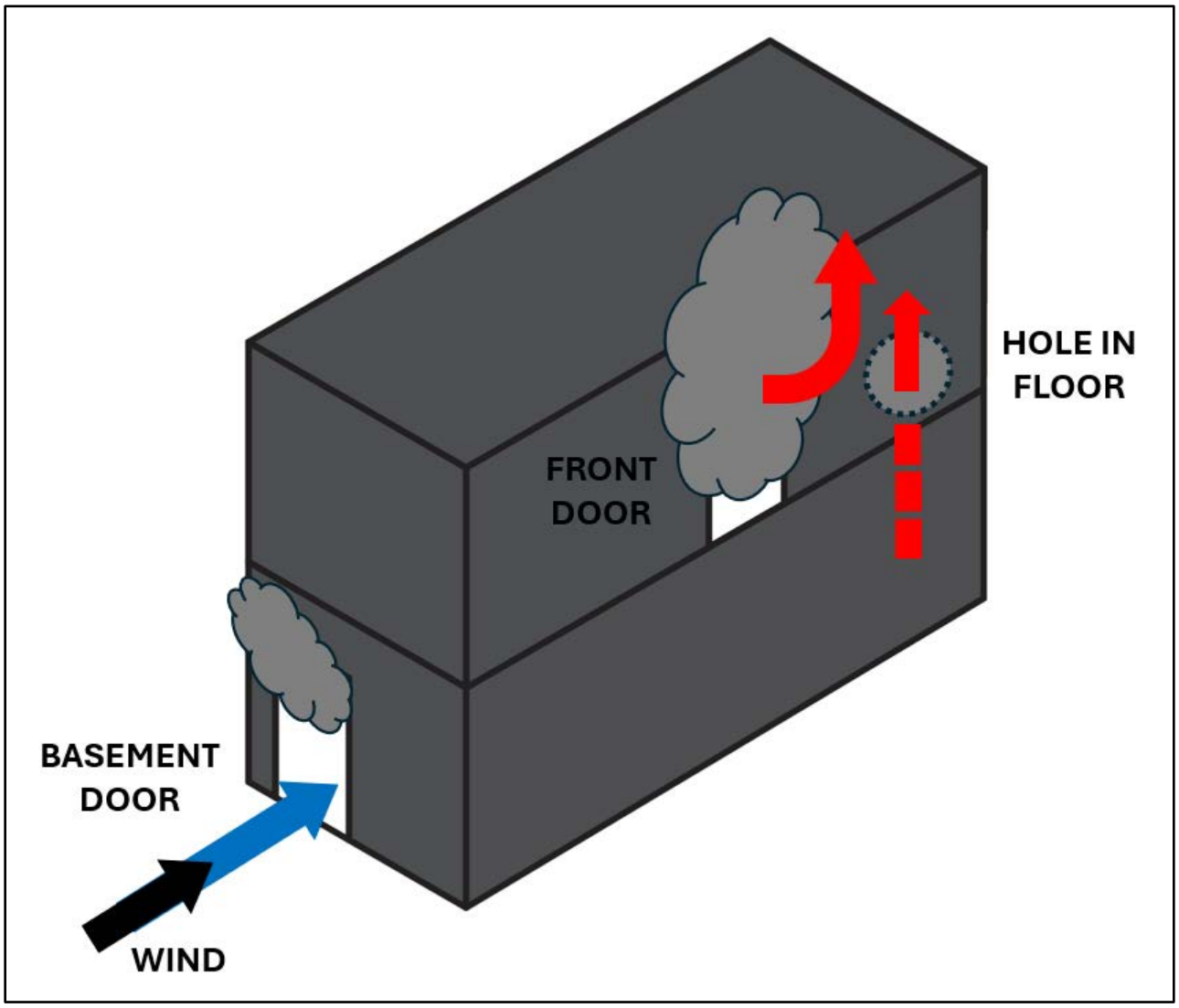

Diagram 8. When the firefighter from Engine 52 fell through the kitchen floor into the basement, a flow path was created. The basement door and the front door were open.
Diagram courtesy of UL FSRI.

At 1134 hours, the structure was well involved. Command assembled three crews to staff hoselines and to try and locate the missing firefighter from the exterior. Two hoselines were operating on Side Alpha and one hoseline on Side Delta. All hoselines were operating from the exterior. At approximately 1135 hours, Pumper 27 arrived on-scene. At approximately 1136 hours, Battalion 82, Engine 81, Tanker 81, and Squad 82 arrived on-scene. At approximately 1137 hours, Pumper 27 made an attempt to enter the house through the front door to try and locate the firefighter from Engine 52. Due to the deteriorating conditions, the crew from Pumper 27 could not make entry and were driven out of the structure.

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At 1138 hours, Battalion 82 was assigned as rapid intervention group supervisor. Battalion 82 assigned Squad 82 to the roof for vertical ventilation. Engine 81 removed the kitchen bay windows and cut the wall under the bay windows down to the floor level. Upon removing the windows, Engine 81 discovered that a portion of the kitchen floor had collapsed. This confirmed the firefighter from E52 had fallen into the basement. A roof ladder was lowered into the basement from the bay window area through the collapsed area. Firefighters tried to go down ladder to conduct a search. The firefighters were unable to make it to the basement do to the intense heat conditions.

At 11:42:19 hours, Command contacted the fire dispatcher and requested a box alarm assignment from the metropolitan fire department. At 1143 hours, Command advised the strategy was now defensive. The fire dispatcher called the metropolitan fire department dispatcher and requested a box alarm respond to this incident for a missing firefighter at 11:43:41 hours. At 11:49:48 hours, the metropolitan fire department dispatched Pumper 45, Pumper 42, Pumper 41, Pumper 36, Truck 15, Truck 11, Rescue 9, Rescue 31, Car 107, and Car 101 to this incident.

At 1209 hours, Car 107 (District Chief) from the metropolitan fire department arrived on-scene. At approximately 1210 hours, Car 107 (District Chief) met with Command to develop a strategy and incident action plan to find and rescue the missing firefighter from Engine 52.

At 1213 hours, Car 107 conducted a 360-degree walkaround of the structure. Car 107 said he heard multiple PASS alarms sounding outside the structure. Car 107 advised Command to have all firefighters turn off their SCBA cylinders and reset the PASS alarm. Car 107 looked into the basement. There was at least 6" of standing water on the basement floor and fire in the void spaces. There were 3 hoselines in operation from the exterior – two on Side Alpha and one on Side Delta. At 12:13:40 hours, the 1st Box Alarm assignment from the metropolitan fire department started to arrive on-scene (**See Timeline**).

Once the companies from the metropolitan fire department were in place and the incident action plan was communicated by Car 107, companies entered the basement. At 1222 hours, Pumper 45 took a 1¾-inch hoseline into the basement with Truck 15. Pumper 42 was operating a hoseline on Side Charlie. Truck 11 was assigned as RIC. These companies used hoselines already in place for fire attack. The basement was well involved, and Pumper 45 and Truck 15 worked to knock down the fire while searching with a thermal imager for the missing firefighter. Pumper 45 and Truck 15 found the firefighter submerged under water and covered with debris. The missing firefighter was located near the wall on Side Alpha directly under the double windows in the kitchen/dining room. He was under a workbench on the Side Alpha wall and a table (**See Diagram 9**). He was found face down and his facepiece was not in place. The captain from Rescue 9 entered the basement via the ground ladder. The officer of Pumper 45 showed the captain where the missing firefighter was located in the basement. The captain stated he could hear the PASS alarm sounding and could see the lights on the SCBA. Rescue 9 had removed the double windows including the stud.

A ground ladder was placed into the basement. The time was 12:34:13 hours. There was no radio communications between Command and companies from the metropolitan fire department until a radio

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patch was made. All companies then operated on "RegComm7." Prior to the patch, Car 107 had to communicate on the fireground through a mutual aid medic unit.

Pumper 45 and Truck 15 came out of the basement due to being low on air at 1236 hours. At 1237 hours, Car 101 assumed Command of the incident. The incident action plan was changed from a rescue to a recovery. Car 107 was assigned as the recovery group supervisor. The incident action plan was:

- Integrate other companies
- Hold the fire with minimal water
- Companies sent into the basement to move debris off the missing firefighter
- All members in the basement were to be on air.

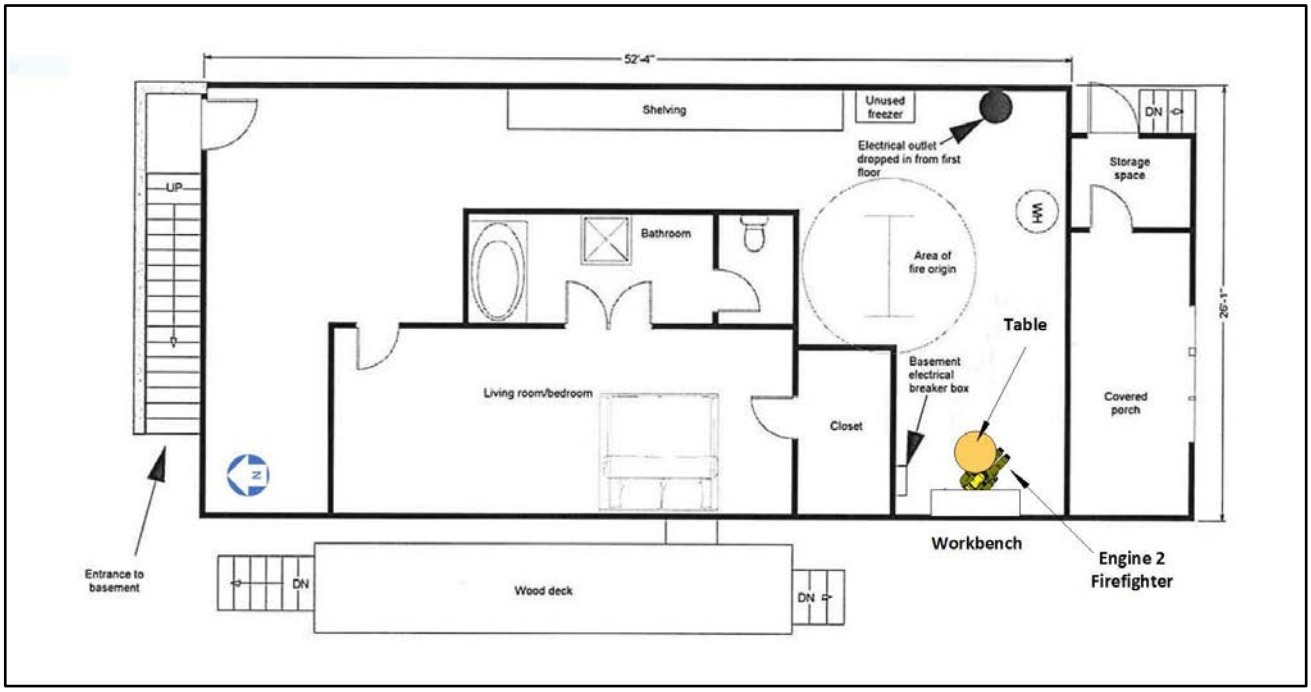

Diagram 9. Basement. Pumper 45 and Truck 15 found the missing firefighter from Engine 562 under a wall-mounted workbench in the basement. The firefighter was covered with debris, a table and submerged under water. The time was 12:34:13 hours.

At 1241 hours, Rescue 9 and Rescue 31 entered the basement via the ground ladder closest to the firefighter from Engine 52. The fire was mostly under control by this time. Rescue 9 did have a hoseline with them. There was limited visibility due to smoke and steam. The water was 20-24 inches deep in the basement and was extremely hot. Rescue 9 had to move a lot of debris to get the firefighter from underneath the workbench. A carabineer was hooked to the firefighter's SCBA strap, and the members of Rescue 9 were able to pull the firefighter to the doorway at the Side Bravo/Side Charlie corner of the basement. During the interviews with Pumper 45, Truck 15, Rescue 9 and Rescue 31, all members stated they found the missing firefighter due to the PASS alarm sounding. The auditory

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PASS alarm was critical because the firefighter was not visible due to being submerged underwater and covered with a table and debris.

A Stokes basket was brought into the basement by Rescue 31. The firefighter was missing his helmet, one glove, and his protective hood was pulled down around his neck. Rescue 9 and Rescue 31 packaged the firefighter in the Stokes basket. They silenced the PASS alarm and prepared for him to be removed from the basement. The time was 12:59:49 hours. Rescue 9 and Rescue 31 had the firefighter out of the basement at 1305 hours.

Rescue 9 and Rescue 31 were met by Medic 821 and a life flight nurse. The firefighter's SCBA was removed and then the firefighter was moved from the Stokes basket to the stretcher. The firefighter was in cardiac arrest and had burns to his face and hands. Members of Medic 821 started CPR with advanced life support. The firefighter was transported to a regional hospital at 1308 hours. The firefighter was pronounced deceased at 1328 hours at the hospital.

At 13:43:19 hours, Command advised the fire dispatcher that the fire was under control. At 1705 hours, the fire was placed out. At 19:32:04 hours, all units were clear.

Fire Origin and Cause

Investigators from the Missouri Department of Public Safety, Office of the State Fire Marshal provided the following conclusion of the investigation of this fire: "Based upon the observations and evidence from the fire scene examination, the possibility of an electrical failure or arcing event could not be excluded as a possible cause of the fire. However, due to extreme structural damage and the inability to completely test the entirety of the electrical system components, the fire is listed as *undetermined*."

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 fatalities:

- *Delayed notification of the fire to the 9-1-1 center*
- *Lack of continuous scene size-up and risk assessment*
- *Lack of crew integrity*
- *Building construction – modular home*
- *Basement fire*
- *Wind-impacted fire*
- *Lack of incident management, including management of a Mayday*
- *Lack of personnel accountability*
- *Lack of a rapid intervention crew(s)*
- *Inadequate fireground communications*
- *Portable radio operational issues*
- *Inadequate staffing*

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- *Initial lack of a secured water supply*
- *Lack of proficiency training.*

Cause of Death

According to the autopsy report, the medical examiner listed the deceased firefighter's cause of death as complications of thermal injuries and inhalation of products of combustion. The manner of death was accidental.

Recommendations

Recommendation #1: Fire departments should ensure the first arriving resource assumes command, conducts a scene size-up and risk assessment, determines the incident's strategy, and incident action plan. This information is communicated in the initial radio report.

Discussion: At this incident, Engine 51 arrived on-scene and the captain advised the fire dispatcher that there was gray smoke showing and Engine 51 was investigating. The captain did not talk to the occupants nor did the fire dispatcher advise Engine 51 that everyone was out of the house. The case comments did indicate that the fire was in the laundry room around the dryer. The captain tried to conduct a 360-degree size-up but didn't go to Side Delta. The occupants tried to fight the fire for approximately 6 – 9 minutes prior to calling 9-1-1, which was never communicated to Engine 51.

The strategy and incident action plan (IAP) of an incident are dictated by the size-up, initial risk assessment, and situational report made by the first arriving officer. The priority is to get fire department resources to Side Charlie as quickly as possible for a size-up and risk assessment. However, unless an obvious life safety issue exists (e.g., visible victims requiring immediate assistance), interior firefighting operations should not commence until a report from Side Charlie is received. If physical barriers make the 360-degree size-up impractical for the 1st arriving officer, the delegation of the size-up of Side Bravo, Side Charlie, and Side Delta may go to another company on the 1st Alarm assignment. Even if a 360-degree size-up was conducted, the assignment of resources should go to Side Charlie. Resources could include any unit—engine, truck, medic unit, or chief—, preferably an engine company with a hoseline [Fire and Rescue Departments of Northern Virginia [FRDNV) 2013]. Until the initial 360-degree assessment is completed, incident commanders must be cautious in committing fire crews to the interior. Constantly monitoring changing conditions and being prepared to immediately adjust crew assignments or withdraw crews all together should be considered.

The tasks that need to occur at any fire, regardless of the occupancy are:

- an initial radio report upon arrival, which includes:
  - Building description
    - Size, height, and type of occupancy
  - Problem description
    - Smoke and fire conditions
  - Initial incident action plan
    - The company's
      - Task(s), location, and objectives

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- Declaration of the incident strategy
  - Offensive or defensive
- Resource determination
- Assume and name command [SKCFTC 2023].

At any incident, life safety is always the first priority, followed by incident stabilization (second priority) and then property conservation (third priority). The task of ensuring for the safety of firefighters is a continuous process throughout the incident. A sound risk management plan ensures that the risks are evaluated and matched with appropriate actions and conditions. The following risk management principles should be used during fireground operations:

- Limit activities that present a significant risk to the safety of members to situations where there is a potential to save endangered lives
- Recognize activities that are routinely employed to protect property as inherent risks to the safety of members and take actions to reduce or avoid these risks
- Do not risk the safety of members when it is not possible to save lives or property
- Limit activities to defensive operations in situations where the risk to fire department members is excessive [NFPA 1500 2021].

Fireground operations are very dynamic and fast-paced. An incident commander must determine a strategy and then develop an IAP. Incident commanders must follow the decision-making model that includes identifying incident critical factors (through a situational evaluation or size-up), considering the standard risk management plan, declaring the strategy (offensive or defensive), and then setting tactical objectives (**See Diagram 10**). This model will lead to the development of an IAP, which serves as the tactical road map to effectively manage the incident. An IAP defines where and when resources are assigned throughout the incident, along with tasks and objectives [NFPA 1561 2020].

To ensure a standard outcome for each incident, incident commanders should match the standard conditions to standard actions. This is the core of the incident command system and the basis for all operations. The incident commander should identify the incident's current critical factors before taking any action.

Initial and continuous size-ups of the incident's conditions including Side Charlie should produce the information that becomes the basis for the incident strategy and the IAP. The collection of current, accurate, and relevant information will provide the foundation for effective initial and ongoing actions. Ultimately, this systematic evaluation process will produce standard, safe, and well-managed incident outcomes [Brunacini 2002].

When developing an IAP, the strategic goals are developed first, followed by development of the tactical objectives that are assigned to responding companies. At each incident, the incident commander should start with a standard placement-oriented operational plan that develops a strong, dependable beginning for command and control of the incident [Brunacini 2002; FRDNV 2013]. Often the initial incident commander is a company officer who arrives on-scene prior to a chief officer. The company officer should provide a detailed size-up, which is communicated to all responding resources, including the dispatch center or fire alarm office. The company officer assumes command

and makes decisions regarding the strategy and the IAP. Events can occur very quickly before a detailed tactical worksheet or written IAP is developed. When the company officer does not have the ability or time to record the IAP on paper, a verbal IAP is appropriate when transferring Command [Brunacini 2002; Harms, 2010].

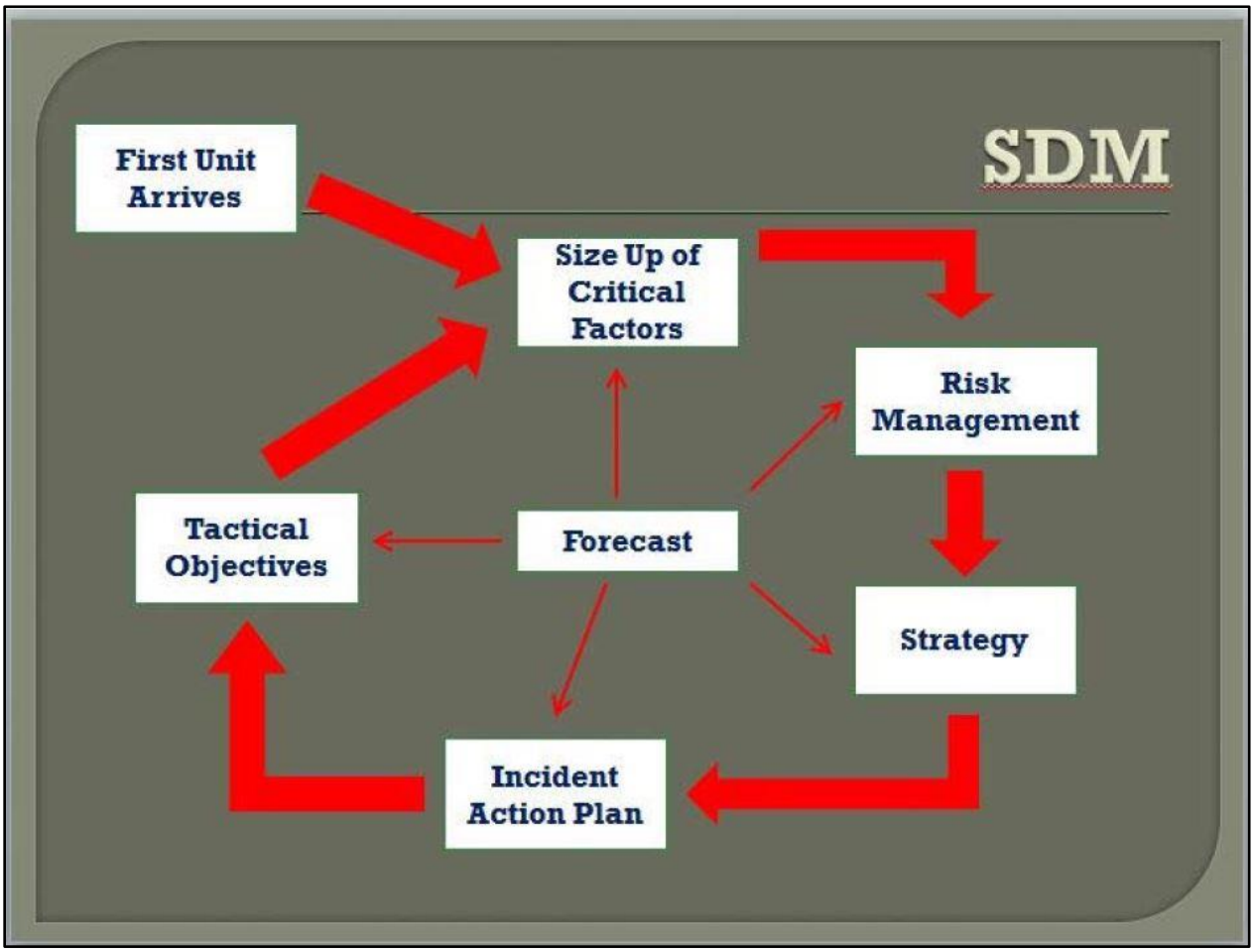

Diagram 10. This model displays the strategic decision-making process in a standard sequence.
(Diagram courtesy of the Phoenix Fire Department.)

Once an officer assumes command, the overall strategy is communicated. Command should make specific assignments to arriving companies along with tactical objectives, such as search, rescue, fire attack, ventilation, utility control, and exposure protection. The responding chief officer should monitor radio communications and document tactical objectives on a tactical worksheet. When the chief officer arrives on scene, an update from the initial incident commander should occur with a CAN (conditions, actions, and need) report (face to face or by radio). The chief officer will then assume command at a stationary location. By following this process, the initial and subsequent incident

commanders will have a stronger position to manage an incident should an emergency event occur [NFPA 1561 2020].

NFPA 1561, *Standard on Emergency Services Incident Management System and Command Safety* defines an IAP as a verbal plan. The IAP reflects the overall incident strategy, tactics, risk management, and member safety that are developed by an incident commander. NFPA 1561 requires the following regarding an IAP:

- 5.3.16.1. The incident commander shall be responsible for developing and/or approving an incident action plan.
- 5.3.16.2*. This IAP shall be communicated to all staged and assigned members at an incident.
- 5.3.16.3 For Type IV and Type V incidents, the incident commander shall communicate the IAP verbally to all on-scene resources.
- 5.3.24. The incident commander shall be responsible for reviewing, evaluating, and revising the IAP and overall strategy of the incident (**See Diagram 11**).

The following are guidelines for developing an IAP for offensive and defensive operations.

Offensive Incident Action Planning

The decision to make an offensive fire attack has to be based in the knowledge, skills, and capabilities to effectively extinguish the fire and search the interior compartments, in the quickest, most effective manner. This is ultimately creating the safest possible operations. In an offensive strategy, the fire attack can begin on the exterior or interior dependent on the conditions, however fire control and search work will ultimately be completed in the interior spaces within the hazard zone.

The constant evaluation of the incident conditions and all initial and ongoing factors could possibly change the strategy. This is coupled with if critical incident benchmarks are being met/not met. This process is critical in evaluating the incident strategy and incident action plan. A change in strategy occurs when an assessment determines the strategy and incident action plan have become out of balance with the extinguishment capability and structural integrity.

The risk management for any incident is determined based on the size-up and critical fireground factors as assessed by the initial arriving incident commander. When an incident's critical factors and the risk management plan indicate an offensive strategy, Command will define the tactical objectives for entering the structure (hazard zone) to attempt to control the incident hazards. An offensive IAP is based on the standard offensive tactical priorities and their corresponding completion benchmarks. The following list serves as a guide for the incident commander to consider:

- Perform a continuous 360-degree size-up
- Put water on the fire
- Life safety – primary and secondary "All Clear(s)" (A/C)
- Water supply established
- RIC is established
- Fire Control (F/C) – "Under Control/Tapped Fire"
- Ventilation coordinated with fire attack

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- Property conservation – "Loss Stopped" (L/S)
- Post fire control firefighter decontamination (Decon)

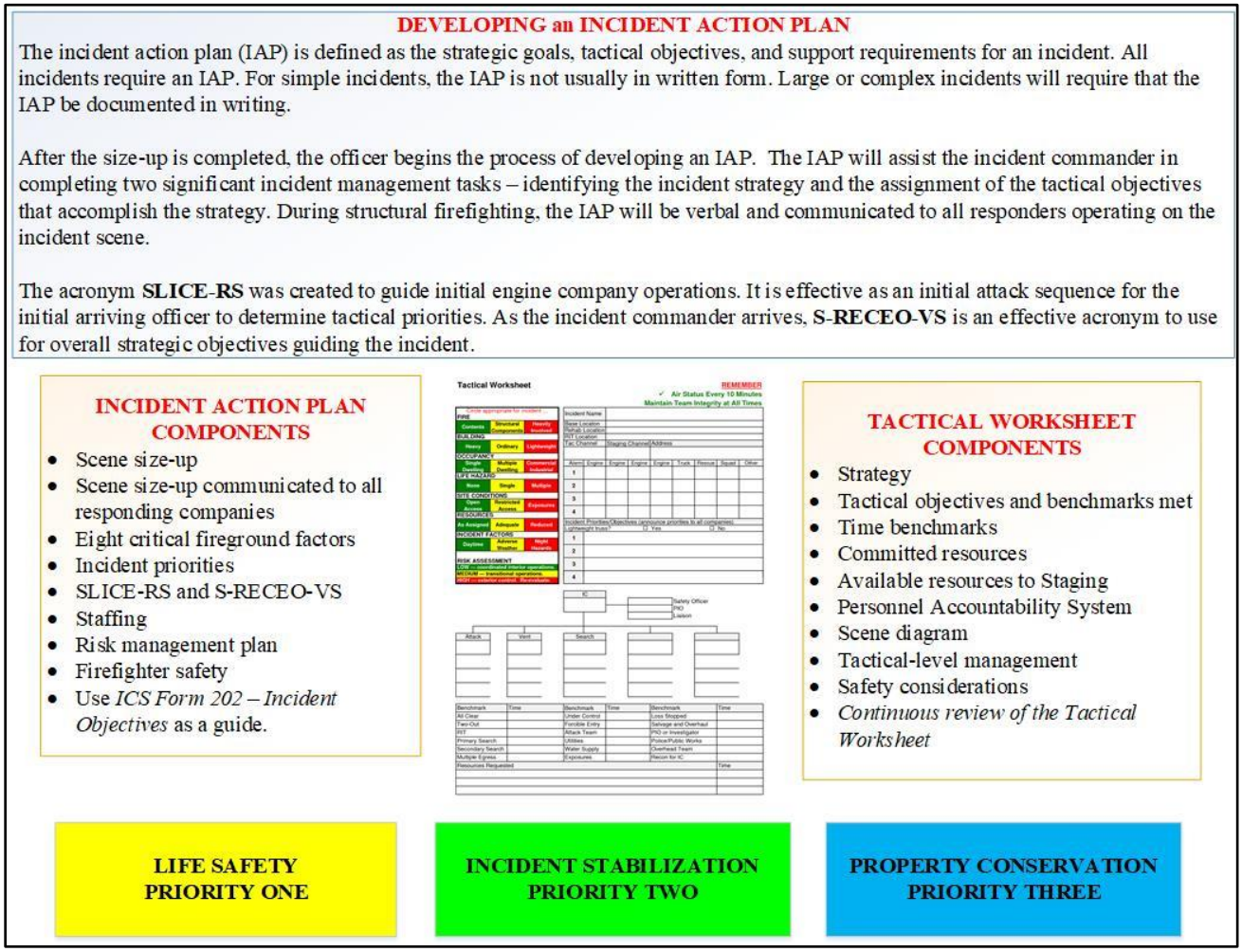

Diagram 11. A guide for developing an incident action plan at Type V and Type IV incidents. For these types of incidents, the incident action plan is most often communicated verbally.
(Courtesy of FireFighterCloseCalls.com.)

Defensive Incident Action Planning

In a defensive strategy, the fire control actions will be done from the safest, most effective positions outside of the hazard zone. A defensive situation is where the incident problem has evolved to the point that lives and property are no longer savable and offensive tactics are no longer effective or safe. The entire defensive strategy is based on protecting firefighters. All firefighters should operate outside the collapse zone to prevent harm. Firefighter safety is the #1 defensive priority.

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Defensive strategy tactical priorities and their corresponding completion benchmarks are:

- Identify critical fireground factors
- Quick determination on additional resources
- Evaluate fire spread/write-off lost property
- Search exposures
- Protect exposures
- Prioritize fire streams, provide big, well placed master streams
- Surround and drown
- While operating in the defensive mode, no firefighters should be injured [SKCFTC 2023].

Defensive operations represent a standard organizational response to when offensive tactics cannot control the situation. Command must write off lost property and decide where the cutoff comes between operating offensively or defensively. If defensive operations are conducted from the onset of the incident, the involved structure(s) will not have a primary search. During defensive operations, Command will coordinate the rotation of crews for rest and rehydration.

Recommendation #2. Fire departments need to ensure that company officers and firefighters maintain crew integrity when operating in the hazard zone.

Discussion: At this incident, Engine 51 members went into the basement together and then moved to Side Alpha. The captain of Engine 51 and a firefighter from Engine 52 entered the house through the front door. The firefighter took the hoseline into the front bedroom by himself and then moved towards the kitchen. The captain met the firefighter as he was entering the kitchen area. The firefighter was ahead of the captain as he entered into the kitchen area. The firefighter fell through the kitchen floor into the basement. The captain could not locate the firefighter from Engine 52. The firefighter from Engine 51 was at the front door. The captain and the firefighter from Engine 51 left the building. The captain didn't inform Command that the firefighter from Engine 52 was missing for approximately 3 minutes.

NFPA 1500, *Standard on Fire Department Occupational Safety, Wellness, and Health Program* states in Paragraph 8.5.6 states, "Company officers shall maintain an ongoing awareness of the location and condition of all company members." Paragraph 8.5.7 states, "Where assigned as a company, members shall be responsible to remain under the supervision of their assigned company officer." [NFPA 1500 2021].

If a firefighter becomes separated and cannot re-connect with his/her crew immediately, the firefighter should 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 1 minute, a Mayday should be declared.

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 firefighters always enter a burning building as a team of two or more members and no firefighter is allowed to be alone at any time while entering, operating in, or exiting a building. A critical element for firefighter

survival is crew integrity. *Crew integrity means firefighters 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, have the proper personal protective equipment, and have 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. Just 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 [IAFC 2009].

It is the responsibility of every firefighter and company officer to stay in communication or contact with crew members at all times 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 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. If crew integrity is lost, and firefighters are placed at increased risk. A Mayday should be called if any member cannot be accounted for as described above.

NFPA 1500, *Standard on Fire Department Occupational Safety, Health, and Wellness Program*, 8.6.5, states, "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 [NFPA 1500 2021]." NFPA 1500, Paragraph 8.6.4 states, "Members operating in hazardous areas at emergency incidents shall operate in crews of two or more" [NFPA 1500 2021]. Additionally, NFPA 1500, 8.6.6, states, "Crew members shall be in proximity to each other to provide assistance in case of an emergency" [NFPA 1500 2021].

Recommendation #3: ***Fire departments should ensure that all companies are operating based upon the assignment given by the incident commander. The Task-Location-Objective assignments should be communicated over the radio, which prevents freelancing and ensures that tactical priorities are met.***

Discussion: At this incident, Command did not communicate an IAP (tactics) upon arrival. Engine 51 was never given an assignment by Command to go to the basement or move to Side Alpha. Command met with Engine 51 in the front yard. Command told Engine 51 to try and locate the fire near the dryer in the utility room.

The IAP is a methodical process that ensures life safety, incident stabilization, and property conservation. Assigning the tactics in the order of accomplishment will aid in the coordination of the fireground activities. Companies should communicate their progress reports on the tactical objectives given them by Command to complete the tactical priorities. This focuses the operation on making sure everyone is out of the hazard zone and safe, eliminating the incident problem, and reducing the damage to the customer's property. Incident operations are conducted around the completion of the tactical priorities. Incident communications should mirror this simple concept. This will help keep communications short and effective. It maximizes the available free airtime.

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The incident commander will need to use the following structure when assigning any unit into the hazard zone: The initial IAP should include the following:

- The tasks of the initial arriving unit
- The location of the tasks
- The objectives of the tasks [SKCFTC 2023].

An assigned tactic provides a direction to a company, which serves as the basis for feedback to the incident commander as to whether the tactic is completed. If a company is unable to complete the assignment, the incident commander needs to know as soon as possible in order to adjust the IAP. The incident commander must understand why the company is not capable of completing its assigned tactic. This can include no water, unable to locate the fire, unanticipated conditions, or conditions that have deteriorated since the original assignment [USFA 2009].

The IAPs communicated on the initial radio report should be short and to the point describing what actions the first arriving company intends take to mitigate the critical factors.

- **Tasks**: Some of the standard tasks that should be communicated:
  - Investigating (nothing showing)
  - Establishing a water supply
  - Stretching attack lines (for Quick Hit/Fire Attack)
  - Operating a master stream
  - Performing forcible entry (takes a while)
  - Performing a physical rescue.
- **Location**: Some of the standard locations of those tasks should include:
  - What floor you will be operating on
    - Structures that have multiple units (occupancies such apartments or strip malls) will need to have the specific unit identified, i.e., main fire unit/building/Bravo 1 or Delta 1 Exposure along with floor number.
  - What occupancy/exposure will be operating in
  - What side you will make entry on
  - What side you will be operating on (defensive).
- **Objective:** Some of the standard objectives include:
  - Fire attack/primary search
  - Primary search/check for extension
  - Overhaul
  - Salvage
  - Secondary search
  - Defensive fire attack
  - Exposure protection [SKCFTC 2023].

When assigning companies to areas that already have units assigned, the incident commander should inform the newly assigned unit to whom it will report to/work under. The incident commander should inform the division/group supervisor of the newly assigned companies(s).

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Recommendation #4: Fire departments need to ensure that critical incident benchmarks are communicated to the incident commander throughout the incident.

Discussion: At this incident, no incident benchmarks were communicated to Command. This includes entering the basement, conditions encountered in the basement, then moving to Side Alpha, unable to locate the fire on the 1st floor, and the firefighter from Engine 52 was missing.

Company officers should communicate with the incident commander when benchmarks are met or not met. This is an essential element of the IAP because this process allows Command to consider and account for changing fireground conditions. Moreover, Command must be able to forecast the direction of the incident in order to stay ahead of the fire. Without this information, the IAP becomes out of sequence with the phase of the fire. Once an incident benchmark has been met, the IC is obligated to communicate this information to all companies operating at the incident.

Fire departments should consider incident management system training and a certification program for company officers and chief officers that prepares members for dynamic events that they will encounter. This program would benefit officers who serve in the role of incident commander, as well as those who supervise and manage emergency and hazard zone operations for everyday local National Incident Management System, Type V and Type IV incidents [NFPA 1561 2020].

Fireground benchmarks are an essential element for accomplishing successful and safe outcomes. To ensure that the proper benchmarks are communicated at fireground incidents, fire departments should develop and maintain a consistent process for communicating critical benchmarks in the form of an SOP/SOG. The SOP/SOG should include effective hands-on classroom and practical training programs with annual live fire training, a defined department deployment model, an effective incident management system, adequate radio equipment (mobile and portable radios), and adequate radio channels (dispatch, tactical, and command channels) [NIOSH 2014a, NIOSH 2014b, NIOSH 2015]. Because the IC is located at the Command Post (outside the hazard zone), operating crews should communicate the interior conditions to the incident commander as soon as possible. Interior conditions can change the incident commander's strategy and IAP. 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 when benchmarks are met (e.g., "primary search complete, all clear" and "the fire has been knocked down").

A fire department's communications SOP/SOG should include communications necessary to gather and analyze information to plan, issue orders, and manage operations. For example:

- Additional resources required
- Status of water on the fire
- Assignment completed
- "All clear" – primary search is complete
- Unable to complete an assignment
- Special information
- Emergency traffic or Mayday [FIRESCOPE 2015].

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Communication of critical 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. Incident commanders should use the critical factors in their order of importance, as the basis for making the specific assignments that make up the IAP. Incident commanders should not assume action-oriented responders engaged in operational activities will stop what they are doing so they can feed command with a continuous supply of accurate, objective information. It is the incident commander's responsibility to do whatever is required to stay effectively informed [Brunacini 2002].

For all members operating at an incident scene, radio discipline is essential. All members should receive training on and use the thought process of "is my transmission necessary" as a part of fireground behavior. It is necessary to reserve all radio transmissions for relevant messages, such as benchmarks, CAN report, PARs, safety issues or concerns, needed resources, changing conditions, emergency traffic, and a Mayday. Members should refrain from transmissions that add little information to the IAP.

As the incident progresses, the following information needs to occur between Command and companies operating on the fireground:

- Follow-up radio report—CAN Report (conditions, actions, needs)
- Safety concerns
- Status of water on the fire
- Additional detailed report of fire/smoke conditions and location(s)
- Status of personnel accountability (announce the initial accountability location, e.g., Engine 19)
- Disposition of resources
- Rapid intervention crew in place and location
- Any notable results of the initial fire attack [FIRESCOPE 2015].
-

Recommendation #5: Fire departments should use NFPA 1700, Guide for Structural Fire Fighting to develop and revise fireground operational procedures.

Discussion: NFPA 1700 is largely based on firefighting research studies conducted by National Institute of Standards and Technology (NIST) and Underwriters Laboratories Fire Safety Research Institute (FSRI). NIST and UL FSRI have conducted a series of live-burn experiments designed to replicate conditions in modern homes and other residential structures, This research is to validate testing which occurred in laboratory settings. The results of these experiments enable firefighters to better predict and react to the effects of fire in these types of occupancies. The fire research experiments were conducted in cooperation with the Fire Department of New York (FDNY); Chicago Fire Department (CFD); Spartanburg Fire and Rescue, Spartanburg, South Carolina; and other agencies. The live-burn tests are aimed at quantifying how fires are different today, largely because of new building construction and the composition of home furnishings and products. In the past, these products mainly were composed of natural materials, such as wood and cotton, but they now contain large quantities of petroleum-based products and synthetic materials that burn faster and hotter and generate large volumes of fuel-rich smoke. Where a fire in a room once took approximately 20 minutes

to "flashover"—igniting all the contents—this can happen with today's furnishings in as little as 4–5 minutes [Kerber 2012, Madrzykowski 2013].

The NIST and UL experiments evaluated individual and combinations of methods for strategically ventilating and isolating fires to prevent or delay flashover. In contrast, kicking a door open or breaking a window without knowledge of conditions inside could create a portal for air that can literally fan the flames by introducing oxygen into an oxygen-limited fire environment. Traditionally, fire suppression operations were conducted from the interior of a structure to reduce water damage and limit fire damage. It is essential to coordinate these operations with the ventilation operations. Previous research and investigations of line-of-duty deaths have shown that ventilation events occurring prior to suppression while firefighters are in the structure have led to tragic results [NIOSH 2012a, 2013a, 2013b]. One method of eliminating this risk is by using a transitional attack. Prior to the firefighters entering the building, water should be directed into the structure from the exterior to cool the fire gases and reduce the heat-release rate of the fire. The major concern with this type of operation is the potential harm that can occur to people trapped in a structure or the amount of water damage to a structure. It is possible to lose structural integrity in less than 5 minutes once the floor assembly becomes involved in fire [Kerber et al. 2012]. Therefore, UL has shown that effective suppression operations, either from the interior or exterior, did not increase the potential burn injuries to the occupants. However, the delay of suppression operations provides the potential for longer occupant exposures and increased potential for further injury or death [Zevotek et al. 2017].

Other challenges from basement fires and related tactical considerations were noted in a recent study conducted by the International Society of Fire Service Instructors (ISFSI) and UL FSRI on Understanding and Fighting Basement Fires [Madrzykowski and Weinschenk 2018]. Research has shown below-grade fires present a high risk to firefighters, stemming from unexpected floor collapse and high heat. Research also indicated the tools that firefighters have traditionally used to determine the structural integrity of the floor are not effective with lightweight construction [Madrzykowski and Weinschenk 2018].

The key findings are:

- Size-up is critical
- Below-grade fires are likely ventilation-limited
- Coordinating ventilation with water application is required to limit the growth of a ventilation-limited fire
- Ventilation without suppression was shown to increase the hazard to trapped occupants
- Water application in the below-grade space is key to smoke cooling
- Effective water application into below-grade space reduces the hazard throughout the structure
- Options exist to make a coordinated and effective attack
- It is best to fight the fire on its own level.

The ISFSI/UL FSRI study went beyond earlier research by increasing the size of the basement and incorporating three different ventilation and access conditions to the basement. Those access conditions included no exterior access to the basement, limited exterior access to the basement, and exterior access to the basement. The results of the experiments showed the importance of identifying a

basement fire, controlling ventilation, and flowing an effective hose stream into the basement from a position of advantage as soon as possible.

The basement experiments highlighted the importance of identifying a basement fire during size-up and subsequently choosing the appropriate tactics that coordinate ventilation with suppression. In all experiments, the basement fire was ventilation limited. Various nozzles and appliances (Bresnan distributors, piercing nozzles, and cellar nozzles) were used to flow water into the basement. Water streams applied through the floor, through a small window remote from the seat of the fire, and through a basement-level access door controlled the fire and reduced the hazard throughout the structure.

Effective water application into a basement cooled the fire gases to prevent flashover, slowed the destruction of the structure and the floor assembly, and reduced the hazard from fire. This action made entry conditions into a basement with active burning possible for a fully protected firefighter. Effective water application also supported search operations and reduced the threat from heat and toxic gases for any trapped occupants [Madrzykowski and Weinschenk 2018].

Based upon the NIST and UL research, fire departments should consider implementing the following fireground operations.

- **Size-up**
  Size-up must occur at every fire. It is necessary to consider the resources available and situational conditions, such as weather, fire location, size of the fire and building, and the construction features. A 360-degree size-up should be conducted whenever possible and be continuous. It is necessary to develop, communicate, and implement tactical objectives (incident action plan) for each fire.
- **Ventilation**
  Fire departments should manage the openings to the structure to limit fire growth and spread and to control the flow path of inlet air and fire gases during tactical operations. It is necessary to coordinate all ventilation with suppression activities. Uncontrolled ventilation allows additional oxygen into the structure, which may result in a rapid increase in the fire development and increased risk to firefighters because of increased heat-release rates within the flow path.
- **Firefighting Operations**
  Given the fuel-rich environment that the fire service operates in today, fire departments should apply water to the fire as soon as possible. In many cases, the best first action is water application through an exterior opening into a fire compartment, prior to committing firefighting resources to the interior. Fire departments should cool the interior spaces of a fire building with water from the safest location possible, prior to committing personnel into spaces with, or adjacent to, fully developed or smoldering (ventilation-limited) fire conditions.
- **Rapid Intervention**
  Fire department rapid intervention procedures should include providing water on the fire as soon as possible and controlling ventilation openings during firefighter Mayday incidents [ISFSI 2013].

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These research findings are presented to assist fire departments in making an informed decision related to changing fireground tactics. Much of this research was directed toward developing a better understanding of the characteristics of modern fire behavior. While firefighting always will have risk, this research represents a vital contribution to overall efforts to reduce risks and to save lives.
A flow path is composed of at least one inlet opening, one exhaust opening, and the connecting volume between the openings. The direction of the flow is determined by difference in pressure. Heat and smoke in a high-pressure area will flow through openings toward areas of lower pressure. Based on building design and the available ventilation openings (doors, windows, etc.), several flow paths can exist within a structure. Any operation conducted in the exhaust portion of the flow path will place members at significant risk because of the increased flow of fire, heat, and smoke toward their position. Operations conducted in the flow path, between where the fire is and where the fire will travel, place firefighters at significant risk because of the increased flow of fire, heat, and smoke toward their positions. This risk is true for natural-ventilation cases with or without wind. In cases with the potential for wind to affect the heat release rate and the movement of the fire, it is important to keep the wind at your back and attack the fire from the upwind side [Fire Department of New York (FDNY) 2013; NIST 2013].

Another important safety procedure to remember, practice, and utilize in the event of becoming trapped or in distress in the hazard zone is door control (closed) and isolation. This allows a firefighter or firefighters to have protection until a rescue can occur.

Recommendation #6: Fire departments should develop and implement a standard operating procedure (SOP)/standard operating guideline (SOG) for tactical operations involving modular homes.

Discussion: At this incident, the fire department did not have a SOP/SOG for tactical operations involving modular homes.

Manufactured and modular dwellings are built off-site, may not have the same fire resistance as site-built structures, and may propagate fire rapidly due to the geometry and construction materials of the building. These structures may be susceptible to early failure due to lightweight building construction materials [NFPA 1700 2021].

NFPA 1700, *Guide for Structural Fire Fighting* provides the following fire specific tactical considerations for manufactured or modular dwellings:

- 12.8.1: Due to the building construction, fire conditions may result in considerable destruction of the floor, resulting in firefighters falling through the floor.
- 12.8.2; In a ventilation limited condition, an earlier flashover condition should be anticipated.
- 12.8.3: The utilization of exterior stream placement is a tactic that should be considered as all of the compartments in the structure are generally accessible from the exterior.
- 12.8.4: Vertical ventilation is not a recommended tactic due to the potential for early collapse.

One of the most important aspects of dealing with fires or potential fires in modular homes is to conduct pre-incident planning to identify the location of modular homes. These homes are typically

built in rural areas, where the emergency response could be slower. In fact, modular construction makes up 15 percent of construction in rural areas, compared to three percent in urban areas [Morgan 2021].

A pre-incident plan is one of the most valuable tools available for aiding fire department members in effectively controlling an emergency. The needs and benefits of pre-incident planning should be explained in detail to fire department members. Although there are many types of incidents that require emergency response, fires generally represent the most frequent challenge to firefighters. Many of the requirements pre-incident planning for fires and fire protection features can be applied to other types of incidents.

Pre-incident planning is a total concept based upon the following:

- Situation awareness
- Management commitment
- Education
- Prevention
- Protection
- Emergency organization [NFPA 1620 2021].

A thorough pre-incident plan involves information gathering, analysis, and dissemination; applying the "what-if" approach; planning; reviewing; training; and evaluating. Pre-incident plans within a jurisdiction should be similar in style, procedures, and content to maximize effectiveness and to reduce the time required to familiarize responding forces with the pre-incident plan. Emergency response programs are planned; emergencies are not. The best time to learn about an occupancy is before the incident [NFPA 1620 2020].

When arriving at an incident, the first arriving fire department resource (e.g., company officer) communicates the initial scene size-up and risk assessment. Whenever possible, prior to making entry into a structure fire, the company officer (initial incident commander) should perform a 360-degree assessment of the fire building/area to further determine:

- The fire's size, location, and extent
- Verify basement type (if present) and the stories from Side Charlie
- The ventilation profile of the structure (the identification of flow paths – or potential flow paths)
- Identify the safest, most appropriate attack position
- Life safety profile of the incident
- Confirmation of the initial strategy and IAP [FIRESCOPE 2015].

Additionally, a thermal imager is an essential tool for sizing up a structure's fire conditions. If available, a thermal imager should be used during the entire 360-degree assessment. Thermal imager readings of the interior of the fire compartment should be obtained prior to committing crews to entry. If possible, communicate the readings to Command and companies operating in the hazard zone.

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The six steps listed above, regardless of the type of structure, ensures that companies understand what is initially occurring on the fireground.

Recommendation #7: Fire departments should review and update their SOP/SOGs for tactical operations involving below-grade fires.

Discussion: At this incident, the fire department did not have a standard operating procedure/standard operating guideline for fighting basement fires.

Recognizing a below-grade fire is essential to ensuring that proper strategy and tactical objectives are developed for an incident. These types of fires are low frequency/high-risk events for several reasons. Below-grade fires sometimes are difficult to initially detect; sometimes are difficult to access; and require adequate staffing for hoseline placement, operation, and ventilation. In addition, firefighters may be working over the fire [Madrzykowski and Weinschenk 2018].

These types of fires are high-risk events for several reasons:

- Limited ingress and egress into a basement
- Weakened floor joists and rafters
- Potential for becoming caught in the fire's exhaust portion of the flow path
- Unknown fire loading
- Ventilation concerns
- Electrical panels and meters plus connections
- Hanging wires
- Furniture and appliances.

During below-grade fire operations, every firefighter should remember two key issues: access and ventilation. Access includes how easily a firefighter can get water in and how they can make an attack via a window or door. Ventilation may not exist in a below-grade area. There may be residential structures with no exterior vents to the basement or below-grade area. The main path for air and smoke to move through the home will be from the basement, up the stairs towards an open door or windows above grade. If the fire has not penetrated into the structure, you will see bi-directional flow at the doorway. The air supply to the fire is inefficient and limited, therefore the potential for flashover is reduced when no exterior vents to the basement are present.

Potential ventilation via windows or doors connected to the below-grade compartments enables rapid changes in fire growth. Unidirectional exhaust flows in the stairwell(s) result in an increased burning rate of a wood-floor assembly, increasing the potential for floor collapse and reducing safe operating time on the floor above. Ventilation of below-grade space was a key factor in several firefighter line of duty deaths, including the Pang Fire (Seattle, WA); the Cherry Road Fire (Washington, DC); the Squirrelsnest Lane Fire, (Colerain, OH); the Berkley Way Fire, (San Francisco, CA); and the Pater Road Fire, (Hamilton, OH). [Madrzykowski and Weinschenk 2018].

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Key factors that aid in recognizing a below-grade fire are:

- Fire or smoke venting from a cellar window or smoke pushing from the chimney (especially during warmer weather)
- Heavy smoke with no visible fire on the 1st floor
- Floorboards not appearing hot—look for smoke around the edges of the baseboard or heating, ventilation, and air-conditioning ducts
- Smoke from attic windows or louvered vents, especially in older homes with balloon frame construction [Kerber et al. 2012; Madrzykowski and Kent 2011].

Below-grade fires in dwellings with balloon-frame construction likely will extend to the attic via hidden voids. Units operating above the basement must stretch enough hoseline to reach the upper floors. Checking the intermediate floors for fire before a hoseline is committed to the top floor is essential because floor construction can isolate the fire. Flooring systems and floor coverings are good insulators and may not transfer a significant amount of heat from a basement fire. Laboratory experiments, field-testing, and modeling have shown that in post-flashover basement fires, even after the floor supports start to lose structural integrity:

- High heat conditions may not generate to the floor above
- Thermal imagers may not provide clear information on the level of hazard
- Floor supports that hold up to a strike from a tool during sounding may not have the ability to carry the weight of a firefighter or firefighters [Kerber et al. 2012; Madrzykowski and Kent 2011].

A fire department's SOP/SOG for below-grade fires needs to include the following topics:

- Community risk assessment
- Scene size-up
- Building construction
- Strategy and tactics
- Use of a thermal imager
- Ventilation considerations
- Proper size and adequate hoselines.

Below-grade fires are one of the most challenging situations firefighters encounter. As with all fires, use of a risk assessment and an occupant survivability profile can evaluate what is at risk, lives or property. Fire departments should conduct a post-incident analysis for significant incidents, especially following below-grade fires. Findings from these analyses can help in updating the department's SOPs/SOGs [NIOSH 2018].

Recommendation #8: Fire departments should develop and implement SOP/SOGs, training programs, and tactics for wind-impacted fires.

Discussion: At this incident, the fire department did not have a SOP/SOG on tactics for wind-impacted fires.

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Based on the analysis of this fire incident and results from current research and field studies, adjusting firefighting tactics to account for wind conditions in structural firefighting is critical to enhancing the safety and the effectiveness of firefighters. A wind-impacted fire may be one of the most dangerous operations firefighters will encounter. The term "wind-impacted" fire is used to describe a fire in which the wind has the potential to, or is already causing, a dramatic and sudden increase in fire, heat, and smoke. Experienced fire officers and firefighters who have survived wind-impacted fires have all described the following:

- Upon arrival, conditions appeared to be routine
- Within seconds, fire, heat, and smoke conditions changed without warning "from routine to life threatening."
- An operating 2½-inch hoseline flowing from the downwind position or into the exhaust portion of the flow had little or no effect on the incredible heat being produced; flowing water into the intake or inlet side of the flow path is very effective.
- Directly attacking these fires with one or even two 2½-inch hoselines proved ineffective and ultimately led to firefighters incurring serious injuries [FDNY 2013].
- Wind-impacted fires have resulted in firefighter line of duty deaths in single story, single family homes [Barowy, A. and Madrzykowski, D. 2012]
- Investigation reports involving wind-impacted fires that have resulted in firefighter line of duty deaths:
  - Investigation Report F2007-12 VA
  - Investigation Report F2009-11 TX
  - Investigation Report F2013-16 TX
  - Investigation Report F2014-09 MA
  - Investigation Report F2015-19 OH
  - Investigation Report F2017-14 TX
  - Investigation Report F2019-18 MA

When responding to a reported structure fire, an overriding consideration concerning size-up must be wind conditions and its potential effect on the fire. The key to successfully operating at wind-impacted fires in a structure depends on recognizing the wind-impacted fire conditions that may change a seemingly routine fire into a "blowtorching" fire. "Blowtorching" is the appropriate description of what will occur when fire conditions are impacted by wind conditions.

The impact of the wind will be affected by the size of the opening of the window or door, the fuel load, and the stage of the fire when the window or door failed. When wind-impacted fire conditions exist in a structure, the incident commander should notify the dispatcher so this information can be relayed to all responding units. The incident commander needs to make an announcement on the tactical channel as well. Once the contributing factors are identified, steps can be taken to minimize the hazards to firefighters [FDNY 2013].

Fire departments should develop standard operating procedures for incidents with high-wind conditions or areas where high-wind conditions are likely. It is important that fire officers and firefighters develop an understanding of how wind conditions influence fire behavior and impact fireground tactics that may be necessary under wind-driven conditions. Wind conditions can have a

major influence on structural fire behavior. When wind speeds exceed 10 mph (16 km/hr.) the incident commander, division/group supervisors, company officers, and firefighters should use caution and take wind direction and speed into account when selecting a strategy and developing tactics. The National Institute of Standards and Technology (NIST) has determined that wind speeds as low as 10 mph (16 km/hr.) are sufficient to create wind-driven fire conditions if the flow path is uncontrolled [Madrzykowski D, Kerber S 2009]. NIST, in a recent study on wind-driven fires in structures, has shown that wind speeds as low as 10 mph can turn a routine "room and contents fire" into a floor to ceiling fire storm or "blowtorch effect," generating untenable conditions for firefighters, even outside of the room of origin. Temperatures in excess of 600 ºC (1100 ºF) and total heat fluxes in excess of 70 kW/m² were measured at 4 feet above the floor along the flow path between the fire room and the downwind exit vent. These conditions were attained within 30 seconds of the flow path being formed by an open vent on the upwind side of the structure and an open vent on the downwind side of the structure.

Fire departments are encouraged to develop and implement an SOP/SOG addressing such issues as obtaining the wind speed and direction, considering the possible fuel load associated with a particular occupancy, determining proper strategy and tactics for fireground operations, consideration of ventilation, and establishing possible scenarios associated with the wind speed based upon risk assessment. Under wind-impacted conditions, an exterior attack from the upwind side of the fire may be necessary to reduce fire intensity to the extent that firefighters can gain access to the involved compartments [FDNY 2013].

In simulations and in previous full-scale experiments, it has been demonstrated that wind can increase the thermal hazards of a structure fire [NFPA 1700 2021]. Therefore, wind must be considered as part of the initial size-up of the fire conditions and must be monitored and reported throughout the fire incident. It is critical for firefighters to not be in the exhaust portion of the fire flow path. The directional nature of the fire gas flow path results in higher temperatures than the area adjacent to the flow path or upwind of the fire. The flow path can be controlled by limiting ventilation. Previous studies demonstrated that applying water from the exterior into the upwind side of the structure can have a significant impact on controlling the fire prior to beginning interior operations.

In a wind-impacted fire, it is most important to use the wind to your advantage and attack the fire from the upwind side of the structure, especially if the upwind side is the burned side. The unexpected ventilation from a broken window can suddenly change the interior thermal conditions. Interior operations must be aware of potentially rapidly changing conditions.

A fire department should incorporate the following into their training and education component on wind-impacted fires:

- Ensure that an adequate initial size-up and risk assessment of the incident scene is conducted before beginning interior fire-fighting operations
- Ensure that firefighters, company officers, division/group supervisors, and the incident commander have a sound understanding of fire behavior and the ability to recognize indicators of fire development and the potential for extreme fire behavior (such as smoke [color, velocity, and density], visible fire, and heat)

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- Ensure that firefighters and company officers are trained to recognize the potential impact of windy conditions on fire behavior and implement appropriate tactics to mitigate the potential hazards of wind-driven fire
- Ensure the incident commander's strategy considers high-wind conditions if present
- Ensure that firefighters understand the influence of ventilation on fire behavior and effectively apply ventilation and fire control tactics in a coordinated manner
- Ensure that firefighters and officers understand the capabilities and limitations of thermal imagers
- Ensure a thermal imager is used as part of the size-up process
- Ensure that firefighters are trained to check for fire in overhead voids upon entry and as charged hoselines are advanced
- Develop, implement, and enforce a comprehensive Mayday SOP/SOG. Train and educate firefighters to ensure they understand the process and know how to initiate a Mayday
- Ensure firefighters are trained in fireground survival procedures
- Ensure all firefighters on the fire ground are equipped with radios capable of communicating with the incident commander and the dispatch center [FDNY 2013].

Recommendation #9: Fire departments should ensure incident commanders establish a stationary command post that is tied to a vehicle for effective incident management, which includes the use of a tactical worksheet.

Discussion: At this incident, Command did not utilize a command vehicle and did not utilize a tactical worksheet, which aids in maintaining the incident action plan and personnel accountability.

When a command officer (e.g., battalion chief, district chief, deputy chief) arrives on-scene at an incident, the command officer should automatically assume a standard stationary, exterior, and remote command position and immediately assume Command. The IC should function inside their vehicle or at the rear of the vehicle, which has a command board with a tactical worksheet.

NFPA 1561, *Standard on Emergency Services Incident Management System and Command Safety*, 5.3.1 states, "The incident commander shall have overall authority for management of the incident." The incident commander must establish and maintain a Command Post outside of the structure in order to assign companies, delegate functions, and continually evaluate the risk versus gain of continued firefighting efforts [NFPA 1561 2020].

In establishing a command post, the incident commander shall ensure the following:

- 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 the incident commander's designee, is always present at the command post
- The command post is located in the incident cold zone [NFPA 1561 2020].

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The use of a tactical worksheet can assist the incident commander with tracking various task assignments on the fireground. The tactical worksheet identifies critical incident information in a fill-in format and allows for the tracking of initial alarm assignments, additional alarms, division/group assignments, and tactical/functional considerations. It is important that the incident commander start using the tactical worksheet as early in the incident as possible [NFPA 1561 2020], along with pre-plan information and other relevant data, to integrate information management, fire evaluation, and decision-making. The tactical worksheet should record unit status, benchmark time, and include a diagram of the fireground, occupancy information, activities checklist(s), and other relevant information. The tactical worksheet can help the incident commander in continually conducting a situation evaluation and maintaining personnel accountability [NFPA 1561 2020]. The tactical worksheet provides reminders, prompts, and a convenient workspace for tracking companies and apparatus. It allows the incident commander to slow down during an incident and record vital information that may help make future operational decisions [NFPA 1561 2020].

The advantages of using a tactical worksheet are that the tactical worksheet:

- Provides the documentation necessary to manage an incident
- Includes a location to quickly note individual assignments
- Provides prompts for the incident commander, such as time, air management, and PARs
- Provides tactical benchmarks, such as "water on the fire," "primary search complete," "fire under control," and "loss stopped"
- Documents the command structure—strategic, tactical, and task
- Facilitates consistent, organized information
- Documents assignments and responsibilities
- Expedites passing of Command or support for the incident commander
- Provides resource status [NFPA 1561 2020].

Using a tactical worksheet is critical for the successful outcome of an incident. A staff aide, incident command technician, or field incident technician is responsible for maintaining the resource status and situation status of an incident with a tactical worksheet. This ensures that vital incident information is properly captured and accurately maintained (**See Appendix Two**).

A sample checklist for initial fireground operations is provided in *Appendix Three* to assist the initial incident commander and then strategic positioned battalion chief (**See Appendix Three**).

Recommendation #10: Fire departments should incorporate the principles of command safety into the incident management system. This ensures that the strategic-level safety responsibilities are incorporated into the command functions throughout the incident.

The purpose of command safety is to provide the IC with the necessary resources to use, follow, and incorporate safety into the incident management system at all incidents. Command safety is used as part of the eight functions of command developed by Fire Chief Alan V. Brunacini. Command safety is designed to describe how the IC must use the regular, everyday command functions to complete the strategic level safety responsibilities during incident operations. Using the command functions creates an effective way and a close connection between incident safety and incident command.

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The functions of command in the "Command Safety" book differ than the eight functions of command [Brunacini and Brunacini 2004]. The functions of command safety are:

- Assumption, confirmation, and positioning of command
- Situation Evaluation
- Communications
- Deployment
- Strategy and Incident Action Planning
- Organization
- Review, Evaluate, and Revise
- Continue, Transfer, and Terminate Command.

The incident commander must follow each of these functions in order without skipping or missing any function. Automatically connecting and integrating safety with command becomes a simple and essential way that the incident management system protects assigned resources at an incident. These functions serve as a practical performance foundation for how the incident commander completes their responsibility as the strategic-level incident manager and the overall incident safety manager [Brunacini and Brunacini 2004].

Command safety focuses on the balance between the level of the hazards that are present in relation to the size of the standard safety system. The book refers to this term as "safety math" and becomes a simple way to make operational position/action decisions about the survivability of where firefighters can go, and what firefighters can do. This becomes a survivability index the IC can use to make offensive/defensive strategy decision for the incident [Brunacini and Brunacini 2004].

The IC cannot assign firefighters to positions where the safety system will not offer effective protection. If the safety system is bigger than the hazard, the incident commander defines the strategy as an offensive strategy. If the hazard is bigger than the safety system, the incident commander defines the strategy to be operated in a defensive strategy.

Once the overall incident strategy has been determined and the IAP developed, the incident commander should manage the completion of the tactical priorities for the chosen strategy. Each strategy has a different set of tactical priorities to complete. Tactical priorities provide the incident commander with a simple, short list of major categories that are designed to act as a practical guideline during the difficult initial stages of fireground planning. The IAP must be short, simple, and effective. A complicated IAP tends to break down during this critical time.

Generally, the incident commander tries to achieve the same objectives from one incident to the next. Tactical priorities offer a regular set of tools that the incident commander can utilize for tactical activities in order to develop a standard approach to solving incident problems. With this standard approach, the incident commander can manage the basic work sequence at every incident, in the same manner.

During most incident situations, the IC must develop an IAP based only on the critical factors they can see at the beginning of operations. Most of the time, the initial information is very incomplete. The

ability to identify the "known" and the "unknown" emerges when the IC uses the standard inventory of the critical factors. The IC must:

- Quickly size up what they know and what they do not know
- Identify and address critical "unknowns" during incident operations
- Some unknowns must be addressed immediately, especially in situations that involve firefighter safety and survival before the problem can even be engaged (such as basement fires)
- Some forecasted critical unknowns are so critical that they may drive the initial or current strategy choice.

The two separate strategies create a simple, *understandable* plan that describes how close the emergency responders will get to the incident's hazards. The incident's overall strategic decision is based on the incident's critical factors weighed against the risk management plan (**See Diagram 9**).

Declaring the incident strategy up front, as part of the initial radio report will:

- Announce the overall incident strategy to everybody
- Eliminate any question on where firefighters will be operating on the incident scene inside the structure
- Offensive and defensive strategies should not be combined [SKCFTC 2023].

Basic, structural firefighting incident hazards that often injure or kill firefighters includes:

- Structural collapse
- Toxic insult from the products of combustion
- Thermal threat posed by the fire
- Becoming trapped, lost, or disoriented.

The safety system components used to protect firefighters includes:

- Adequate number of fit and trained firefighters (adequate staffing)
- Proper turnout gear and SCBA being worn
- Functional and operational equipment and apparatus
- Sustainable water supply
- Safety SOPs
- Incident Management System [Brunacini and Brunacini 2004].

The beginning of the safety system starts with the firefighters. Every firefighter that operates with a company must take responsibility for their own actions and compliance with the department's safety plan. This requires every member to behave in the following manner:

- Understand the details, dynamics, and effects of firefighting hazards
- Understand the department's safety plan and its limitations
- Be physically, mentally, emotionally, and organizationally capable of doing their job
- Monitor their own safety and wellbeing
- Continually evaluate and self-adjust their own safety procedures in relation to the incident
- Directly stop any unsafe acts they can impact
- Always assist those nearby

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- Actively report safety conditions throughout the incident organization
- Comply with safety orders and instructions [Brunacini and Brunacini 2004].

This information emphasizes the important roll a firefighter has regarding their own personal safety. Everyone in the organization has a role and responsibility at an incident. No operational level of the organization (task, tactical, or strategic) can perform the duties or responsibilities of another level. Firefighters are not absolved from their own personal responsibility to the safety system because the IC is in place. Firefighters play an integral role in the safety system and if they aren't following the recommendations above, injuries or losses can occur [Brunacini and Brunacini 2004].

The incident commander must follow each of these functions in order without skipping or missing any function. Automatically connecting and integrating safety with command becomes a simple and essential way that the incident management system protects assigned resources at an incident. These functions serve as a practical performance foundation for how the incident commander completes their responsibility as the strategic-level incident manager and the overall incident safety manager [Brunacini and Brunacini 2004].

The incident commander must use the incident management system as the basic foundation for doing the strategic level safety function. Command safety is an important factor in achieving the highest level of safety for fire department members operating at emergency incidents. The incident commander completes their operational and safety responsibility to the firefighters by performing the eight command functions. These functions serve as a very practical performance foundation for serving as the strategic level incident manager and the overall incident safety manager [NFPA 1561 2020].

A major objective of the incident management system is to support the incident commander who will direct the entire incident on the task, tactical, and strategic levels. Issues develop for the incident commander when these three standard levels are not in place, not operating, and/or are not effectively connected. The incident commander should develop the strategic level at the very beginning of the incident. They should then build an effective incident organization to stay on the strategic level while firefighters are operating in the hazard zone [SKCFTC 2023].

Recommendation #11: Fire departments should ensure that all firefighters and fire officers are trained for Mayday operations.

The ability of a firefighter to call a Mayday is a complicated behavior that includes the affective, cognitive, and psychomotor domains of learning and performance. Any delay in calling a Mayday reduces the chance of survival and increases the risk to other firefighters trying to rescue the "downed" firefighter. Firefighters should have 100% confidence in their competency to declare a Mayday. Fire departments should ensure that any personnel who enter a hazard zone meet the department's standards for Mayday competency throughout their active-duty service. A RIC typically is not activated until a Mayday is declared. Any delay in calling a Mayday reduces the window of survivability and increases the risk to the RIC [NFPA 1561 2020].

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One important point is that every firefighter should be equipped with a portable radio when operating in the hazard zone. If a firefighter becomes lost or trapped in the hazard zone, the firefighter should activate the orange emergency button on the portable radio prior to transmitting a Mayday [NIOSH 2023]. This action will give the member in distress the best chance for the dispatcher and/or IC to acknowledge the Mayday. This ensures the Mayday will be addressed in a timely manner. This process should be supported by a SOP/SOG and practical training.

The rescue of a lost, missing, trapped, or injured firefighter is time sensitive. A very narrow window of survivability exists for a firefighter who is out of air or trapped in a hazardous environment. Firefighters must not delay in communicating a Mayday, ensuring the incident commander is notified. When it comes to rapid egress or removing a downed firefighter, the most appropriate action to take due to conditions may be to use a window in the immediate area. A task such as this can be challenging if it is not trained on or practiced regularly. It is important to remember that the safest way to remove a downed firefighter from an upper level of a building is by using a staircase if at all feasible.

Firefighters may be forced to use windows for removal for a variety of reasons. The route taken into the structure may have been altered or changed during the course of operations by collapse, deteriorating fire conditions, the malfunction of a self-contained breathing apparatus (SCBA), an air-supply issue or disorientation. Factors such as surroundings, fire conditions, collapse or building construction can further increase the challenges that must be overcome. A constricted-space window removal requires at least three rescuers. These maneuvers are labor intensive and will require a RIC to be operating on the exterior as well as the interior. Communication between these crews is of highest priority. The exterior RIC will need to know the specific equipment and exact location necessary to affect the rescue. This will normally take place after the initial RIC locates the downed firefighter. Two of the most common ways to perform a removal of this nature are the "Denver" and "Fulcrum" techniques [Pindelski, J. 2010].

The incident commander is required to revise the strategy and IAP (tactics) to incorporate a priority rescue. This will impact fireground communications as well. A Mayday condition is transmitted on the radio, using distinctive emergency traffic alert tones. Then the incident commander and/or Dispatch Center is responsible for taking action to clear the radio channel and to determine the member's location, situation, and resources needed to remedy the situation. In the event of a Mayday, a RIC officer will take responsibility for the resolution of the Mayday. It is necessary for the incident commander to support the RIC with appropriate and adequate resources to manage the Mayday. At the same time, the incident commander should reinforce the surrounding groups and division to continue the incident mitigation. Projecting resource requirements for the rescue group operations has the potential to increase the survivability of a Mayday situation.

The incident commander should ensure that firefighting operations are continued in conjunction with the rescue operations, especially in the area of the Mayday, by assigning this responsibility to a division or group supervisor. This allows the availability of adequate resources to hold or extinguish the fire while the rescue operations are conducted. The two most important Mayday rescue tasks that must occur are protecting the "downed" firefighter from fire and getting air to the "downed"

firefighter. The incident commander has the responsibility for ensuring these two tasks are assigned and occurring.

Responsibilities of the RIC include:

- Responding to the Mayday from the inside out
- Managing communications with the "downed" firefighter
  - The incident commander is required to revise the strategy and IAP (tactics) to incorporate a priority rescue, which impacts fireground communications as well
  - Command should declare the use of emergency traffic only until the situation is resolved
  - Once a Mayday condition is broadcast on the radio, using distinctive emergency traffic alert tones, the incident commander and/or dispatch center/fire alarm office is responsible for taking action to clear the radio channel and determine the member's location, situation, and the resources needed to remedy the situation
- Managing the search and rescue efforts for the "downed" firefighter if necessary
- Increasing and maintaining resources assigned to the rapid intervention group
- Managing the logistical support well
- Improving survivability and tenability
- Improving ventilation
- Increasing exterior access for the rapid intervention group
- Utilizing the RIC bag and requesting additional RIC bags if necessary
- Recognizing and supporting the help order of a Mayday
- Positioning or staging crews in a position or outside of the rapid intervention group as a tactical reserve
- Requesting additional resources from the incident commander
- Overseeing crews from other groups or divisions
- Requesting additional stage resources [SKCFTC 2023].

When a Mayday occurs, this requires action at the strategic, tactical, and task levels. Each level plays a critical role in the successful outcome of a Mayday.

If a division supervisor is in place where the Mayday is declared, Command should assign the division supervisor to manage the Mayday. The division supervisor is in the best position to manage the rescue activities that need to take place in the division to resolve the Mayday. The IC is then in the best position to coordinate and support the rescue, firefighting, and treatment efforts with the other divisions and companies as required by the incident's critical factors.

If no division supervisor is in place when a Mayday is declared on the incident scene, the incident commander should continue to manage all tactical rescue efforts required to resolve the Mayday.

Recommendation #12: Fire departments should provide a Mayday tactical worksheet for incident commanders in the event of a Mayday.

Discussion: At this incident, the incident commander did not use a Mayday tactical worksheet.

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When a Mayday is transmitted, the incident commander has a very narrow window of opportunity to locate the lost, trapped, or injured member(s). The incident commander must restructure the strategy and IAP (tactics) to include a priority rescue [NFPA 1561 2020].

Some departments have adopted the term LUNAR—location, unit assigned, name, assistance needed, and resources needed—to gain additional information in identifying a firefighter who is in trouble and in need of assistance. The incident commander, division/group supervisors, company officers, and firefighters need to understand the seriousness of the situation. It is important to have the available resources on scene and to have a plan established prior to the Mayday [Brunacini and Brunacini 2004; NFPA 1561 2020]. A checklist is provided in **Appendix Four**, I*ncident Commander's Tactical Worksheet for Mayday*.

A Mayday specific checklist can assist the incident commander in ensuring the necessary steps are taken to clear the Mayday as quickly and safely as possible. This structured checklist serves as a guide, and it is possible to tailor the checklist to any fire department's Mayday procedures. This process is too important to operate from memory and risk missing a vital step that could jeopardize the outcome of the rescue of a firefighter who is missing, trapped, or injured.

Recommendation 13: Fire departments should ensure all members and dispatchers are trained on the safety features of their portable radio, particularly the features useful during a Mayday.

Discussion: At this incident, due to issues with the portable radios freewheeling, several portable radios were turned off. The department portable radios have a functional emergency alert button (EAB). The firefighter from Engine 52 did not use the EAB.

Like turnout gear and SCBA, the portable radio assists firefighters operating in the hazard zone. Therefore, each firefighter should be equipped with a portable radio and trained on its use and safety features. This training process should extend to the fire department's dispatchers because the dispatchers are a critical component of the response and responsible for designating a channel for emergency alert button (EAB) transmission [NFPA 1802 2021; NIOSH 2022].

The design of portable radios changed significantly when NFPA issued 1802, *Standard on Two-Way, Portable RF Voice Communications Devices for Use by Emergency Services Personnel in the Hazard Zone* [NFPA 2021]. This standard resulted from the findings and recommendations of a NIOSH line of duty death investigation [NIOSH 2012], the safety investigation report from the affected fire department, the International Association of Fire Fighters, and the International Association of Fire Chiefs [NFPA 1802 2021].

The safety features on portable radios include:

- emergency alert button (EAB), which is commonly referred to as the "orange" button on top of a portable radio or remote speaker microphone
- the man-down notifier (MDN)
- the dispatcher's ability to "alert" a portable radio.

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In addition, several portable radio manufacturers have developed the ability for a dispatcher for on-scene ICs to remotely activate a firefighter's EAB.

Emergency Activation Button (EAB) [NIOSH 2022, NFPA 1802 2021]
The EAB is preprogrammed to send an emergency transmission on a pre-designated channel or talkgroup. A talkgroup is defined as a group of radios addressed as a single entity by the system and the functional equivalent to a conventional repeater channel. When operating on a simplex channel or in the direct mode, the radio can revert to a channel/talkgroup monitored by the IC or a dispatch center. The communication system administrator must program the transmission channel/talkgroup for the EAB.

The EAB is activated by pressing it for at least 1 second, but not more than 3 seconds. When the EAB is activated, the portable radio identifies the user's department identification or riding position (e.g., Engine 19 Officer). This signal overrides any other communication over the selected radio channel for 10 to 30 seconds depending on the programming. Once activated, the portable radio operating on a trunked system is given priority access to the talkgroup until the EAB is reset. While in the EAB mode, transmissions will be at the device's highest radio frequency (power), and an audible beacon will sound at full volume until the EAB is reset [NIOSH 2022, NFPA 1500 2021].

Man-down Notifier (MDN)
The MDN is an alternate way to activate the EAB. The MDN can be activated in two ways: 1) a certain radio tilt angle, or 2) a combination of the radio tilt angle and the lack of radio motion. The MDN function alerts the firefighter that the EAB is about to activate which, if appropriate, allows the firefighter to dismiss the transmission [Motorola 2014; NIOSH 2022; NFPA 1500 2021].

Dispatcher Alert
The third safety feature is the dispatcher's ability to "alert" a firefighter's portable radio. This is a valuable function when trying to locate a lost, missing, or down firefighter. The "alert" will continue to sound until reset but is only as loud as the volume is set on the portable radio.

For these three safety features to operate properly, the firefighter must take several key actions before entering the hazard zone. The portable radio must be turned on and on the proper channel that has been assigned to the incident and is being monitored by the dispatcher or IC. If the portable radio is on a different channel, dispatch or the IC may not be alerted or notified of the Mayday. Also, the scan function on the portable radio needs to be turned off when operating in the hazard zone.

Recommendation #14: Fire departments should ensure all firefighter portable radio volume-power knobs cannot be accidentally turned down or off when in use.

Discussion: At this incident, most communication that took place inside and outside the structure from the members of Engine 51 and Engine 52 to Command were primarily face to face or shouting. This

was due to the past experience with the portable radio volume-power knob freely spinning to off or low volume. Freewheeling was known to have hindered fireground communication during past incidents.

During interviews with fire officers and firefighters involved with this incident, NIOSH investigators received complaints that the radio volume-power knobs turned off or turned down. This was due to the radio volume-power knob being rubbed against the firefighter's turnout gear or against an object. Investigators could not confirm the position of the knob of the deceased firefighter at the time of the incident. Investigators noted the volume-power knob could freewheel (spin freely).

Please see the following NIOSH FFFIPP Safety Advisory. Preventing Freewheeling of Public Safety Portable Radio Volume-Power Knob | NIOSH | CDC

Recommendation #15: Fire departments should use a functional personnel accountability system, requiring a designated accountability officer or resource status officer.

Discussion: At this incident, no one was assigned as an accountability officer or resource status officer. The metropolitan fire department instituted a personnel accountability system when their members entered the hazard zone.

A personnel accountability system is a system that readily identifies both the location and function of all members operating at an incident scene [NFPA 1561 2020]. The philosophy of the personnel accountability system starts with the same principles of an incident management system—company unity and unity of Command. It is possible to fulfill unity initially and maintain it throughout the incident by documenting the situation status and resource status on a tactical worksheet or a resource status/accountability board.

A personnel accountability system shall be adopted and routinely used to collect and maintain the status and location of the resources working in, or potentially working in, the hazard zone of an incident. All members operating at an incident are responsible for understanding and participating in this system. The incident commander should be responsible for the overall accountability for the incident. Incident commanders may delegate to other appropriate staff members the facilitation of the accountability for those resources to meet those goals, objectives, and tasks as needed. An integral part of the accountability system is to make sure that the firefighters who are assigned and operating in the hazard zone are accounted for, starting with the initial operations through the entire incident.

One of the most important functions of command safety is for the incident commander to initiate a personnel accountability system that includes the functional and geographical assignments at the beginning of operations until the termination of the incident. NFPA 1561, *Standard on Emergency Services Incident Management System and Command Safety*, states in Paragraph 8.12.4, "The incident commander and members who are assigned a supervisory responsibility that involves three or more companies or crews under their command shall have an additional member(s) (e.g., staff aide) assigned to facilitate the tracking and accountability of the assigned companies or crews" [NFPA 1561 2020].

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An important aspect of a personnel accountability system is the personnel accountability report (PAR). PAR is an on-scene roll call in which supervisors report the status of their crew when requested by the incident commander [NFPA 1561 2020]. It is necessary to conduct the PAR every 15–20 minutes or when benchmarks are met.
A functional personnel accountability system requires the following:

- Development and implementation of a departmental SOP/SOG
- Necessary components and hardware, such as an accountability board, individual name tags, and company name tags
- Training for all members on the operation of the system
- Strict enforcement during emergency incidents.

A functional personnel accountability system should have the ability to identify:

- All members operating in the hazard zone (who)
- Where all members are in the hazard zone (where)
- The conditions in the hazard zone (conditions)
- What actions are in use in the hazard zone (actions)
- Paths of access and egress in and out of the hazard zone (exits)
- RICs and their assignments.

Many different methods and tools are available for resource accountability, including:

- Tactical worksheets
- Command boards
- Apparatus riding lists
- Company responding boards
- Electronic bar-coding systems
- Accountability tags or keys [NFPA 1561 2020].

Personnel who are responsible for maintaining the location and status of all assigned resources at an incident should handle resource accountability. As an incident escalates, resource status should be placed under the Planning Section. This function is separate from the role of the incident commander. The incident commander is responsible for the overall command and control of the incident. Because of the importance of responder safety, the size and complexity of the incident should help determine resource status assignments. A properly initiated and enforced personnel accountability system enhances firefighter safety and survival.

For the personnel accountability system to properly function, the process should include an SOP/SOG that defines each function's responsibility and the necessary hardware required to ensure this process is successful on the fireground. Another key to the success of the personnel accountability system is to include a training component (both classroom and practical) to ensure this process functions properly during emergency incidents.

Recommendation #16: Fire departments should regularly review and revise their SOP/SOG on the deployment of rapid intervention crews (RICs).

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Discussion: At this incident, there were no RIC(s) designated until the metropolitan fire department arrived on-scene. The rapid intervention group from the metropolitan fire department were able to remove the downed firefighter under very difficult conditions.

To ensure compliance with 29 CFR 1910.134 *Respiratory Protection* [OSHA 1998], fire departments must maintain a RIC when members are operating in an immediately dangerous to life and health (IDLH) or potentially IDLH atmosphere [NFPA 1500 2021]. In some organizations, the crew is known as a rapid intervention team (RIT), or a firefighter assist and search team (FAST).

The RIC function should be incorporated into the department's incident management system and personnel accountability system [NFPA 1500 2021]. Resource assignments should always be made with the goal of having the RIC function in place. When ICs need additional resources, the consideration of deploying the RIC for an operational assignment without additional resources on-scene to function as the RIC should be carefully assessed [NFPA 1500 2021].

The following restrictions regarding the use of RIC should be considered by the IC during fireground operations:

- When firefighters are operating in the hazard zone, a RIC should be assigned
- The RIC should not be used for firefighting operations until another company is on-scene to operate/function as the RIC
- The RIC is dedicated to assist and, if necessary, rescue members who become lost, trapped, distressed, or involved in other serious life-threatening situations
- The RIC should not be used to provide relief for operating companies until the fire/incident has been declared "under control" by Command
- If a RIC unit officer is assigned to other duties by a superior officer, the RIC unit officer should remind such officer of RIC designation [Toledo Fire & Rescue Department 2012; TSFRS 2014].

At all fireground operations, at least one RIC should be designated and available to respond before an interior attack operation begins. The size and complexity of the incident will determine the number of rapid intervention crews to utilize.

The RIC should report to the IC and follow department SOP/SOG for RIC operations. The RIC should remain in a designated ready position until an intervention is ordered. The RIC should have all tools necessary to complete the task. The following is the minimum equipment that should be made available to a RIC:

- RIC pack (extra SCBA complete with harness, regulator, and extra masks). Also, 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
- a hoseline
- ladder complement

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- thermal imager
- high intensity handlight [FRDNV 2013c].

The RIC'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 RIC should pre-plan a rescue operation by finding out fire structure information. They should complete 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 size and condition of building
- number of floors
- presence of burglar bars (consider removing them)
- 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
- location and experience level of interior crews
- stay focused and stay together [FRDNV 2013c].

When the RIC enters to perform a search and rescue, have full SCBA cylinders, and be physically and mentally prepared. When a RIC is used in an emergency situation, an additional RIC should be put into place in case an additional emergency situation occurs.

During firefighter rescue operations, the incident commander should consider:

- committing the RIC from stand-by mode to deployment
- changing from strategic plan to a high-priority rescue operation
- enhance firefighting efforts to protect the trapped firefighter(s) and operating crews
- initiating a personnel accountability report (PAR)
- assigning a rapid intervention group supervisor
- assigning a safety officer
- assigning a back-up RIC(s)
- assigning an advanced life support (ALS) 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
- staging additional resources [SKCFTC 2023].

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Many fire departments have a defined response plan for the dispatch of an additional company (engine, truck, squad, rescue, and/or command officer) to respond to an incident and stand by as the RIC. Based upon the complexity, magnitude, configuration of the structure or geographical layout of the incident, the IC may deploy an additional RIC/FAST by location or function [NFPA 1500 2021].

The RIC officer/rapid intervention group supervisor and RIC members/rapid intervention group members will coordinate with Command to formulate rescue plan contingencies and continue to monitor the radio and fireground conditions. The RIC process 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. The RIC function is critical for firefighter safety and safe fireground operations.

To ensure that firefighters and fire officers are properly trained to conduct RIC operations, they should meet the requirements of NFPA 1407, *Standard for Training Fire Service Rapid Intervention Crews* [NFPA 1407 2020].

Recommendation #17: Fire departments should review and/or develop SOG/SOP to ensure that water supply is established and maintained during initial fireground operations, particularly in areas with limited or no hydrants.

Discussion: At this incident, the fire protection district did not have a SOG/SOP for water supply in areas with limited or no hydrants.

The establishment of a water supply at a fireground is a critical operations benchmark. In areas with limited or no hydrants, a comprehensive preplanning process is needed. This process may include information on map book pages, case notes, or comments on the dispatch to a defined address. For non-hydrant areas, this preplan information should be assembled in a water supply preplan book and sent to applicable engine and tanker/tender companies. In addition, this information should be shared with automatic aid and mutual companies [Fire and Rescue Departments of Northern Virginia 2019].

While enroute to the fire, the first-arriving engine officer should initiate the incident's water supply plan. Using area preplans, the officer can designate dump sites, fill sites for the shuttle operation, or relay positions for in-coming units. Upon arrival, the first-arriving officer's scene size-up and risk assessment should include an estimate of the fire flow requirements on the anticipated water supply. This information allows the development of an appropriate IAP and dictates whether an offensive operation is appropriate. The first-arriving officer should then communicate the IAP to all responding resources and dispatch.

It is vital that an adequate water supply is maintained throughout the incident. ICs should reassess the water supply issue regardless of whether the incident is served by fire hydrants or requires a rural water supply [Fire and Rescue Departments of Northern Virginia 2019]. When water requirements exceed the amount available from nearby hydrants or the amount of water carried by the 1st alarm apparatus, a water supply group and water supply group supervisor should be designated. All units in the water supply group will be under the management of the water supply group supervisor. The water

supply group supervisor is the individual responsible for resourcing adequate water supplies required to implement the tactics outlined by the IC [FCFCA 2015].

When a hydrant is not located close enough to the scene to provide a pressurized water source, a water shuttle operation should be set up and utilized as soon as possible. Because a water shuttle operation takes place outside of the hot zone, pumping engineers and water shuttle apparatus operators should consider being placed on a separate radio channel or talk group that is managed by a water supply supervisor or water supply group supervisor. This will greatly reduce radio traffic on the primary tactical channel.

Water shuttle operations utilizing portable water tanks and tenders represent a unique scene management challenge and should be well understood by members working in response areas that depend on these operations. The lack of, or delay in obtaining, a continuous water supply must be considered as a critical factor when making strategic decisions.

The defensive strategy MUST be considered when adequate fire flows cannot be established early in the operation.

Recommendation #18: Fire departments should ensure that all members engaged in emergency operations receive annual proficiency training and evaluation on fireground operations, including live fire training. This training should be conducted with automatic aid fire departments.

Discussion: The fire protection district did not require annual live fire training.

To ensure the proficiency and competency of fire department members, fire departments should conduct annual skills evaluation to verify minimum professional qualifications. This evaluation should address the qualifications specific to the member's assignment and job description with the goals of preventing skills and abilities degradation and ensuring the safety of members. Proficiency evaluation and training provide an opportunity to ensure that all fire officers and firefighters are competent in fireground operation knowledge, skills, and abilities. This process should include annual live fire training.

NFPA 1500, *Standard for a Fire Department Occupational Safety, Health, and Wellness Program,* requires a fire department to establish and maintain a training, education, and professional development program with the goal of preventing occupational deaths, injuries, and illnesses [NFPA 1500 2021]. This ensures members are trained and competencies are maintained in order to execute all responsibilities effectively, efficiently, and safely. This process is consistent with the organizational statement that establishes the existence of the fire department, the services the fire department is authorized and expected to perform, the organizational structure, and the job descriptions and functions of fire department members [NFPA 1500 2021].

As members progress through various job duties and responsibilities, the department should ensure they have necessary knowledge, skills, abilities, and are able to demonstrate competencies for the

defined position. The training and education process should also ensure the ongoing development of existing skills [NFPA 1500 2021].

NFPA 1410, *Standard on Training for Initial Emergency Scene Operations*, defines basic evolutions that can be adapted to local conditions and serves as a method for the evaluation of minimum acceptable job performance during initial fireground operations [NFPA 1410 2020]. Proficiency training for fireground operations and emergency incidents should be conducted annually. This training should include scene size-up, situational awareness, use of the incident management system, personnel accountability system, strategy and tactics, search and rescue, hoseline operations, ladder operations, ventilation, thermal imaging cameras, fireground communications, use of RICs, and Mayday operations.

Recovery Process

After this incident, the fire protection district implemented many changes. These changes were based on the department's critique of what happened and information gained during the NIOSH FFFIPP field investigation.

The following are actions the fire protection district has taken since January 5, 2020.

- New handheld radios and microphones were purchased and placed on all apparatus. These radios are the latest version of handheld fire radios from Motorola. Training was provided at the time of placing the portable radios in service and is provided annually. Bluetooth microphones were purchased and installed in SCBA masks that pair with radios.
- Utilizing the International Fire Service Training Association's ResourceOne®, the department conducts monthly classroom fireground training and drills. This is to ensure all members are reviewing the basics as well as staying current with updated techniques.
- An SCBA confidence course has been constructed to give firefighters more time working their turnout gear and SCBA. The training focused on Mayday scenarios and firefighter down situations.
- A new Mayday policy has been written and implemented. This was conducted with input from the fire dispatch center. The department is training with all mutual aid companies. This ensures all resources are properly trained and utilize the procedures in this new policy.
- An operational battalion chief position was funded and an appointment was made. The battalion chief is assigned to a 40 workweek with a take home vehicle. The battalion chief responds to all structure fires and as requested. This position allows a faster response of a command officer to incidents.
- The personnel accountability system policy has been reviewed and training is being provided prior to implementation of this new policy. Accountability boards have been placed in all command vehicles.
- An emphasis has been placed on exterior fire attack, while waiting for adequate units to arrive on-scene, and before making an interior attack. Adherence to "two in/two out" for interior attacks has been communicated and is being included in fireground operations training.

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- The training budget was doubled to allow for firefighters to attend more outside training. Captains and above are being sent to the National Fire Academy in Emmitsburg to receive leadership and incident management training.
- Automatic and mutual aid departments are responding battalion chiefs to all automatic or mutual aid requests for structure fires. This allows vital positions within the incident management system to be utilized on the fireground.
- New thermal imaginers were purchased to include smaller thermal imagers, so each apparatus or vehicle has a thermal imager. Classroom and practical training was provided through Missouri University Fire and Rescue Training Institute.
- Countywide meetings were held to develop a plan for the use of tactical channels and how to patch radio channels together. Additional training was provided to all members on radio communications.
- A review of the incident management system was conducted with all members.
- A part-time training officer position was added to oversee and conduct training and drilling.
- Additional full-time and part-time personnel have been hired to raise staffing from five per shift to six members per shift.

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Investigator Information

This incident was investigated by Steven T. Miles, Safety and Occupational Health Specialist; Murrey Loflin, Investigator; and Matt Bowyer, General Engineer with the Fire Fighter Fatality Investigation and Prevention Program, Division of Safety Research, Surveillance and Field Investigations Branch, NIOSH located in Morgantown, WV. A technical review was provided by Dennis L. Rubin, Fire Chief of the Kansas City, KS Fire Department and Chris Stewart, Deputy Chief (Retired) with the Phoenix Fire Department. A technical review was also provided by the National Fire Protection Association, Public Fire Protection Division. This investigation report was authored by Murrey Loflin.

Additional Information

International Association of Firefighters (IAFF) Fire Ground Survival Program

The IAFF Fire Ground Survival Training addresses Mayday prevention and Mayday operations for firefighters, company officers, and chief officers. Firefighters 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 through the Assistance to Firefighters (FIRE Act) grant program, this comprehensive fireground survival training program applies the lessons learned from firefighter fatality investigations conducted by the National Institute for Occupational Safety and Health (NIOSH). It was developed by a committee of subject matter experts from the IAFF, the International Association of Fire Chiefs (IAFC), and NIOSH.

NFPA 1561, *Standard on Emergency Services Incident Management System and Command Safety* (2020 edition)

The primary focus of the revision to NFPA 1561 in the 2020 edition was to develop requirements directly aimed at reducing and eliminating fireground injuries and fireground deaths of fire department members. The most apparent change to this edition is the inclusion of "Command Safety" in the document title and the creation of a new chapter, "Command Safety." This chapter is intended to provide a foundation on how to incorporate the incident management system at all emergency incidents, especially *Type V* and *Type IV* incidents.

The chapter on Command Safety clearly defines the requirements for the IC to meet, including establishing a fixed command post, personnel accountability, the use of staff aides, rapid intervention crews, and the appointment of a safety officer and assistant safety officer(s) (as needed), plus the expectations and authority of the safety officer. Annexes cover Functional Assignments for High-Rise Building Incidents, Development of Subordinate Officers or Implementing a More Efficient Management System, Incident Management for the Fire Service on Type V or Type IV Incidents, and Structural Fire-Fighting—Risk Assessment and Operational Expectation.

NFPA 1700, Guide for Structural Fire Fighting (2021 edition)

NFPA 1700, *Guide for Structural Fire Fighting*, 2021 edition, is the first NFPA document connecting fire dynamics research and its application to strategy, tactics, and best practices for fire fighters in controlling fires within a structure.

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Initiated through a project request in April 2015, the Standards Council requested input by June 21, 2015, on the proposed guide. Creation of the Technical Committee on Fundamentals of Fire Control Within a Structure Utilizing Fire Dynamics, the committee responsible for NFPA 1700, was approved at the August 2015 Standards Council meeting. This technical committee was charged with developing a document outlining techniques and methods used in firefighting based on accepted scientific principles and research in fire dynamics. The technical committee includes a balance of representatives from the fire service, insurance industry, subject matter textbook publishers, special experts, and stakeholders actively engaged in fire dynamics research.

NFPA 1700 addresses fire control within a structure by establishing a basic understanding of fire science and fire dynamics. NFPA 921, *Guide for Fire and Explosion Investigations*, served as a model for how to translate fire dynamics understanding in practicable, applicable ways. Current information from recognized research efforts complements fundamental occupancy, building construction, and building service considerations. While acknowledging occupant life threats, the document further addresses the protection of fire fighters from the immediately dangerous to life and health environment by reinforcing the need for personal protective equipment and methodologies for contamination control.

The focus of the document is to provide guidance to individuals and organizations on interacting within a structure on fire with proven approaches based on documented fire investigations, research, and fire dynamics testing to achieve the most successful outcome. Chapters are dedicated to establishing strategies with tactical considerations to provide effective search, rescue, and fire suppression operations, as well as civilian and responder safety.

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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Appendix One
SCBA Annual Flow Test

SCOTT

Posi3 USB Test Results 1/27/2020 9:10:14 AM
Functional Test

Scott
Air-Pak 4500 NFPA 25% - CGA

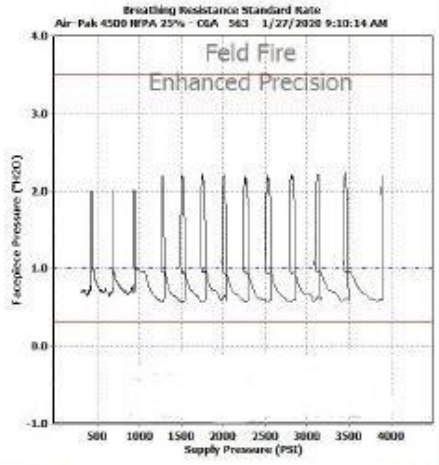
Posi3 USB serial # L03068 - Calibration was up to date when the test was performed

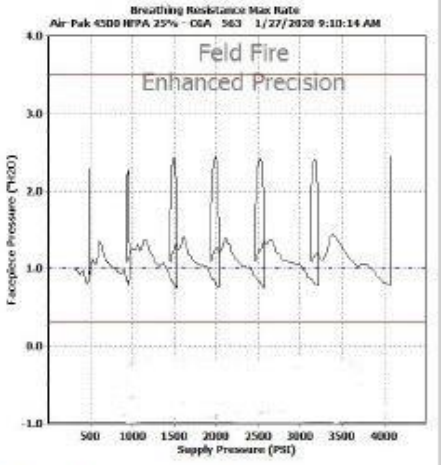
Auxiliary IDs	
Regulator	115S0619007863
Reducer	115S0619007570
-	
-	
-	
-	

Visual Inspection	
Facepiece	Pass
Backframe/Harness	Pass
Cylinder	Pass
Low Pressure Warning	Pass
Hoses	Pass
Manifold Volume: 0.084	

Functional Tests			
Exhalation Pressure	Pass	2.0	"H2O
Facepiece Leakage	Pass	0.2	"H2O
Positive Pressure	Pass	1.0	"H2O
Primary Lockup	Pass	92.9	PSI
Primary Creep	Pass	-2.5	PSI
Air Saver Switch Activation	Pass	-3.9	"H2O
Transfer	Pass	1077	PSI
Secondary Lockup	Pass	162.5	PSI
Secondary Creep	Pass	-0.1	PSI
High Pressure Leakage	Pass	27	PSI
Secondary Pr. at High Cylinder	Pass		
Purge	Pass	180	L/min
Alarm Activation Pressure			
HP Vibralert	Pass	1077	PSI
Gauge Accuracy			
HP Numbers	Pass		

1000 PSI		2000 PSI		3000 PSI	
Pass	977	Pass	2139	Pass	3104





Minimum	Maximum		Breathing Results	Minimum	Maximum	
0.6 "H2O	2.2 "H2O	Pass	Facepiece Pressure	0.7 "H2O	2.4 "H2O	Pass

1/27/2020 9:29:12 AM - Technician was called to test ait pack worn by a firefighter who died in the line of duty. Visual inspection noted right side strap cut and was informed that was cut during the rescue operation of the firefighter. Noted the nose cup was not secured to voice mitter on the right side may have come unseated during rescue operation no way to confirm. Also noted cylinder locking tab was deformed as if it was drug on or snagged on something. Noted reducer would not slide as it appeared the teflon slides may have

Tested by :

EP
Page 1 Version 4.1.1.161S

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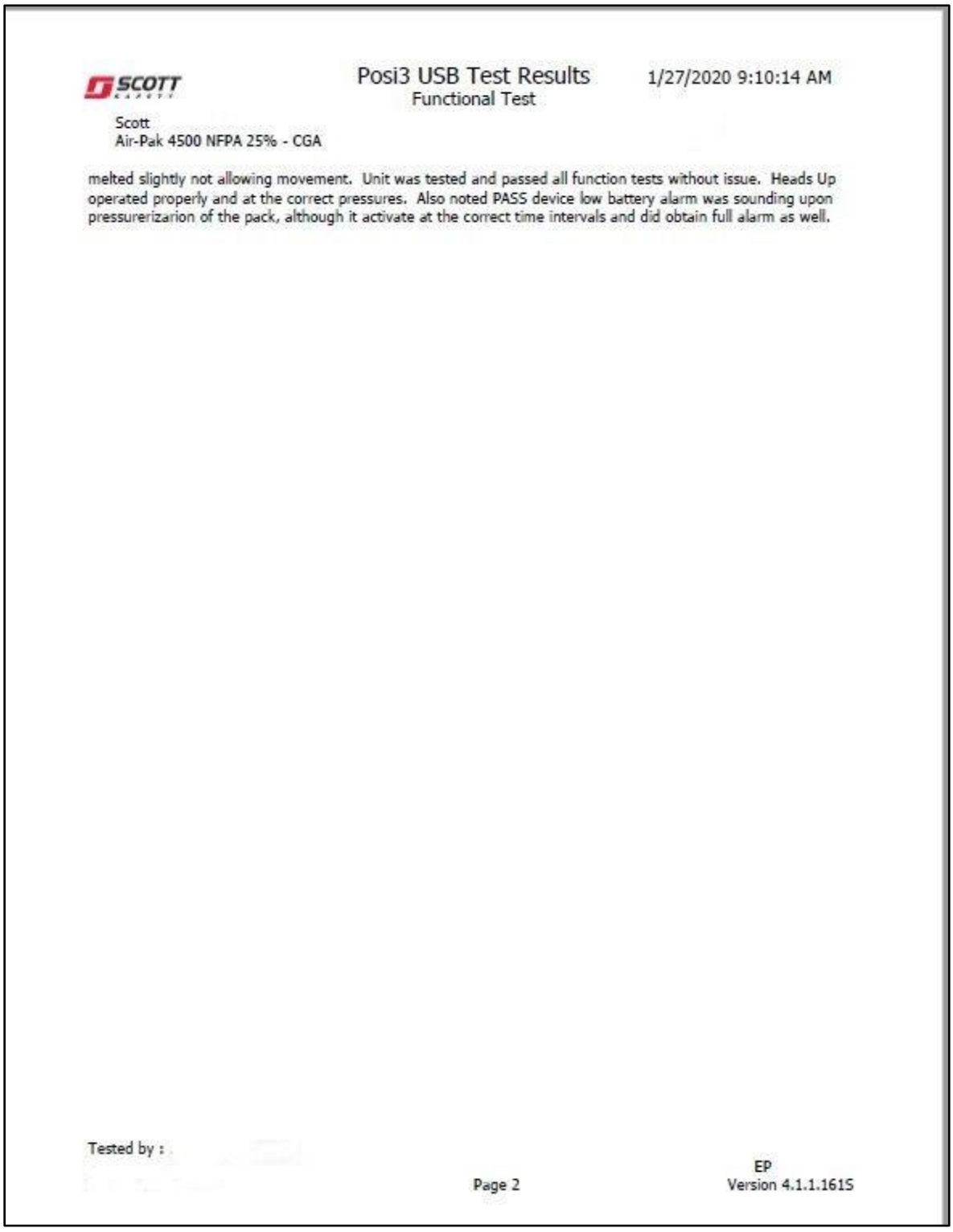


SCOTT

Posi3 USB Test Results
Functional Test

1/27/2020 9:10:14 AM

Scott
Air-Pak 4500 NFPA 25% - CGA

melted slightly not allowing movement. Unit was tested and passed all function tests without issue. Heads Up operated properly and at the correct pressures. Also noted PASS device low battery alarm was sounding upon pressurerizarion of the pack, although it activate at the correct time intervals and did obtain full alarm as well.

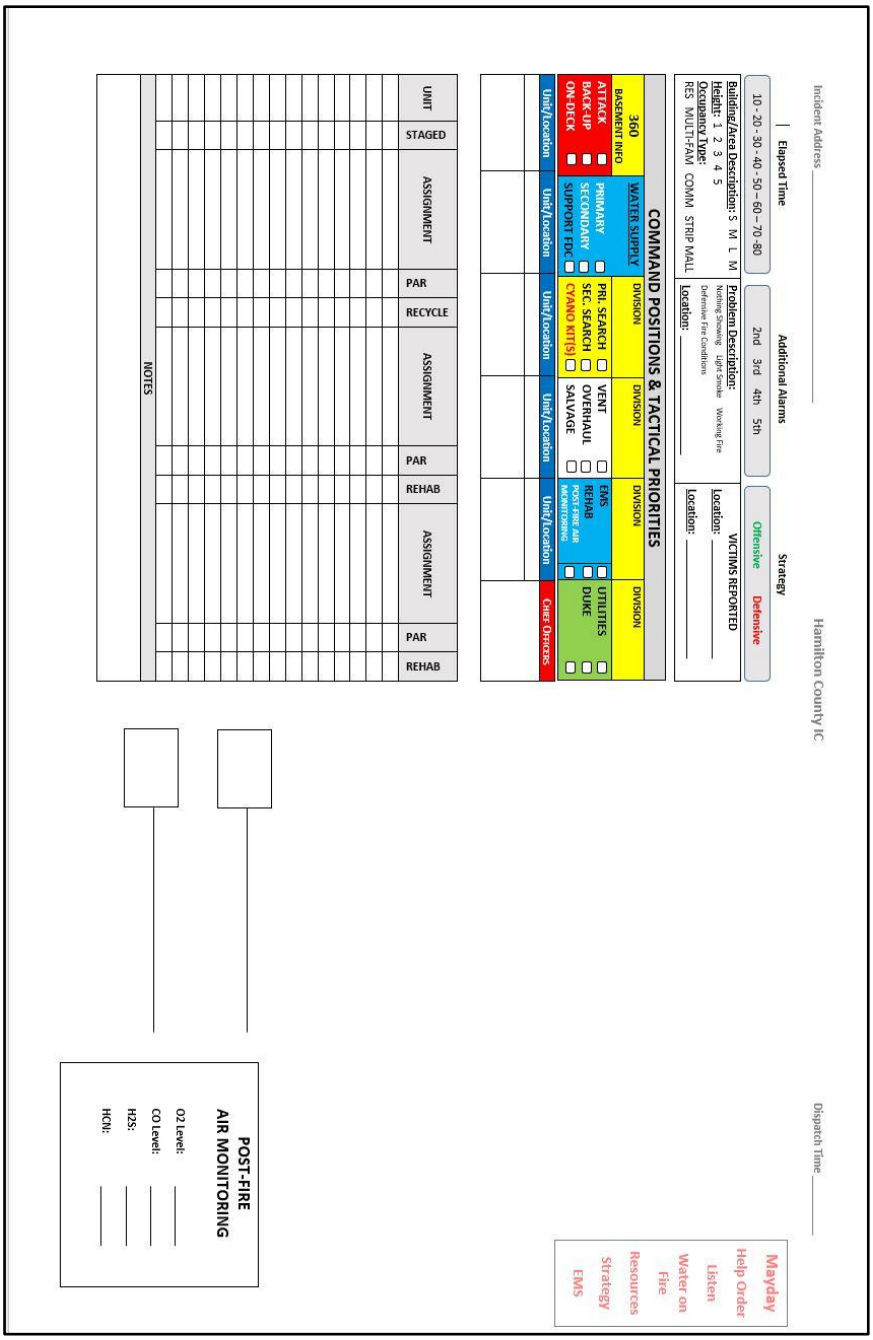
Tested by :

Page 2

EP
Version 4.1.1.1615

Firefighter Dies After Falling into the Basement due to Floor Collapse at a Modular Home Structure Fire – Missouri

Appendix Two
Sample Tactical Worksheet



Firefighter Dies After Falling into the Basement due to Floor Collapse at a Modular Home Structure Fire – Missouri

Appendix Three
Guide and Checklist for the Initial Fireground Operations

Brief Initial Report:

1. Confirm Address
2. Incident Description
3. Incident Conditions
4. Request Assistance
5. Initial Action Plan
6. Assumption of Command

Conduct 360 & Update

- ☐ Hazards identified
- ☐ Points of Entry & View Sides
- ☐ If unable to complete advise (IC)

Personnel Accountability Checklist:

- ☐ Who is in the Hazard Zone?
- ☐ Where are they in the Hazard Zone?
- ☐ What actions are they taking?
- ☐ What are the conditions in the Hazard Zone?
- ☐ Identify Hazard zone exits?
- ☐ RIT identified & in place

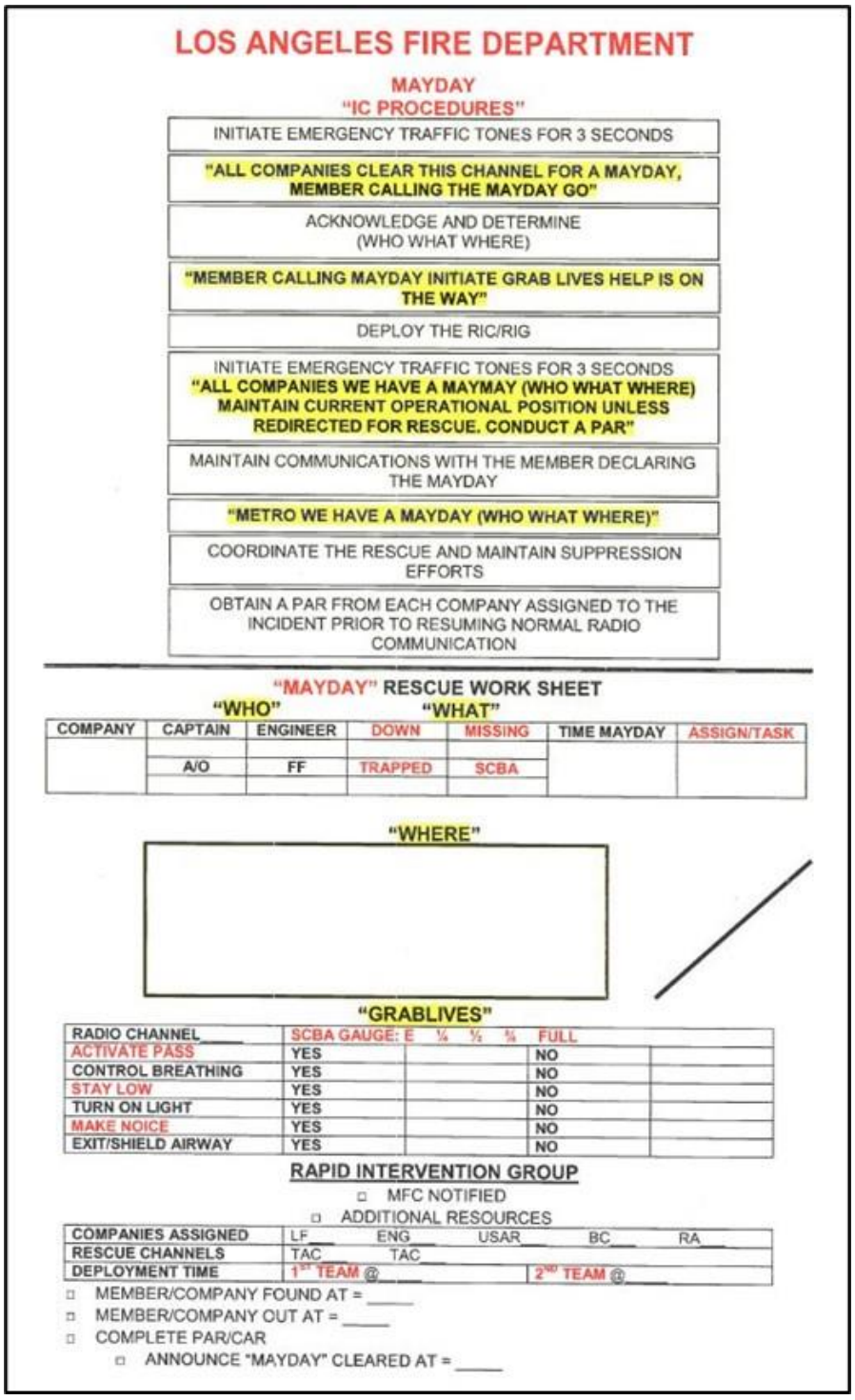
Ten-Minute Checklist

- ☐ Situation Report & Assume Command
- ☐ Activate Personnel Accountability
- ☐ Ensure Supply & Attack Lines
- ☐ Supply FDC & Reference Preplan
- ☐ Safety Officer & Initial 360°
- ☐ RIT in position
- ☐ Primary Search - All Clear
- ☐ Control Utilities
- ☐ Confirmed Working Fire
- ☐ Cover All 7 Exposures
- ☐ Staging Area & Manager Identified
- ☐ Rehab. & DECON Crews

(Guide and checklist courtesy of the Kansas City, KS Fire Department)

Firefighter Dies After Falling into the Basement due to Floor Collapse at a Modular Home Structure Fire – Missouri

Appendix Four
Incident Commander's Tactical Worksheet for a Mayday



LOS ANGELES FIRE DEPARTMENT

MAYDAY
"IC PROCEDURES"

INITIATE EMERGENCY TRAFFIC TONES FOR 3 SECONDS

"ALL COMPANIES CLEAR THIS CHANNEL FOR A MAYDAY, MEMBER CALLING THE MAYDAY GO"

ACKNOWLEDGE AND DETERMINE (WHO WHAT WHERE)

"MEMBER CALLING MAYDAY INITIATE GRAB LIVES HELP IS ON THE WAY"

DEPLOY THE RIC/RIG

INITIATE EMERGENCY TRAFFIC TONES FOR 3 SECONDS
"ALL COMPANIES WE HAVE A MAYMAY (WHO WHAT WHERE) MAINTAIN CURRENT OPERATIONAL POSITION UNLESS REDIRECTED FOR RESCUE. CONDUCT A PAR"

MAINTAIN COMMUNICATIONS WITH THE MEMBER DECLARING THE MAYDAY

"METRO WE HAVE A MAYDAY (WHO WHAT WHERE)"

COORDINATE THE RESCUE AND MAINTAIN SUPPRESSION EFFORTS

OBTAIN A PAR FROM EACH COMPANY ASSIGNED TO THE INCIDENT PRIOR TO RESUMING NORMAL RADIO COMMUNICATION

"MAYDAY" RESCUE WORK SHEET

"WHO" "WHAT"

COMPANY	CAPTAIN	ENGINEER	DOWN	MISSING	TIME MAYDAY	ASSIGN/TASK
	A/O	FF	TRAPPED	SCBA		

"WHERE"

"GRABLIVES"

RADIO CHANNEL ____	SCBA GAUGE: E ¼ ½ ¾ FULL			
ACTIVATE PASS	YES		NO	
CONTROL BREATHING	YES		NO	
STAY LOW	YES		NO	
TURN ON LIGHT	YES		NO	
MAKE NOICE	YES		NO	
EXIT/SHIELD AIRWAY	YES		NO	

RAPID INTERVENTION GROUP

- ☐ MFC NOTIFIED
- ☐ ADDITIONAL RESOURCES

COMPANIES ASSIGNED	LF ___	ENG ___	USAR ___	BC ___	RA ___
RESCUE CHANNELS	TAC ___	TAC ___			
DEPLOYMENT TIME	1ST TEAM @ ___		2ND TEAM @ ___		

- ☐ MEMBER/COMPANY FOUND AT = ____
- ☐ MEMBER/COMPANY OUT AT = ____
- ☐ COMPLETE PAR/CAR
  - ☐ ANNOUNCE "MAYDAY" CLEARED AT = ____

Firefighter Dies After Falling into the Basement due to Floor Collapse at a Modular Home Structure Fire – Missouri

Appendix Four (Continued)
Incident Commander's Tactical Worksheet for a Mayday

MAYDAY	Talk Group		Time MAYDAY CALLED		Time MAYDAY CLEARED	
WHO		WHAT		WHERE		

○	1	Confirm MAYDAY	"Command to all units on the scene, a MAYDAY has been declared. STOP all routine radio traffic & continue operations. The following units are assigned to the MAYDAY Branch (read units). Stand by for an accountability check."
○	2	SCENE ANNOUNCEMENT	
○	3	LOCATION OF MAYDAY	
○	4	Unit with mayday	
○	5	Name of member(s)	
○	6	Air status of member(s)	
○	7	Resources needed	
○	8	Deploy RIT - Action Plan	"Command to RIT, deploy to _____ for (units) _____"
○	9	Notify Dispatch	"Command to dispatch, a MAYDAY has been declared at (address)." Give "LUNAR". "Send me (additional units) _____"
○	10	Request resources	
○	11	Continue fire attack (action)	"Command to fire attack (or Division/Group), continue operations while RIT works."
○	12	Conduct Accountability	"Command to Division 1, PAR", wait for response, "Command to Roof, PAR", etc. Division & Group supervisors report units/# of personnel operating, what action is being done, and announces "PAR", or announces missing assigned members
○	13	Assign MAYDAY Branch Director	
○	14	Assign RIT Safety Officer	
○	15	Establish Point of Entry Accountability	
○	16	ALS Resources	
○	17	Create defendable space	
○	18	Develop alternative strategies	
○	19	Control unassigned resources	
○	20	Risk Assessment	
○	21	Control information release	
○	22	NOTIFY ALL when MAYDAY is CLEARED	

Location	QUAD	UNIT	NAME	AIR SUPPLY	RESOURCES NOTES	CLEARED

MAYDAY Branch Director							RIT Supervisor	
Units Assigned to MAYDAY & RIT	# Personnel Assigned					MAYDAY Group	Location	EMS Group Supervisor
	2	3	4	5	6			UNITS / Hospital