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Death in the line of duty...

National Institute for Occupational Safety and Health NIOSH

A report from the NIOSH Fire Fighter Fatality Investigation and Prevention Program

August 15, 2020

One Firefighter Killed and Two Firefighters Injured in Fire Apparatus Crash —Mississippi

Executive Summary

On September 9, 2016 a 40- year-old firefighter was killed, and two firefighters were seriously injured when their fire apparatus left the roadway, rolled over, flipped and crashed into a ditch.

The fire apparatus (Engine 3) was responding to a reported camper trailer fire in their first due response area along with another Engine (Engine 1), a Rescue truck (Rescue 1) and a Battalion Chief (Battalion 1). During the response, Engine 3's crew realized a mistake in the response destination and adjusted their response route to the site of the reported camper trailer fire.

Engine 3 left the roadway and crashed into a large ditch on the right side on the roadway. *(Photo by NIOSH)*

The second due engine company would now arrive first. While continuing their response, Engine 3 entered a left curve on a two-lane city/county roadway and ran off the road after coming out of the curve. It then crashed into a large ditch on the right hand side of the roadway, rolled, and then flipped end over end. The driver, Captain, and jump-seat firefighter were all ejected from the apparatus. The Captain and jump-seat firefighter (firefighter 2) were treated and transported to a local hospitals. The Captain was then flown by air ambulance to a trauma hospital. The driver was pronounced dead at the scene.

Contributing Factors

- *Excessive speed and lack of control of the vehicle*
- *Driver experience and training*
- *Exiting curve on a narrow roadway with minimal shoulder and deep ditch*
- *Age of the fire apparatus*

- *Initial misidentification of the address of the emergency incident.*

Key Recommendations

- *Fire departments should ensure that fire equipment driver/operators are trained and proficient in techniques to keep control of the emergency vehicle at all times and reduce speed when necessary.*
- *Fire departments should ensure that fire equipment driver/operators have experience and specific training and proficiency in the class of vehicle that they are expected to operate prior to responding in an emergency mode.*
- *Fire departments should ensure that fire equipment driver/operators have the necessary experience and training in assigned areas before they are allowed to drive apparatus in emergency conditions.*
- *Fire departments should consider including rollover protection for the crew areas of fire apparatus when upgrading or purchasing new apparatus to improve crashworthiness for firefighter survivability in rollover crashes.*

Additionally, governing municipalities (federal, state, regional, and local) should:

- *Consider options to reduce dangerous road conditions including reducing approach speeds, adding additional guardrail shoulder protection in curves, increasing the hard shoulder in problem areas and implementing other roadway engineering solutions.*
- *Consider upgrading dispatch capabilities to provide map cross reference grids to aid responding companies in locating street addresses.*

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Introduction

On September 9, 2016 a 40-year-old firefighter was killed, and two firefighters were injured when their fire apparatus crashed responding to a reported camper trailer fire. On September 12, 2016, the U.S. Fire Administration notified the National Institute for Occupational Safety and Health (NIOSH) of this incident. On October 31- November 4, 2016, an investigator/safety and occupational health specialist from the NIOSH Firefighter Fatality Investigation and Prevention Program in Morgantown, West Virginia, traveled to Mississippi to investigate this incident. The NIOSH investigator conducted an opening meeting with the fire chief, assistant fire chief, officers and firefighters of the involved department and members of the local IAFF union. The NIOSH investigator conducted interviews with the officer of the engine and with officers and firefighters of the involved departments who responded to the apparatus crash. The NIOSH investigator also visited the incident scene and met with personnel from the Mississippi State Fire Academy.

The NIOSH investigator reviewed the local police accident report, the medical examiner's report, the fire department's standard operating guidelines, the apparatus maintenance records, and the victim's training records.

Fire Department and Equipment

The victim's department is a career department that protects approximately 40,000 residents in 45 square miles with 8 stations with 8 engines (2 of the engines are combination quints) and 1 ladder (platform), and 1 heavy rescue truck. The department has 122 uniformed personnel (with 108 of those in suppression). Operational firefighters work a 24-on-48-off work schedule with a 56-hour work week.

The department has 1 operational battalion chief on duty each shift with a staffing of 36 firefighters per shift and a minimum staffing level of 31 per shift. The department does not have ambulance transport responsibilities but does provide first responder assistance delivered off the fire apparatus. They respond to approximately 2,500-3,000 fire and EMS calls per year.

Engine 3 was a 1997, 4 door, 6 person, 2 axle cab custom pumper chassis with a 1,000 gallon baffled, poly water tank, and a 1,500 gallon-per-minute pump. The gross vehicle weight rating (GVWR) was 42,740 pounds with 18,740 on the front axle and 24,000 on the rear. The weight of Engine 3 with water was noted on the chassis file sheet as 34,700 pounds. This truck did not have an event data recorder and the speed of the truck just prior to the crash was not recorded or known.

The local police department and the fire department did not report finding any mechanical issues with the truck post-crash. There were no reported fire department operator complaints concerning Engine 3. Extensive maintenance records for Engine 3 were made available to NIOSH.

Training and Experience

The fire department requires new career firefighter applicants to attend a recruit school approved by the Mississippi State Fire Academy. Prior to the academy, this participating fire department has a two week (40 hours per week) period where the recruits are given local training on the department's standard operating procedures (SOPs) and rules and regulations of employment. A new firefighter must then pass a preplacement physical and a drug screening. The firefighter then attends the 8-10 week State Fire Academy recruit school (delivered in the locality) to be trained to the NFPA 1001 Firefighter I and II levels. After the academy, the recruit will travel to the State Fire Academy to take the state tests. The State requires career firefighter candidates to meet the State Minimum Standards and Certification Board guidelines, which are equal to the National Fire Protection Association (NFPA) 1001, *Standard for Fire Fighter Professional Qualifications* [NFPA 2013a].

The candidate graduates from the academy with Firefighter I and II certifications. After graduation and assignment to the field, the firefighter is then on probation for 1 year. After completion of their first year, the firefighter attends a driver's school through a field delivery by the State Fire Academy authorized personnel. After 2 years with driver-operator certification, a Captain can submit the firefighter's name for promotion to senior firefighter, which allows them to drive. During the 2 year period, firefighters may perform driver training and non-emergency driving to gain experience.

The senior firefighter classification is for driver-operators of fire apparatus and other emergency vehicles. In addition to regular firefighting duties, a senior firefighter is also expected to assist in training new and existing firefighters on the importance of equipment and station maintenance. The minimum qualifications for a senior firefighter are vocational training in firefighting techniques and emergency medical assistance, supplemented by 1 year of previous experience and/or training involving fire suppression, safety and emergency medical care or any equivalent combination. Senior firefighters have to maintain their firefighting certifications and a valid driver's license along with CPR and emergency response certification.

The victim was assigned to Station 1 in November of 2013 after completing training. He was promoted to senior firefighter (driver/operator) on November 25, 2015. He was assigned to station 3 in March 2016 and began driving Engine 3 in May 2016. The crash occurred on September 9, 2016. The department told the NIOSH investigator that he had driven Engine 3 for approximately 4.5 months on 57 emergency incidents. Prior to that he had driven Engine 1 for approximately 1 month on 7 incidents and Rescue 1 on 7 incidents in a 2-3 month period.

The victim had completed the following training and records and certificates were in his training file:

- NFPA 1001- Firefighter I and II, 262 hours completed January 2014

- Hazmat NFPA 472 Awareness and Operations level 32 hours completed January 2014
- NFPA 1002- Driver/Operator, Pumper Apparatus 80 hours completed September 2015
- National Incident Management System (NIMS) 100, 200 700 completed January 2014
- Station level training hours documented in 2014 (468 hours); 2015 (478.5 hours); and 2016 (409 hours)
- In-service training on SCBA and RIT (1 hour), LP Gas training live fire drill (6 hours), CPR certification.

Timeline

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

- **0854 Hours.** 911 Center received a phone call for a camper trailer on fire next door to the caller's location.
- **0855 Hours.** 911 Dispatched Engine 3 (first due), Engine 1, Rescue 1 and Battalion 1.
- **0856 Hours.** Engine 1, Rescue 1, Battalion 1 responded, Engine 3 responded and asked for a cross street for the address. Dispatcher provided a cross street on the radio.
- **0857-0904 Hours.** During the response, Engine 3 noted an address "cross up" and corrected their response, but now would not be first due.
- **0903 Hours.** Battalion 1 and Engine 1 arrived on the scene of the reported camper trailer fire and advised Engine 3 and Rescue 1 that they could disregard the call and return to the station. It was a trash fire and Engine 1 would extinguish.
- **0904 Hours.** Rescue 1 cleared the call for the reported camper trailer fire.
- **0904 Hours.** Phone call to dispatch advising of a "bad flip accident on Old 8th Street Rd." Caller stated it was a fire truck and to "get out here as quick as you can, that there is a fatality of a fireman."
- **0905 Hours.** Dispatcher tried to call Engine 3 twice on the radio. No response. Dispatch then sent Rescue 1 to an approximate location on Old 8th street for a report that Engine 3 flipped.

Rescue 1 responded. Dispatch advised all units to "step it up".

- **0907 Hours**. Battalion 1 arrived on the crash scene, also Chief's 1 and 2 responded.
- **0908 Hours**. Rescue 1 arrived on crash scene.
- **0909 Hours**. Battalion 1 requested multiple metro units (rescue/ambulance).
- **0913 Hours.** Engine 1 cleared from the reported camping trailer on fire call and responded to the Engine 3 crash scene.
- **0915 Hours.** Additional metro resources (rescue/ambulance) arrived.
- **0916 Hours.** On scene rescue units requested alert for head trauma patient.
- **1013 Hours**. Fire Department units clear the scene.

Note: The medical examiner report noted that the victim was pronounced dead at the scene from massive chest trauma at 0909 hours.

Weather and Road Conditions

On September 9, 2016, just prior to the original dispatch, the local weather was reported as clear conditions. The local temperature was 79 degrees F, the dew point was 72 degrees and the local humidity was 79%. Visibility was reported as 10 miles with winds out of the south at 4.6 miles per hour [Weather Underground 2017].

The road surface was reported as dry. The shoulder of the road falls away significantly into a deep ditch after exiting the curve and beyond the guardrail (see Photo 1). The unrepaired guardrail damage in the photo was reported by police as previous damage not related to this incident. The two-lane roadway has a posted speed limit of 40 miles per hour in this area and no recommended reduction in speed for the curve. There are curve-ahead warning signs in both directions approaching the curve. The local news, citing police sources, reported that several crashes had occurred on that stretch of roadway since 2006 claiming two lives.

Investigation

On September 9, 2016, at approximately 0906 hours (approximately 2 hours into their shift), a camper trailer fire was reported and assigned to Engine 3. Engine 3 was dispatched along with Engine 1 and a Battalion Chief. Engine 3 was heard on the radio asking for a cross street for the reported camper trailer fire address. The dispatcher provided the cross street and units responded.

During the response, the Engine 3 crew realized a mistake in their response destination and adjusted their response to the appropriate destination.

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Battalion 1 and Engine 1 arrived at the reported camper trailer fire scene and Battalion 1 cleared Engine 3 and Rescue 1 to return to the station.

After adjusting their response route, Engine 3 entered a left curve on a 2-lane asphalt roadway. They failed to turn with the roadway (West bound) and ran off the right side of the road hitting a speed limit sign after coming out of the curve (See Photo 1). The apparatus' right rear wheels were approximately 3 feet off the right side of the roadway and the driver was likely attempting to turn the truck back onto the roadway (See Photo 2). The Captain later indicated during NIOSH interviews that he thought he had told the driver to "get it back" or "get it over" meaning to get the Engine back on the roadway. The Captain didn't remember anything else after that until waking up in the hospital.

The roof of the cab of the truck was torn off and the 1,000 gallon water tank and multiple pieces of equipment and hose were separated from the truck, and scattered about the crash scene (See Photo 3).

The dispatcher received a phone call reporting a very bad crash involving a fire truck and the caller stated that it appeared a "fireman was dead and please hurry". The dispatcher tried to raise Engine 3 twice on the radio and then dispatched Rescue 1 to the crash site. Battalion 1 cleared and responded to the crash scene followed by Engine 1 a short time later.

Much of the following description is taken from the police accident reconstruction report. The reconstruction report noted that the truck failed to turn with the roadway running off the right edge of the roadway. According to the police report it appeared that the driver was attempting to turn the truck back onto the roadway with the right wheel approximately 3 feet off the roadway. The rear of Engine 3 then began to go down into the ditch. The right front wheel re-entered the roadway as the right rear of Engine 3 rotated counterclockwise. The Engine 3 rear wheels then dug into the ground and caused Engine 3 to begin rolling side to side (rolling clockwise). While still rolling and upside down, the rear portion of the apparatus on the driver's side struck a tree which caused the water tank to be knocked out of the bed of the truck. The impact with the tree had enough force and angle to cause Engine 3 to catapult end over end while still rolling over in a clockwise direction. During the end over end flipping, the passenger side front corner of Engine 3 struck the side of the berm "with such force that it caused the cab of the truck to pop off of the engine" (See Photos 4 and 5). According to the police accident reconstruction report, "This violently threw Engine 3 over the berm" (See Diagram 1).

The reconstruction report indicated that the driver and the jump-seat firefighter (firefighter 2) were ejected first during the rollover motion of the crash followed by the Captain being ejected. They landed in the wooded area beside the ditch and were seriously injured.

The Captain and firefighter 2 were treated and transported to local hospitals. The Captain was then flown by air ambulance to a trauma hospital. The driver was pronounced dead at the scene.

The local police department investigated the crash. Their crash report and accident reconstruction report were reviewed by the NIOSH investigator. The police report indicated lap and shoulder belt

usage by the driver and all passengers. However, the violent manner in which the roof was torn off the cab of Engine 3 made it difficult to confirm or comment on seat belt performance.

Photo 1. Engine 3 left the roadway on the right side on the roadway just passed the guard rail, leaving tire track markings on shoulder. The damage to guard rail is from a previous crash. ***(Photo by NIOSH)***

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Photo 2. Engine 3 ran off the right side of the road into the ditch and then struck the berm causing the truck to roll over and an end over end flip. ***(Photo by NIOSH)***

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Photo 3. Engine 3's water tank, hose and equipment that were ejected during the roll over and end over end flip. ***(Photo courtesy of the fire department)***

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Diagram 1. showing the direction of travel and area where the crash occurred. Not to scale. (Photo Courtesy of Google Earth/adaptation by NIOSH)

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Photo 4. Engine 3 position after rolling and flipping end over end. The roof of the cab was torn off in the crash and not cut off by emergency workers. ***(Photo courtesy of the fire department)***

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Photo 5. Engine 3 in the locality's storage facility after removal. Note that the damage shown in photo is not due to extrication procedures, rather from the rollover and end over end flipping. ***(Photo by NIOSH)***

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Contributing Factors

Occupational injuries and fatalities are often the result of one or more contributing factors or key events in a larger sequence of events that ultimately result in the injury or fatality. NIOSH investigators identified the following items as key contributing factors in this incident that ultimately led to the fatality:

- Excessive speed and lack of control of the vehicle
- Driver experience and training
- Exiting a curve on a narrow roadway with minimal shoulder and deep ditch
- Age of apparatus
- Initial misidentification of the address of the emergency incident.

Cause of Death

According to the state medical examiner, the victim's cause of death was massive chest trauma.

Recommendations

Recommendation #1: Fire departments should ensure that fire equipment driver/operators are trained and proficient in techniques to keep control of the emergency vehicle at all times and reduce speed when necessary.

Discussion: Fire apparatus driver/operators are responsible for safely transporting firefighters, apparatus, and equipment to and from the scene of an emergency or other calls for service. Crashes are second only to cardiac events as the leading cause of on-duty deaths of firefighters [Fahy 2019]. Under all circumstances, the fire apparatus driver/operator must exercise care for the safety of others and must maintain complete control of the vehicle [IFSTA 2006]. NFPA 1500 *Standard on Fire Department Occupational Safety and Health Program*, Chapter 6.2.4, states, "Drivers of fire apparatus shall be directly responsible for the safe and prudent operation of the vehicles under all conditions." [NFPA 1500b] The International Association of Fire Chiefs provides a *Guide to IAFC Model Policies and Procedures for Emergency Vehicle Safety* [IAFC 2009].

Many human elements can be involved in failing to maintain the safe control of fire apparatus while responding to an alarm. NFPA 1500 *Standard on Fire Department Safety and Health Program* [NFPA 2013b] and NFPA 1002 *Standard for Fire Apparatus Driver/Operator Professional Qualifications* [NFPA 2003] describe the requisite knowledge and skills individuals need to be a driver/operator. These include intersection practices, preventive maintenance inspections, and demonstration of the proper operation of an apparatus under a variety of conditions.

Insufficient training, excessive speed, inexperience with the apparatus, failure to recognize a dangerous situation, overconfidence in one's driving ability, a sense of urgency, and poor driving habits are some of the human elements that firefighters and officers have a shared responsibility to understand and train to avoid [NIOSH 2012]. According to the United States Fire Administration's *Safe Operation of Fire*

Tankers [USFA 2009] a significant percentage of crashes involving fire department tankers is attributed to the vehicle being driven at a speed that is excessive for the given conditions.

According to the United States Department of Transportation, National Highway Traffic Safety Administration, "a vehicle in transport sometimes leaves the travel lane and encroaches onto the shoulder, median, roadside, parking lane or a separator and hits one or more natural or artificial objects. This event usually involves a single vehicle and is referred to as a run-off-road crash (ROR). ROR crashes account for a significant percentage (around 70%) of all fatal single-vehicle crashes. Curved road segments, rural roads, high-speed-limit roadways and roadways with fewer lanes are found to be more likely to be involved in fatal single vehicle ROR crashes" [NHTSA 2009].

In this incident, Engine 3 entered a left curve on a 2-lane asphalt roadway, failed to turn with the roadway (West bound), and ran off the right side of the road hitting a speed limit sign after coming out of the curve (See Photo 1). The apparatus' right rear wheels were approximately 3 feet off the right side of the roadway and the driver was likely attempting to turn the truck back onto the roadway.

It is important to note that driving an emergency vehicle always requires the driver/operator to remain focused during the response. Driver/operators and officers riding up front should understand that there are many factors that could possibly cause an adrenaline rush and other factors that could cause an adverse reaction such as increasing the vehicle speed or losing control. Emergency vehicle driving experience is critical to learning to control emotional actions that may lead to excessive speed or driving on the edge of full vehicle control. The experience of the driver and officer riding up front are very important to establish the safe operation of emergency vehicle fleets. When there are gaps in the experience levels, departments should consider other control measures for emergency response safety such as an increase in practical training and more comprehensive SOPs.

Recommendation #2: Fire departments should ensure that driver/operators have experience, specific training, and proficiency in the class of vehicle that they are expected to operate prior to responding in an emergency mode.

Discussion: While some firefighters may have adequate training to operate a specific piece of fire apparatus, they can still lack adequate experience and the proficiency needed for the class of vehicle they operate on any particular response. As an example, a brush truck, ambulance or a SUV will handle significantly different than a fire pumper with 500, 1000 or 1500-gallon water tank, and they handle much differently than a tanker or ladder truck. Each type of apparatus may have individual characteristics that vary with the age, manufacturer, and other factors.

Drivers should have sufficient experience and be proficient with the class of vehicle they are expected to operate. They should train under a variety of conditions at slower speeds, in areas and conditions similar to those expected. This experience is gained under non-emergency conditions with a trained supervisor or instructor. Speed may then be increased as the driver becomes more proficient with the apparatus. This experience should be in a non-emergency mode and measured and evaluated by

supervisors or designated trainers. Additional training or skill building may be required with different classes of vehicles or new response areas.

Difficult road conditions in the expected routes of travel should be experienced by the driver at slower speeds in a non-emergency mode so he/she will be familiar with the handling characteristics of that particular apparatus before being allowed to drive at a higher rate of speed in an emergency-response mode. Experience handling the heavy class of apparatus should be gained at slow speeds and training in those areas of their response territory should emphasize the importance of maintaining control first and foremost by reducing speed. Specific training should point out the dangers of speed and benefits of slowing down and maintaining control. As an example, if a fire apparatus was responding at 40 miles per hour verses 50 miles per hour on a 2-mile section of highway, the slower response only adds 25 seconds to the response [IAFC 2009].

Driving and operating a heavy class of apparatus to an emergency requires extensive skillsets beyond those needed to drive a light duty SUV or utility vehicle. The driver/operator position should be a recognized and developed position that candidates should train for and gain experience to achieve this promotion (whether the promotion is formalized or an informal experience-based promotion). A firefighter's results from a driver training and experience program can then be evaluated and used to determine appropriate promotion to the level of apparatus driver/operator.

Drivers who don't attain or retain the requisite skills and proficiency in a specific class of vehicle should not be allowed to operate vehicles in an emergency mode. If proficiency is not achieved in a class of emergency response vehicle, the driver operator or candidate should be sent back to the beginning of the training program to start over in a less challenging class of apparatus.

In this incident, the victim was assigned to this station in March 2016. He had driven Engine 3 for approximately 4.5 months on 57 emergency incidents. He began driving this apparatus in May 2016 and the crash occurred on September 9, 2016. The victim and officer had worked together since March 2016.

Recommendation #3: Fire departments should ensure that fire equipment driver/operators have the necessary experience and training in assigned areas before they are allowed to drive apparatus in emergency conditions.

Discussion: Fire departments should provide additional training on handling fire apparatus in difficult road conditions that may be specific to an assigned response area. Difficult road conditions are frequently encountered during emergency response and can contribute to an unexpected loss of control of an apparatus. Difficult road conditions can include:

• Sharp curves and grade changes in roadway and steep grades

• Grade changes at intersections

• Complex intersections

• Reduced visibility

• Narrow secondary roadways

• Crowned roadways

• Roadway surface conditions

• Limited access and high traffic

• Railroad crossings

• Weather

In this incident, the difficult road conditions encountered were a left curve after a bridge with very little shoulder and a very large ditch. This required a slowed controlled response after transitioning from a straight two lane 45 mile-per-hour roadway into the curve. There is very little roadway shoulder and recovery area in the area where the crash occurred. Although there were curve-ahead warning signs in both directions approaching the curve, there was no recommended reduction in speed for the curve. It was reported to the NIOSH investigator that there had been numerous crashes at this location in the past and in fact the guard rail showed evidence of a recent crash in the same curve area as this crash (See Photo 1).

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Photo 6. Overview of Crash Site, courtesy Google Earth.

Photo 7. Curve ahead sign, but no recommended reduction in speed limit for the curve, courtesy Google Earth.

Recommendation #4: Fire departments should consider rollover protection for the crew areas of fire apparatus when upgrading or purchasing new apparatus.

Discussion: Fire departments should consider rollover and crash avoidance/protection systems when upgrading or purchasing new fire apparatus. Many features are available that can add to the safety of firefighters involved in crashes. Many of the new rollover protection components are integrated systems designed to increase protection for the firefighters riding inside the apparatus. Strengthened cabs, combined with roll protection systems that sense the moment a vehicle is in a side roll, provide passenger protection through air bag systems and automatic seat belt pre-tensioners that retract the seat downward to increase the clearance between the firefighter's head and the ceiling of the apparatus and therefore improve survivability.

In this incident, the fire truck was a 1997, four-door custom chassis that met all of the minimum requirements for fire truck safety standards and design in effect on the date of manufacture. It did not have rollover protection such as air bags, curtains, strengthened compartmentation or other protective measures noted above. This 1997 model engine was approaching the end of its 25-year life cycle recommended by NFPA 1911 [NFPA 2017].

Recommendation #5: Fire apparatus manufacturers, researchers, and standard setting bodies should continue to improve crashworthiness for firefighter survivability in rollover crashes.

Discussion: The minimum requirements for crashworthiness in rollover incidents should be improved to increase firefighter survival in rollover crashes. Minimum cab roof strength should be reviewed and evaluated with other protection systems to prevent cab intrusion into the passenger compartments. Rollover fatalities and injuries in the fire service may be reduced by increasing the crash worthiness of fire apparatus. NFPA 1901, annex A,1 section A.14.3.2 notes, "The U.S. standards developed by SAE and the United Nations ECE regulation mirror each other except that SAE J2422 requires a roof preload impact prior to the roof crush. The ECE standard was established in 1958, while the SAE standards did not add performance criteria until 2003. Both the SAE and ECE standards are viable minimum measures of cab integrity. Manufacturers may test in excess of the standards" [NFPA 2009].

Section A.4.13.1 of NFPA 1901, annex A1 notes, "Several features and factors affect vehicle safety in a rollover.

• Custom Fire Apparatus Cab. The nature of the custom fire apparatus cab makes it much stronger in rollover than typical conventional commercial cabs. There is much anecdotal evidence to indicate that the crashworthiness of a typical custom fire apparatus cab is significantly greater than a typical commercial cab, and most custom chassis manufacturers can provide test data on cab integrity (The engine involved in this incident was a Custom Fire Apparatus).

• Lateral Acceleration Alert Device. There are both mechanical and electronic devices available that will measure the lateral acceleration of a vehicle. Although these devices will not prevent rollover, they can be used effectively as a driver training tool to indicate when the vehicle is

approaching the rollover threshold and as a reminder to the driver that excessive lateral acceleration can lead to a rollover event.

• Side Roll Protection. Many custom fire apparatus manufactures offer side air bags or curtains that inflate during a roll event and that are usually combined with seat belt pre-tensioning devices and suspension seat pull-down devices. This option can reduce injury during a rollover as long as the occupants are seated and belted.

• Electronic Stability Control (ESC). ESC uses a steering wheel position sensor, a vehicle yaw sensor, a lateral accelerometer, and individual wheel brake controls in conjunction with the antilock brake system (ABS). The system tracks the direction that the driver intends to steer and uses brake application at individual wheels to help straighten out the vehicle to reduce the potential for a rollover event.

• Driver Skill and Experience. While the design and features of the vehicle are important to safe driving, the most important aspect of crash prevention is the skill and experience of the operator. The operator's training, experience, qualifications, and the application of those qualities are the most important elements in crash prevention. The operator must ensure that the physical limits of the vehicle are not exceeded. Driver skill is developed only through training and practice" [NIOSH 2009].

In this incident, the fire truck was a 1997, four-door custom chassis that met all of the minimum requirements for fire truck safety standards and design in effect on the date of manufacture. It did not have rollover protection such as air bags, curtains, strengthened compartmentation or other protective measures noted above. This 1997 model engine was approaching the end of its 25-year life cycle recommended by NFPA 1911 [NFPA 2017].

Recommendation#6: Fire apparatus manufacturers, researchers, and standard setting bodies should continue to evaluate apparatus seating and seat belt design to ensure that riding positions and seat belts are comfortable and effective for firefighters wearing personal protective equipment.

Discussion: Fire apparatus manufacturers, researchers, and standard setting bodies should continue to evaluate apparatus seating and seat belt design to ensure that riding positions and seat belts for those positions are sized to accommodate firefighters clothed in personal protective gear and the seat belts are easy to wear and effective.

Firetruck crashes, occurring at a rate of approximately 30,000 crashes per year, have potentially dire consequences for the vehicle occupants and for the community if the firetruck was traveling to provide emergency services. Data from the United States Fire Administration and the National Highway Traffic Safety Administration shows that firefighters neglect to buckle their seatbelts while traveling in a fire apparatus, thus putting themselves at a high risk for injuries if the truck crashes, especially in rollover crashes. Despite national regulations and departmental guidelines aiming to improve safety

on fire apparatuses, belt use among firefighters remains dangerously low. The results from this study indicate that further steps need to be taken to improve belt use. One promising solution would be to redesign firetruck seatbelts to improve the ease of buckling and to accommodate wider variations in firefighter sizes [NIH 2012].

NIOSH has conducted research and produced anthropometric information (body dimensions) of the U.S. firefighter population that can be used for ergonomic and safety specifications for fire apparatus and firefighter protective equipment. "Collection of Anthropometric Information on Firefighters for Fire Apparatus Design and Standards " These data can be used to design fire and rescue equipment and cabs in the apparatus.

Recommendation #7: Fire departments should consider upgrading older fire apparatus in accordance with NFPA 1912 Standard for Fire Apparatus Refurbishing [NFPA 2006] and retiring or replacing older apparatus in accordance with current standards such as NFPA 1901 Standard for Automotive Fire Apparatus [NFPA 2009].

Discussion: To maximize firefighter safety as well as the safety of the traveling public, fire apparatus should be equipped with the latest safety features and rollover protection for firefighters. In the last 15 to 20 years, much progress has been made in upgrading the safety features and capabilities of fire apparatus. Fire departments should also consider retiring apparatus sooner if the apparatus becomes obsolete or unreliable due to age or use [NIOSH 2011].

Fire departments should consider rollover and crash avoidance/protection systems when upgrading or purchasing new fire apparatus. There are many features available that can add to the safety of firefighters that are involved in crashes. Many of the new rollover protection components are integrated systems designed to increase protection for the firefighters riding inside the apparatus. Strengthened cabs, combined with roll protection systems that sense the moment a vehicle is in a side roll, provide passenger protection through air bag systems and automatic seat belt pretensioners that retract the seat downward to increase the clearance between the firefighter's head and the ceiling of the apparatus and therefore improve survivability [NIOSH 2009].

In this incident, the fire truck was a 1997, four-door custom chassis that met all of the minimum requirements for fire truck safety standards and design in effect on the date of manufacture. It did not have rollover protection such as air bags, curtains, strengthened compartmentation or other protective measures noted above. This 1997 model engine was approaching the end of its 25-year life cycle recommended by NFPA.

Recommendation #8: Fire departments and emergency response organizations should train driver/operators to recognize and control stimuli that may increase adrenaline and lead to driving too fast and losing control.

Discussion: Although there is no evidence that the following recommendation would have prevented this fatality, it is being provided as a reminder of best safety practice for the fire service.

A Mayday or urgent radio traffic, officer or firefighter in-trouble codes or signals, reports of explosions, victims trapped or even working fires can cause emergency responders to have an increased adrenaline response. Recognizing these stimuli can allow emergency equipment drivers and their officers to react to refocus on the first requirement of responding safely.

An adrenaline response can be even more common among less experienced firefighters and officers. It is important to train drivers and officers to recognize the stimuli and control the response that naturally guides them to push harder on the right pedal. This can occur in all emergency response organizations and needs to be a consistent part of driver/operator training programs.

Every emergency call is urgent and experienced fire officers and firefighters know that the most important function of the emergency apparatus is to arrive safely. It is very important that officers and senior firefighters realize that newer firefighters need to understand and recognize how adrenaline or heightened anxiety levels can affect their response to an action. Officers and senior firefighters should communicate calmly with his/her crew members during a response to help control adrenaline responses from stimuli such as emergency lights and sirens, working fire reports, Mayday or urgent radio traffic, on scene reports or status reports heard through the radio that may add to the driver's sense of urgency [NIOSH 2011]. Even responding to the wrong address and having to re-route can add to a driver's adrenaline if they perceive an embarrassing out of order arrival sequence.

A clear calming instruction (through crew head-sets) during a challenging response condition can slow and help control a response, especially with less experienced personnel. Although there is no evidence that an adrenaline rush or heightened anxiety level affected this incident, it is being pointed out as a reminder of best safety practice for the fire service.

As stated earlier, drivers that don't attain or retain the requisite skills and proficiency in a specific class of vehicle should not be allowed to operate in an emergency mode. The requisite skills for driving and operating in an emergency mode are significantly more challenging than non-emergency driving. Although the physical driver actions are very similar, the awareness and cognitive focus can easily be distracted during an emergency response and a learned response gained through experience can de-escalate a heightened reaction. A calming instruction and/or reminder from crew members will allow all members to focus on the objective.

Recommendation #9: Fire departments should develop, train on, and enforce SOPs that require seat belts to be used at all times the vehicle is in motion to increase the opportunity to survive a rollover crash.

Discussion: Although there is no evidence that the following recommendation would have prevented this fatality, it is being provided as a reminder of a best safety practice for the fire service. Vehicle

crashes are the second leading cause of firefighter line-of-duty deaths [NIOSH 2012]. The use of seat belts along with modern fire apparatus safety features can help increase the survivability in a roll over crash. Although modern fire apparatus may provide better crash worthiness, firefighters still need to be belted securely in the apparatus.

The officer and the driver/operator must always ensure the safety of all personnel riding on the apparatus. NFPA 1500 *Standard on Fire Department Occupational Safety and Health Program* states, "all persons riding in fire apparatus shall be seated and belted securely by seat belts in approved riding positions at any time the vehicle is in motion." NFPA 1500 also states that "drivers shall not move fire apparatus until all persons on the vehicle are seated and secured with seat belts in approved riding positions". Additionally, "while the vehicle is in motion, the donning or doffing of equipment and personal protective clothing that requires removal of any restraining belt or other device shall be prohibited. Seat belts shall not be released or loosened for any purpose while the vehicle is in motion, including the donning of respiratory protection equipment or protective clothing" [NFPA 2013 b].

The department in this incident did have an SOP requiring seat belt usage (by drivers and passengers) when this incident occurred. The police report indicated lap and shoulder belt usage by the driver and all passengers. However, the violent manner in which the roof was torn off the cab of Engine 3 made it difficult to confirm or comment on seat belt performance. All 3 firefighters including the victim were ejected (see Photo 5). Fire departments should continue to enforce seatbelt requirements as they are a proven method to increase survivability in fire truck rollovers and crashes along with newer emergency apparatus safety features.

Additionally, governing municipalities (federal, state, regional, and local) should:

Recommendation #10: Consider options to reduce dangerous roadway conditions including reducing the approach speeds, adding additional guardrail shoulder protection in curves, increasing the hard shoulder in problem areas, and implementing other roadway engineering solutions.

Discussion: Authorities having jurisdiction should consider options such as recommended safe speed advisories for dangerous curves and/or conditions in roadways. Additional measures can also include extending guardrails (especially in situations where there is little or no shoulder) to keep vehicles from sliding down into a ditch if they were to run off the roadway. Rumble strips can also be used to provide an alert to drivers that they have or are getting ready to leave the roadway or crossing over the center of the roadway. The local news reported numerous crashes at the curve involved in this incident and the guardrail showed damage from a recent crash (See Photo 1).

Recommendation #11: Consider upgrading dispatch capabilities to provide map cross reference grids to aid responding companies in locating street addresses.

Discussion: Emergency services dispatching agencies should consider upgrading capabilities that would include response assistance to quickly locate a reported emergency on a mapping system and recommended routing to fire, rescue and police units. The use of map coordinates can provide a smaller area of a map grid to look for a particular address and corresponding approach routes.

Additionally, there are new technologies that include automatic vehicle location (AVL) systems that identify where units are located and which units may be closer to an incident. They can also provide route guidance to individual responding units.

In this incident, Engine 3 was dispatched to a reported camper trailer on fire with Engine 1, Rescue 1, and the Battalion Chief. While enroute, Engine 3 experienced a mix-up in the destination with a very similar sounding street name and had to adjust their response to the correct location. Upgraded dispatch capabilities including AVL, map coordinates and routing guides can help to remove a response error to a street that may phonetically sound similar (especially with different speakers and radio distortion).

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Investigator Information

This incident was investigated by Stephen T. Miles, Investigator/Safety and Occupational Health Specialist, with the Fire Fighter Fatality Investigation and Prevention Program, Surveillance and Field

Investigations Branch, Division of Safety Research, NIOSH located in Morgantown, West Virginia. An expert technical review was provided by Chief Michael Barakey, Fire Chief, Suffolk, (VA) Department of Fire & Rescue, and retired District Chief of the Virginia Beach Fire Department. A technical review was also provided by the National Fire Protection Association, Public Fire Protection Division.

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