1000 FREDERICK LANE, MORGANTOWN, WV 26508 • 304.285.5916

Volunteer Firefighter Dies when Propane from an Underground Tank Leaked into a Residential Home causing a Catastrophic Explosion – Virginia

Executive Summary

On February 16, 2024, a 45-year-old volunteer firefighter (T611FF2) died after being struck by debris during a catastrophic explosion of a residential structure. At 19:36 hours, the Emergency Communications Center (ECC) received a call for an odor of gas outside of a residential home. Approximately two minutes later, two units were dispatched for a report of an outside gas leak in a residential neighborhood. E618 was staffed with five personnel: Captain E618, Driver Operator (E618DO), and three firefighters (E618FF1, E618FF2, and E618FF3). The second unit was T611, staffed with five personnel: Lieutenant T611, Driver (T611DO), and three firefighters (T611FF1, T611FF2, and T611FF3). At 19:43 hours, T611 arrived on-scene. As the crew approached the residence, they noticed a slight odor of gas. They met with the caller who reported an odor of gas outside the home. T611 began to conduct air monitoring around the home. Several neighbors who came outside reported they had no odor of gas in their homes. Lieutenant T611 instructed T611FF2 to check the storm drains using their gas meters. Two drains located in front of an adjacent home were alerted to a positive reading. T611FF2 and Lieutenant T611 noted there was no odor of gas in the storm drain.

Photo 1: Aerial view of structure and surrounding area post explosion. ***(Courtesy of fire department)***

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At 19:48 hours, E618 arrived on-scene. Two of E618's members were approached by a neighbor at an adjacent home, explaining she had a leak in an underground propane tank that supplied her swimming pool. She accompanied personnel from T611 and E618 to the propane tank location. There was a propane delivery earlier in the day. While the propane delivery driver was filling the tank, he noticed a leak. He deposited approximately 125 gallons of propane into the tank before he noticed the leak. He was unable to extract the delivered propane due to a concern with the tank's valves. Captain E618 updated the ECC with the information and the correct address. As the crews approached the area of the propane tank they noticed a strong odor of gas. They opened the tank dome and noticed visible vapors from the ground surrounding the tank.

The homeowner called the emergency contact number for the delivery company, left a message, and a return call was immediately received. Captain E618 and Lieutenant T611 discussed with a company representative how to mitigate the leak who noted the tank had to be removed from the ground. After speaking with the propane delivery company representative, Captain E618 contacted the Fire Marshal Supervisor (FM604) and Lieutenant T611 contacted the hazardous materials (hazmat) team's on-duty officer (HM619 OIC) to discuss the situation. HM619 OIC indicated that the hazmat team should respond. Captain E618 requested the hazmat team along with a second engine. Shortly after the request, he added a Battalion Chief and reported to the ECC that he was establishing himself as the incident commander (IC).

Units entering the structure received elevated gas readings at the front door. T611 placed a positive pressure ventilation (PPV) fan at the front door directing air into the house. The homeowner advised the units there was an occupant living in the basement. Lieutenant T611 and E618FF1 made entry into the home. They advanced down the basement steps, encountering the second occupant of the home. They directed her to immediately exit the house. A gas meter reading was taken in the basement. It went into alarm mode, giving an over range indication exceeding 10% of the Lower Explosive Limit (LEL).

Once the occupant left the basement, Lieutenant T611 and E618FF1 began to manually open the basement windows. Suddenly without warning, there was a catastrophic explosion. The force of the explosion raised the roof, and the walls collapsed propelling outward. The contents soared in all directions. All four walls of the foundation cracked, and heavy fire conditions consumed all the collapsed structural components, along with the home's contents. T611FF2 (deceased firefighter) was standing in the front yard in line with the front door. He was struck by debris from the explosion and sustained a fatal injury. Lieutenant T611 and E618FF1, who were in the basement, survived the explosion. They were trapped and located in voids surrounded by heavy debris. They were conscious and alert with the ability to declare Maydays and execute survival techniques to maintain composure and allow for rescue personnel to assist with extricating them from the rubble. Additional units arrived simultaneously beginning extinguishment and rescue operations. After approximately 40 minutes, both trapped personnel were rescued and transported to medical facilities with serious injuries. T611FF2 was declared deceased.

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Contributing Factors

- *Incident command and management*
- *Personnel accountability*
- *Hazardous materials incident response including air monitoring*
- *Mayday procedure and management*
- *Training and evaluation for rank and skill.*

Key Recommendations

Fire departments should:

- *Establish incident command at the beginning of the incident and ensure initial and ongoing size-ups and risk assessments are conducted throughout the incident.*
- *Use a functional personnel accountability system to readily identify the location and function of all personnel operating at an incident.*
- *Follow standard operating procedures (SOPs)/standard operating guidelines (SOG's) for hazardous materials incidents, such as propane and natural gas emergencies.*
- *Ensure all firefighters and fire officers are trained in Mayday operations and management.*
- *Develop and implement a professional development program that includes routine evaluation based upon rank and skill for all combination fire department personnel. Such a program should also promote resilience and safety communication during an incident.*

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

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Introduction

On February 16, 2024, a 45-year-old volunteer firefighter died following an explosion of a residential home caused by a propane leak. On February 17, 2024, the U.S. Fire Administration (USFA) notified the National Institute for Occupational Safety and Health (NIOSH) of this incident. On March 4, 2024, two NIOSH Fire Fighter Fatality Investigation and Prevention Program (FFFIPP) investigators traveled to Virginia to investigate this incident. The NIOSH investigators met with the fire chief, command staff, volunteer chief, and conducted interviews with fire officers and firefighters that responded to the incident. The NIOSH investigators reviewed training records of personnel involved in the incident and the department's SOPs and professional development model.

Fire Department

The deceased firefighter was a volunteer serving in a combination fire and rescue system that is comprised of over 677 career personnel, 118 civilian personnel, and 1,396 volunteers. The combination system serves approximately 447,837 citizens and covers 521 square miles, including six miles of waterway. There are 20 stations, 11 are county owned and 9 volunteer. The volunteer section of the combination system consists of 15 volunteer corporations, with approximately 1,361 total volunteers: 717 are operational, 421 administrative, 23 support services and 83 junior members. The career section of the system is comprised of 676 uniformed members with authorization for 880 personnel. The fire and rescue system maintains 24/7 staffing at each of the 20 fire and rescue stations, with some volunteer stations providing nighttime staffing from 6:00 PM to 6:00 AM and includes up to four battalion chiefs, two emergency medical services (EMS) supervisors, one safety officer, and a shift commander (deputy chief) assigned to a 7 day/24 hour per day schedule.

Training, Education, and Professional Development

Different performance and training for career and volunteer firefighters is required. The career system trains the recruits through a scheduled fire academy. The volunteer system requires members to obtain minimum qualifications through continuous classes until a certain level of qualifications are met to perform operationally on designated fire equipment. The volunteer station involved in this incident requires a new member to complete a variety of topics to ensure preparation for different situations they may encounter. The path to becoming a fully released firefighter typically requires 12-18 months of training. Eligibility for a volunteer member to become a minimum staffing firefighter or EMS attendant-

in-charge is determined by the company chief (as delegated by the system chief) who is responsible for verifying all certifications and training requirements are met.

Apparatus, Staffing, and Communications

At minimum, the combination system ensures operational fire and EMS resources are staffed daily. The system's minimum staffing consists of 20 staffed stations. There are 19 engines with a minimum staffing of three personnel, five aerial trucks staffed with four personnel, four rescue squads (two with full staffing and two cross-staffed with engine), 11 tankers, 14 medic units, four ambulances, two EMS supervisors, one safety officer, four battalion chiefs, and one shift commander. **Tables 1–4** show the units that were dispatched for this incident.

Table 1: Initial Assignment for Outside Gas Leak

Resource Designation	Staffing Level
Engine 618	5 personnel
Truck 611	5 personnel

Table 2: Additional Units for Outside Gas Leak

Resource Designation	Staffing Level
Engine 619	3 personnel
Battalion Chief 601	1 personnel
Hazmat Support 619	2 personnel
Safety 601	1 personnel

Table 3: Dispatch for Structure Fire

Resource Designation	Staffing Level
Paramedic Engine E 624	4 personnel
Rescue 635	4 personnel
Paramedic Rescue 439	4 personnel
Paramedic Engine 404	4 personnel
Safety 603	4 personnel
Medic 635	3 personnel
Ambulance BLS 635C	2 personnel
Paramedic Engine 412	4 personnel
Shift Commander OPS600	1 personnel
Tiller Truck606	3 personnel
Battalion Chief 402	1 personnel
Paramedic Tiller Truck 425	4 personnel
Battalion Chief 401	1 personnel
Paramedic Engine 422	4 personnel

Emergency Medical Service 601	1 personnel
Battalion Chief 672	1 personnel

Table 4: Dispatch for EMS Task Force

Resource Designation	Staffing Level
Medic 424	2 personnel
Ambulance BLS 412	2 personnel
Medic 606	2 personnel
Ambulance BLS 622	2 personnel
Ambulance BLS 431	2 personnel
Battalion Chief 604	1 personnel
Emergency Medical Service 602	1 personnel
Office of Emergency Management 601	1 personnel
Paramedic Engine 439	4 personnel
Engine 606	4 personnel

The county uses an ASTRO P25 radio system that consists of one 800MHz simulcast cell with 10 Radio Frequency (RF) tower sites. This system contains one Geo-Redundant prime site that interfaces to all current RF sites, the Master Site, and a Dynamic System Resilience (DSR) Site. The Master/Prime System control site is located at the ECC Tower Building, and 10 simulcast remote transmit/receive sites are located throughout the County. The current system is licensed and configured for 11 channels and operates in P25 Phase 1 FDMA, Phase 2 TDMA modes, and is supported by Smart Connect LTE services.

Air Monitoring Equipment

Every suppression unit, battalion chief, and safety officer carries the Industrial Scientific-Ventis MX4 multi-gas meter. These meters can assist in the identification or classification of basic flammability and oxygen deficiency/enrichment hazards. Each station contains a docking station. Fire department policy requires each meter to be bump tested daily per manufacturer instructions.

Personal Protective Equipment

All personnel in this incident were wearing structural firefighting turnout gear compliant with the current requirements of NFPA 1971, *Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting*. The NIOSH Approved® SCBAs, which are owned and maintained by the Department's Respiratory Protection Section, included integrated personal alert safety system (PASS) devices certified to the 2013 edition of NFPA 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus (SCBA) for Emergency Services*. The deceased firefighter was wearing his department-issued personal protective equipment (PPE), consisting of a coat and pants, helmet, hood, boots, SCBA, and radio. His department-issued fire gloves were in his pocket.

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Building Construction

The single-family two-story residential structure was a colonial style type V construction, built in 1985 (**see Photo 2**). It had 2,078 square feet of above ground living space with 1,068 square feet of below grade, fully furnished living space. The below grade portion of the structure was constructed into living space in 2019 (**see Diagram 1**). The home had a lightweight truss gable roof covered with plywood and asphalt/fiberglass shingles, a brick veneer front, a two car 440 square foot attached garage, and a center positioned front porch. The rear of the structure contained an attached wood deck, solid wood fence with a lattice top lining the property, a storage shed, and a concrete swimming pool (**see Photo 3**).

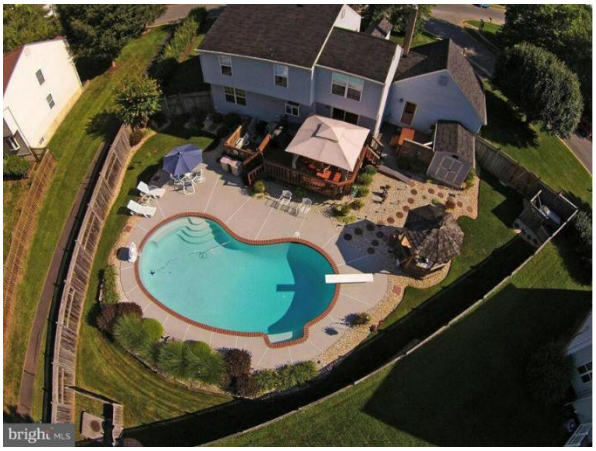

Photo 2 and 3: View of structure pre-incident.
(*Courtesy of Fire Marshal's Office*)

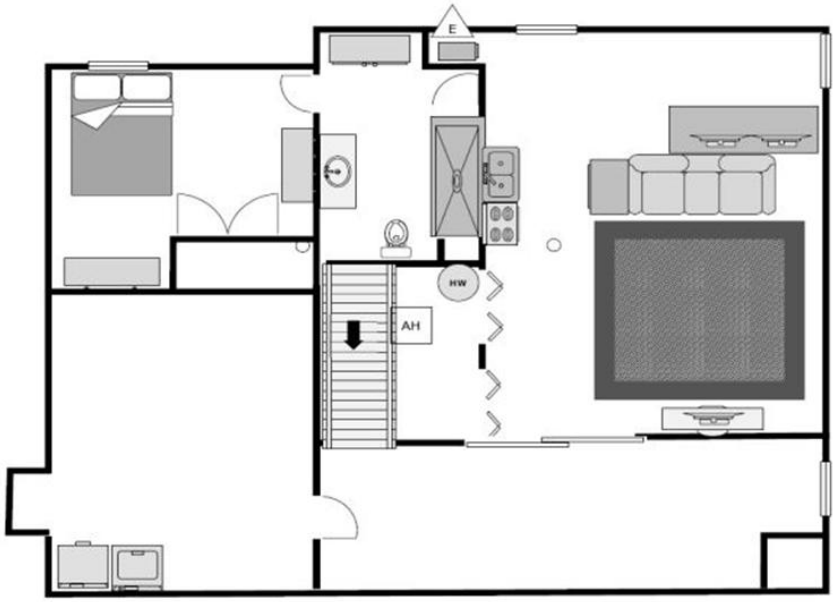

Diagram 1: Basement of the structure.
(*Courtesy of Fire Marshal's Office*)

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Underground Propane Tank

The propane tank was located on Side Delta of the structure approximately 20 feet from the structure's exterior wall. The tank supplied the swimming pool heater located near the Side Bravo/Charlie corner of the house. Underground propane tanks are available in an assortment of sizes (**see Photo 4**). Tanks are typically coated with either a powder phenolic finish or liquid applied epoxy primer coat followed by a urethane topcoat. There is a dome above the ground. A grounding process, which involves attaching a sacrificial anode (similar to a magnesium rod) to the tank, allows it to attract stray electric currents in the soil to prevent corrosion. Details regarding the propane tank involved in the incident were not available to the NIOSH investigators.

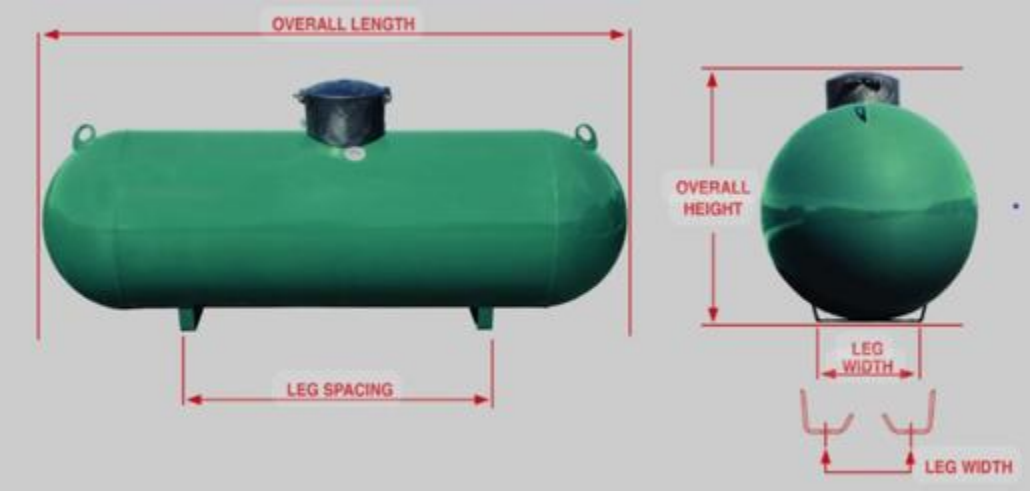

Photo 4: Example of a similar type 500-gal underground propane tank.
(*Courtesy of NIOSH*)

Incident Timeline

The following timeline is a summary of events that occurred shortly after 19:36 hours on February 16, 2024. Not all incident events are included in this timeline. The times are to the minute and were taken from the fire departments' *National Fire Incident Reporting System* (NFIRS) fire reports, dispatch log, on-scene accountability documentation, and interview notes.

Time	Fireground Operations, Response, and Details
19:36 Hours	• Call received indicating smell of gas outside residence. • ECC case created and unit recommendations for fire alarm response initiated.
19:38 Hours	• ECC dispatched units E618 and T611 to outside gas leak.

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Time	Fireground Operations, Response, and Details
19:43 Hours	• T611 on-scene and made contact with caller.
19:48 Hours	• At 19:48 hours, E618 arrived on-scene. Two of E618's members were approached by a neighbor at an adjacent home, explaining she had a leak in an underground propane tank that supplied her swimming pool.
20:03 Hours	• Lieutenant T611 contacted HM619 OIC on duty phone.
20:05 Hours	• Captain E618 requested FM619 to make contact via cell phone.
20:18 Hours	• The homeowner with the underground propane tank made a call made to propane delivery company. • Captain E618 requested 2nd engine and hazmat response. • Captain E618 requested a battalion chief (BC601) and establishes command.
20:20 Hours	• Captain E618 reported multi-gas meter reading of 40% LEL at front door. • Hazmat, E611, and BC601 dispatched.
20:22 Hours	• PPV fan placed at front door directing air into structure.
20:24 Hours	• BC601 requested information regarding the size and volume of propane tank while enroute. • Catastrophic explosion of structure followed by entire structural collapse with heavy fire conditions. • Captain E618 reported catastrophic house explosion to ECC. • E618FF1 trapped in the basement declares Mayday.
20:25 Hours	• BC601 requested incident upgrade to a structure fire box alarm. • Lieutenant T611, trapped in the basement by debris, declares a Mayday. • Mayday acknowledged by BC601. • E618FF1 declared 2nd Mayday.
20:26 Hours	• BC601 ordered E618 to intervene and be part of Rapid Intervention Team (RIT). • Structure fire alarm dispatched.

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Time	Fireground Operations, Response, and Details
	• E611 arrived on-scene and established a water supply.
20:27 Hours	• E611 established command confirming house explosion. • E618FF1 declared 3rd Mayday. • BC601 requested 2nd alarm and RIT task force.
20:28 Hours	• E618FF1 declared 4th Mayday. • BC601 arrived on-scene and assumed command.
20:29 Hours	• E611 began extinguishing fire. • E618DO reported possible deceased T611 officer. • BC601 requested confirmation of deceased T611 officer. • Command requested EMS task force.
20:30 Hours	• BC601 ordered E611 to place their deck gun in service. • BC601 made second request for E611 to place deck gun in service. • E611 told BC601 they were out of water.
20:31 Hours	• Lieutenant T611 declared 2nd Mayday while trapped in basement under heavy debris in a void space. • He indicated fire was slowly moving towards him stating “I need you guys to get down here and put the fire out, ASAP.”
20:32 Hours	• BC601 contacted trapped Lieutenant T611 and made request for him to identify his location (quadrant). • Lieutenant T611 reported he was in the Side Alpha/Delta quadrant of the structure. • BC601 acknowledged Lieutenant T611’s message, states water was being put on the fire.
20:33 Hours	• E611was getting water.
20:35 Hours	• E618FF1 declared 5th Mayday, “please come and help.” • E404 arrived on-scene.
20:36 Hours	• BC401 was notified that there was a deceased firefighter in the front yard. *This was the first notification of the correct identity of the deceased member.*

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Time	Fireground Operations, Response, and Details
20:37 Hours	• R635 requested a ladder stating they had a large open area in the basement and heard a PASS device (E618 trapped firefighter's PASS device).
20:38 Hours	• Units get a visual on E618FF1.
20:39 Hours	• E404 notified command their hydrant was out-of-service.
20:42 Hours	• BC601 asked how many T611 personnel were accounted for and not in the building. • E618FF1 rescued out of basement. • Lieutenant T611 gives update on his condition, indicated he had two thirds air left, going to control his breathing and activate the PASS device.
20:43 Hours	• BC401 announced rescue of one of the trapped firefighters (E618FF1) and that they had eyes on the other (Lieutenant T611), working on extrication.
20:44 Hours	• ECC updated command on Lieutenant T611's status.
20:52 Hours	• BC401 asked if a PAR check had been done. • BC401 stated "Are we 100% sure of how many are missing and what their names are at this point." • BC601 responded stating "That's negative we're trying…still trying to confirm who they are."
21:02 Hours	• Command requested 3rd alarm.
21:03 Hours	• Lieutenant T611 rescued.
21:13 Hours	• BC601 identified all personnel accounted for.

Weather Conditions

The weather conditions starting at 12:00 hours, on February 16, 2024, were mostly cloudy with a temperature of 41° with winds WNW 13 mph, 16°F dew point, 29.72 in pressure, and 37% humidity. The weather conditions remained consistent throughout the day with gradual winds decreasing to 3 mph

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ESE, temperature 45°, 16°F dew point, 29.57 in pressure and 31% humidity at 18:52 [Weather Underground 2024].

Investigation

At 19:36 hours, a 9-1-1 call to the ECC was received reporting an odor of gas outside in a residential neighborhood. The caller did not know the source of the gas odor. At 19:38 hours, E618 and T611 were dispatched for an outside gas leak. At 19:43 hours, T611 arrived on-scene. As T611's crew approached the home, they noticed a slight odor of gas. The caller said her husband noticed an odor of gas around the outside of the home. There was no odor of gas inside the home. Two of T611's crew, T611DO and T611FF3, remained with the apparatus while Lieutenant T611, T611FF1, and T611FF2 proceeded with the investigation. After collecting information from the caller, Lieutenant T611 directed his crew to use gas meters and monitor the air adjacent of the homes. The homes were located up-hill from the reported address. There were two storm drains located in front of an adjacent property that had positive readings. Per Lieutenant T611 and T611FF2, there was no gas odor in either drain.

At 19:48 hours, E618 personnel arrived on-scene and joined T611's investigation. A neighbor approached them from an adjacent home directly next to the original caller's home noting there was an underground propane tank used to supply a pool heater on her property. It had not been used in two years but earlier that day she received a delivery of propane. During the delivery, the driver identified a leak in the tank. Prior to identifying the leak, the driver deposited 125 gallons of propane into the tank. The driver notified the homeowner and advised her the propane could not be extracted, and the tank would need to be removed from the ground at a later date.

At 19:54 hours, Captain E618 transmitted the updated information to the ECC. He reported the corrected address and that the source of the gas leak was identified. T611's personnel proceeded to the propane tank (**see Photo 5**). As they approached the area, a strong odor of gas was noted, along with gas meter readings of 80 to 100 percent on LEL. The propane tank dome was raised, and vapors were coming from the surrounding ground. However, no vapors were observed coming from the tank valves. Lieutenant T611 discussed the situation with Captain E618, and they decided to contact FM604 to discuss the incident. At 20:03 hours, the Lieutenant T611 contacted the

Photo 5: View of the area the propane tank was located. (*Courtesy of Fire Marshal's Office*)

hazmat team by phone, explaining the circumstances of the incident and the heightened concern. He was told the hazmat team should respond.

The homeowner called the 24-hour emergency number for the propane delivery company at 20:18 hours. The representative of the company discussed with the homeowner and the two fire officers that a leak in the tank was identified by the delivery person. He explained that due to the age of the tank and possible damage to a valve, they were unable to extract the propane, and it would need to be removed to mitigate the leak. Lieutenant T611 ordered T611 to be repositioned at a location that could provide a water curtain to cover the propane tank if necessary. As the two units continued the investigation, E618DO retrieved the U.S. Department of Transportation Emergency Response Guidebook (ERG). The ERG evacuation information outlined an immediate precautionary measure to isolate spill or leak area for propane to be at least 100 meters (300 ft) in all directions. He repositioned E618 to a safe distance from the propane tank.

Lieutenant T611 advised Captain E618 that the adjacent houses needed to be monitored and ventilated. Captain E618 requested the hazmat team, a second engine, and battalion chief from the ECC and established command at 20:18 hours. Approximately two minutes later, the hazmat team, E611, and BC601 were dispatched. As the incident progressed, firefighters began monitoring the house and surrounding area for the presence of gas. At 20:20 hours, a reading at the main entrance to the house measured 40% on LEL and there was an additional LEL reading above 60%. Two minutes later, a PPV fan was placed at the front door directing air into the structure. Lieutenant T611 returned to the unit to don full PPE. As he proceeded to the truck, they heard a 67% LEL was measured although there was some question as to the accuracy of the reading. There was no meter alarm activated, the lack of an alarm and absence of a gas odor gave a reduced sense of urgency.

When Lieutenant T611 returned to the home, he demanded the owner exit immediately. The homeowner said there was another occupant in the basement. Lieutenant T611 and E618FF1 entered the house in full PPE including their SCBA. However, they did not don their SCBA facepieces and were not “on air.” They proceeded down the basement and directed the second occupant to leave the basement. E618FF1 received a gas reading from the meter, which gave an over range reading while in alarm. Once the occupant left, Lieutenant T611 and E618FF1, opened the basement windows to ventilate. At approximately 20:24 hours, as they opened a second window, there was a catastrophic explosion destroying the entire structure. Seconds before the explosion, BC601, while enroute, requested an update on the size of the tank and volume of product contained in the tank.

The force of the explosion raised the roof off the home, collapsed the exterior walls, and propelled structural components and interior furnishings hundreds of feet. Nine seconds later, Captain E618 reported to the ECC that a catastrophic explosion had occurred with the entire structure collapsed (**see Photo 6**). Lieutenant T611 and E618FF1, operating in the basement, were trapped under heavy debris surrounded by fire but survived the explosion. At 20:24 hours, E618FF1 declared a Mayday, reporting he was in the basement. At 20:25 hours, BC601 upgraded the incident, requesting a fire box alarm for a structure fire. Lieutenant T611 declared a Mayday, advising he was in the basement trapped by debris. BC601 immediately acknowledged the Mayday. E618FF1 transmitted a second Mayday. BC601 ordered

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E618 to be part of RIT but all of E618's crew were injured and incapacitated due to the force of the explosion. BC601 requested accountability for E618's crew. During that time, E611 arrived on-scene and established a water source, laying a supply hoseline. At 20:27 hours, E611 confirmed a house explosion to the ECC. E618FF1 declared a third Mayday, advising he was stuck in the basement. BC601, still enroute, requested a 2nd alarm and RIT task force. Seconds later, a fourth Mayday was declared by E618FF1. BC601 arrived on-scene and assumed command at 20:28 hours. At approximately 20:29 hours, E611 began to extinguish the fire.

Photo 6: Aerial view of area effected by explosion.
(*Courtesy of NBC News*)

The ECC told BC601 that a firefighter from E618 declared a Mayday and was trapped in the basement. During this time, E618DO thought the officer of the truck was killed (incorrect identification of deceased personnel). BC601 immediately requested confirmation that the deceased firefighter was Lieutenant T611. There was no confirmation or response. T611FF2 (deceased firefighter) was located approximately 30 ft from the front of the structure on Side Alpha. He was struck by an unknown projectile with severe force. Many of the large structural components propelled from the explosion were mangled and destroyed. Several firefighters located around the fatally injured firefighter were injured.

At approximately 20:30 hours, BC601 ordered E611 to place their deck gun in service. Without a response, BC601 made a second request for the deck gun to be placed in service. E611 replied, that they

were out of water. Units on-scene identified that the deceased firefighter was a volunteer assigned to T611. At 20:31 hours, Lieutenant T611 declared a second Mayday. He reported being in the basement in a void space, under heavy debris, with fire advancing towards him, and unable to get out. Both trapped firefighters managed to secure their SCBA facepieces to their face, preventing exposure to the heat and smoke. At 20:32 hours, BC601 contacted Lieutenant T611 requesting information regarding his location. He thought he was on the Side Alpha, left of the basement steps, positioned in the Side Alpha/Delta quadrant. BC601 acknowledged the message and were getting water on the fire. Approximately a minute later, E611 confirmed they were getting a water supply. At 20:35 hours, E618FF1 announced a fifth Mayday stating, "please come and help." During this fifth Mayday, E404 arrived on-scene. The rescue efforts for the trapped firefighters were hampered by the heavy fire conditions, large amount of debris, and heavy structural components blocking access. Units were extinguishing the fire, along with digging through the mound of debris searching for the two trapped members (**see Photo 7**).

Photo 7: View of rescue operations.
(*Courtesy of Fire Marshal's Office*)

At 20:37 hours, a PASS device was heard by rescuers and a ladder was requested. The rescuers made visual contact with E618FF1. At approximately 20:39 hours, E404 notified BC601 that their hydrant was out-of-service. BC601 at 20:42 hours, requested how many of T611 personnel were unaccounted. E618FF1 was removed from the debris. Lieutenant T611 reported that he could not get out, had about two-thirds air, was under debris, and was going to activate his PASS device. At 20:43 hours, BC401 reported that E618FF1 was extricated, and the rescuers were able to get a visual on Lieutenant T611. Approximately one minute later, the ECC updated Lieutenant T611's status. At 20:52 hours, BC401 inquired if a PAR check was completed and if they were 100% sure how many firefighters were missing.

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BC601 responded "negative" advising they are still trying to determine who is missing. At 21:02 hours, BC601 requested a third alarm. Approximately one minute later Lieutenant T611 was rescued. He was mobile and able to climb onto a ladder. It was approximately 40 minutes from the time of the explosion until the rescue and extraction of Lieutenant T611. At 21:13 hours, BC601 reported all personnel were accounted and T611FF2 was declared deceased.

Explosion Cause

A non-seated explosion and subsequent fire occurred when fugitive propane gas reached an unknown ignition source located inside and immediately surrounding the structure.

Cause of Death

According to the county medical examiner report, T611FF2's cause of death was blunt force trauma.

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 injuries or fatalities. NIOSH investigators identified the following items as key contributing factors:

- Incident command and management
- Personnel accountability
- Hazardous materials incident response including air monitoring
- Mayday procedure and management
- Training and evaluation for rank and skill

Recommendations

Fire departments should:

Recommendation #1: Establish incident command at the beginning of the incident and ensure initial and ongoing size-ups and risk assessments are conducted throughout the incident.

Discussion: During this incident, the actions of the assigned units indicated a routine response. However, there were indications upon arrival that the incident was serious and would require additional resources with advanced knowledge of hazardous material mitigation. Approximately six minutes after arrival, personnel learned there was an underground propane tank leaking for which they had to determine the extent. Approximately 32 minutes after arrival of the first unit, command was established.

Typically, the first arriving unit at the incident assumes command until the incident is mitigated or until the arrival of a superior officer if the incident elevates. This initiation indicates the origination of the command structure and reinforces a position of authority. The IC is responsible for an initial situation report after assessing the situation, determines incident priorities, provides direction for all personnel operating on the incident, and reports actions being taken [IAFC 2021]. Establishing command upon

arrival at an incident helps provide an organized structure of the incident. NFPA 1550 [2024], discusses several responsibilities and actions of the IC:

- Overall management of the incident and the safety of all members involved at the scene.
- As the incident escalates in size and complexity, divide the incident into divisions or groups and assign an incident safety officer (ISO) to assess the incident scene for hazards or potential hazards.
- Establish an organization with sufficient supervisory personnel to control the position and function of all members operating at the scene and ensure safety requirements are satisfied.

After incident command is established, initial and ongoing size-ups and risk assessments should be conducted throughout the incident. Continuous communication help manage the safety of on-scene personnel by improving awareness of changing conditions and adjusting to avoid hazards or mitigate risks. Performing a 360° is an important component of the scene size-up and can be used in a risk assessment. The IAFFs' *Rules of Engagement for Structural Firefighting* recommends that the first rule for ICs is to rapidly conduct or obtain a 360° situational size-up of the incident [IAFF, YEAR]. Many incidents contain obstacles to prevent the viewing of all sides of a structure. When the 360° reconnaissance is achieved, it provides the IC and personnel knowledge of the building layout, construction, access/egress points, and obstacles or hazards [NIOSH 2017].

A dedicated ISO can perform initial and on-going size-ups throughout the incident. Expectations and authority for the ISO include determining hazardous incident conditions, advising the IC to modify control zones or tactics to address corresponding hazards, communicate fire behavior and forecast growth, and estimate building/structural collapse hazards. This also includes the authority to stop or suspend incident operations based on imminent threats posed to firefighter safety [NFPA 1550 2024]. The ISO should be separate from the IC, operations, or accountability positions so they can focus on their responsibilities and the primary objective of continually assessing all on-scene hazards to firefighter life and safety.

Recommendation #2: Use a personnel accountability system to readily identify the location and function of all personnel operating at an incident.

Discussion: During the incident, an accountability system was not executed to identify the locations and tasks of on-scene personnel throughout the incident. After the explosion, it was unknown what personnel were trapped inside the collapsed structure and who was injured.

A personnel accountability system is a system that readily identifies both the location and function of all members operating at an incident scene [NFPA 1550, 2024]. This system is implemented during an incident to collect and maintain the status and location of the resources working in, or potentially working in, an immediately dangerous to life and health (IDLH) environment. All members operating at an incident are responsible for understanding and participating in this system. The IC is responsible for but may delegate certain responsibilities to another person such as the ISO. 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 throughout the entire incident. A properly initiated and enforced personnel accountability system can enhance firefighter safety and survival [NIOSH, 2024]. A functional personnel accountability system should have the ability to identify:

- Members operating in the hazard zone (who)
- Where members are in the hazard zone (where)
- Conditions in the hazard zone (conditions)
- Actions used in the hazard zone (actions)
- Paths of access and egress in and out of the hazard zone (exits)
- RITs and their assignments

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

Recommendation #3: Follow SOPs/SOGs for hazardous materials incidents, such as propane and natural gas emergencies.

Discussion: Although the fire department involved in this incident has a firefighting and emergency operations manual for utility emergencies, many of the personnel involved in this incident were unaware of these SOPs. The manual, furnished by the fire department in conjunction with surrounding agencies, describes types of gas emergencies, including propane. Additionally, the manual provides general operational considerations for communications, positioning and staging, investigation procedures, air monitoring operations, and establishing hazard zones.

NIOSH has investigated numerous incidents of firefighter fatalities and injuries resulting from fires and explosions of flammable gases. Similar to this incident, previous fatalities were caused by firefighters being struck by a piece of debris following the explosion of the gas. For many of these incidents, NIOSH recommended that firefighters have SOPs/SOGs that detail responses to hazardous materials incidents and strictly enforce their use by personnel due to the extreme danger they present [NIOSH 1999; NIOSH 2019]. When a fire department has SOPs/SOGs for emergency operations, they should ensure all personnel are able to access them and are provided training on their implementation. This is especially important for developing competencies for response to hazardous materials incidents. For flammable gas emergencies, such as those involving propane and natural gas, department SOPs/SOGs may choose to include several functions outlined below [Noll and Hildebrand 2014].

- Hazard identification and risk evaluation:
    - Hazardous nature of the material involved
    - Quantity of the material involved
    - Design and construction of the container

  - Fixed or engineered safety systems
  - Type of stress applied to material and its container (if any)
  - Size and type of area being affected
  - Identifying and prioritizing exposures
  - Level of expertise of available resources
  - PPE requirements
- Tactical objectives:
  - Establish isolation zones
  - Nonintervention to allow the incident to run its course
  - Defensive tactics to protect exposures while a fire or reaction runs its course
  - Offensive tactics to control the hazard
  - Request additional personnel with higher levels of expertise or training

Additionally, there are other considerations relative to this incident that may be applicable for fire departments to implement.

Initial Operations and Establish Control Zones:

The frequency of flammable gas emergencies can create complacency for firefighters. Once the initial size-up is complete and the presence of a flammable gas is identified, isolation zones should be established to protect personnel and others in the area [Knapp 2017]. NFPA 1550 recommends emergency incident hazard control zones be established at every emergency incident to identify the level of risk to emergency responders and the appropriate level of PPE required for mitigation [NFPA 1550 2024]. Control zones are divided into three hazard levels:

- Hot zone – potentially dangerous area surrounding the incident
- Warm zone – area adjoining hot zone buffer between hot and cold zones for decontamination
- Cold zone – area considered safe, utilized for staging and command post

In this incident, personnel utilized the ERG to identify and implement a control zone for their apparatus but not personnel operating on-scene.

Air Monitoring Equipment Maintenance and Training:

Fire departments often respond to flammable gas leaks. Air monitoring equipment, such as gas meters, are an essential tool for helping to establish whether it is safe to enter an area or structure when a leak is suspected. This equipment requires routine maintenance and frequent calibration, per manufacturers' recommendations, to maintain accuracy during use. Lack of calibration can result in incorrect readings and convey false confidence that a dangerous environment is safe. Firefighters should be thoroughly trained in the use of this equipment. Training should include information on understanding what the equipment will detect, interpreting the readings, any cross sensitivities, alarm points, proper sampling techniques, and limitations. Lack of understanding of or confidence in this equipment's use may delay

critical decisions and allow exposure to life threatening environments, such as those with the potential for explosion [Knapp 2017].

Sampling, Monitoring, and Detection:

All air monitoring tactics, such as sampling and detection, should be conducted in full PPE, including a SCBA. Monitoring should begin on the exterior of a structure to determine the level of the incident. LEL readings identify steps the IC should take to mitigate the incident (**see Table 5**). Personnel should not enter a structure with an elevated gas reading unless there is a life safety action to be performed, including rescue and evacuation. Once the life safety issue has been resolved, all personnel should be removed outside of the hot zone.

Table 5: Action for measured LEL readings

LEL PERCENTAGE	REQUIRED ACTION
10% or Less	Continue with caution to mitigate the hazard
10% to 25%	Continue to monitor in full protective equipment to determine the source of the gas.
25% or Greater	Immediately withdraw from the area to a designated cold zone, outside of the hot/blast zone. Request additional resources including the hazmat team and expand the incident command system.

Once sampling, monitoring, and detection has been conducted, the IC can determine the necessary tactics and resources to mitigate the incident which may include [Noll and Hildebrand 2014; Knapp 2017]:

- Current on-scene resources
- Additional agencies required to control the situation such as the utility company
- Units, technicians, or specialist level hazmat resources needed to control the incident

Recommendation #4: Ensure all firefighters and fire officers are trained in Mayday operations and management.

Discussion: Following the explosion, two firefighters were trapped in the basement under heavy debris along with rapidly escalating fire conditions. Both firefighters called multiple Maydays.

Firefighters should be trained in and have confidence in how to call a Mayday when in danger [IAFF 2010]. Any delay in calling a Mayday reduces the chance of survival and increases the risk to other

firefighters trying to rescue the "downed" firefighter. When a Mayday is transmitted, ICs have a very narrow window of opportunity to locate the lost, trapped, or injured member(s). The IC will need to restructure the strategy and tactics to include a priority rescue [NFPA 1550 2024]. A Mayday tactical worksheet can serve as a tailored guide to any fire department's Mayday procedures such as a reminder to prompt the firefighter to activate their emergency alert button for priority radio transmissions and other important items such as PASS activation, air status, and location information. This worksheet can be easily located on the back of a tactical worksheet to assist ICs in ensuring the necessary steps are taken to clear the Mayday as quickly and safely as possible. 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 [IAFF 2010; NIOSH 2024].

Recommendation #5: Develop and implement a professional development program that includes routine evaluation based upon rank and skill for all combination fire department personnel. Such a program should also promote resilience and safety communication during an incident.

Discussion: During the incident, the initial impressions offered the first arriving units an image of a routine response. The relaxed approach added an element of heightened stress when the perceived routine incident suddenly changed. The fire department involved in this incident maintains a combination fire and rescue system. Responses routinely consist of career and volunteer personnel working together on the same response unit. During this incident, the personnel on-scene had a wide range of training, experience, and skill level. The officers were unfamiliar with some of the personnel along with their training and skill level. Additionally, during the interviews by NIOSH investigators, some firefighters noted expressing concerns to on-scene supervisors. The firefighters felt the concerns were not taken into consideration, creating a level of frustration and discomfort.

Training protocols should be developed for rank and skill level in combination fire departments, regardless of career or volunteer status. The implementation of an education, training, and professional development program can aid in the prevention of injuries and fatalities in the fire service. It will provide technical and academic competencies, maintaining a balanced skill level for all personnel. It will ensure the introduction of the necessary knowledge, skills, and abilities to members who are new in their position as well as ongoing development of existing skills. Fire departments should understand that training should incorporate both technical skill and hands-on task completion, while also addressing academic knowledge and the understanding of "why" things are happening. Combination fire departments can offer training that can be attended by both career and volunteer firefighters. When these firefighters train together, it facilitates communication and a greater understanding of the skills each firefighter.

Finally, preparing members to face these high stress incidents can support readiness to withstand the effects of stress when dealing with high-risk emergency incidents. Fire departments should provide training to all members in an understanding of how emergency incidents may cause rapid spikes in stress, the effects of stress on performance and how to confront operational stress. Organizations such as the National Volunteer Fire Council suggest that fire departments create and maintain an environment that promotes resilience [NVFC 2021; Panel 2022].

Volunteer Firefighter Dies when Propane from an Underground Tank Leaked into a Residential Home causing a Catastrophic Explosion – Virginia

The fire service has a long history of tradition and one of those traditions is that personnel are expected to prove themselves and build knowledge and experience. The challenge to provide personnel with the ability to express themselves and speak up about events involving safety demands strong leadership that is not intimidated by tradition and bias. Safety on the fireground requires all personnel to maintain a strong situation awareness and communicate their observation to supervisor to allow for good tactical decisions, along with continue to understand the evolving conditions that rapidly change during emergency operations. Empowering personnel to offer suggestions, ideas and make decisions shows a level of trust that prevents personnel from avoiding critical information, which may resonate into providing information that may avoid injuries and death in hazardous environments.

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Investigator Information

This incident was investigated by Louis (Rick) Lago, Investigator, and Tammy L. Schaeffer, Investigator, with the Fire Fighter Fatality Investigation and Prevention Program, Surveillance and Field Investigations Branch, Division of Safety Research, NIOSH located in Morgantown, WV. This investigation report was authored by Louis (Rick) Lago and Dr. Wesley R. Attwood, Investigator and Program Advisor, with the Fire Fighter Fatality Investigation and Prevention Program, Surveillance and Field Investigations Branch, Division of Safety Research, NIOSH. A subject matter expert review was provided by Jerry Knapp, Chief, Rockland County, New York, Hazardous Materials Team.

Additional Information

Underwriters Laboratories (UL)
The Fire Safety Research Institute (FSRI), part of the UL Research Institutes, continues to work with fire departments and fire service organizations to conduct research on fire dynamics, fire safety issues, and fire ground operations. Access to reports from completed studies and information from on-going studies can be found at https://fsri.org. Access to free online training on evidence-based firefighting (more than 30 course modules in all) can be found at https://training.fsri.org.

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. *NIOSH Approved is a certification mark of the U.S. Department of Health and Human Services (HHS) registered in the United States and several international jurisdictions.*