1000 FREDERICK LANE, MORGANTOWN, WV 26508 · 304.285.5916

Firefighter dies from head injury during tire inflation – Louisiana

Executive Summary

On December 18, 2021, a 28-year-old career firefighter died from head injuries incurred when a tire bead came off the wheel rim with great force during vehicle maintenance operations. Firefighter 4 (deceased firefighter) was assigned to Station 4. He began his shift by performing apparatus checks. During a check of Engine 4, he checked and inflated the tires to ensure they were all above 95 psi. At 08:30 hours, firefighter 4 called the shift captain to notify him that he was bringing Engine 4 to Station 1 to check and inflate the tires. Upon arriving, he parked Engine 4 in front of bay 1. Firefighter 4 connected a pre-connected 100 ft air line from the external fill port of the station's cascade system to the tires. The regulator for the cascade was set to around 100 psi. Firefighter 4 also secured a manual tire gauge and an air chuck. The air chuck was connected to the airline.

Photo 1: Apparatus tire that came off the wheel rim while being refilled with air.
(Courtesy of the fire department)

The shift captain arrived to assist in checking and inflating the tires. The captain started inflating the front passenger side tire. Firefighter 4 then took over inflating the passenger side rear tires. During inflation, each tire was checked with the manual tire gauge to ensure each was above 95 psi. Both firefighters moved to the driver's side tires after completing the passenger side tires. Upon checking the outer dual configuration tire on the driver's side rear, firefighter 4 noted that the pressure was only 50 psi. He began to inflate the tire by sitting on the ground directly in front of it and holding the air chuck onto the tire valve stem.

After a short amount of time inflating, the tire bead came off the wheel rim with great force which launched the simulator/hubcap as a projectile hitting firefighter 4 in the forehead. Firefighter 4 was

thrown back about 30 ft from Engine 4. Upon witnessing the incident, the shift captain promptly contacted the parish public safety answering point and requested a medic unit and a medical helicopter be dispatched to their location. The captain and another firefighter rendered medical aid to firefighter 4 who was unconscious and bleeding from the head. Firefighter 4 was transported to a local hospital and pronounced deceased.

Contributing Factors

- *Procedure and equipment for inspecting and inflating apparatus tires*
- *Training on daily/weekly visual and operational checks of apparatus*

Key Recommendations

For fire departments:

- *Ensure that firefighters have access to and use appropriate equipment and safe operating procedures to inspect and inflate apparatus tires.*
- *Ensure firefighters are trained on how to conduct daily/weekly visual and operational checks of apparatus.*

For fire service training organizations and fire academies (federal, state, regional/county, and local):

- *Add information about tire explosion hazards and provide hands-on training for safe inspection and inflation of apparatus tires in driver/operator and maintenance training programs and publications.*

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 December 18, 2021, a 28-year-old career firefighter died from head injuries incurred when a tire bead came off the wheel rim with great force during vehicle maintenance operations. On December 20, 2021, the U.S. Fire Administration (USFA) notified the National Institute for Occupational Safety and Health (NIOSH) of this incident. An investigator representing the NIOSH Fire Fighter Fatality Investigation and Prevention Program (FFFIPP) conducted interviews with fire officers, firefighters, law enforcement, and other emergency personnel who were on-scene at the time of the incident. The investigator also reviewed fire department standard operating procedures (SOPs), training records, witness statements, investigation documents, and the Coroner's Office report.

Fire Department

The combination fire department in this incident is a fire district that has a 172 square mile jurisdiction, serves a population of 7,000 residents, annually responds to an average of 984 calls, and provides emergency medical services (EMS). The fire department maintains six stations. Stations 1 and 4 are staffed with career firefighters for 24/7 coverage.

The fire department is comprised of 13 full-time and 30 part-time career firefighters as well as 40 volunteer firefighters. The full-time firefighters are organized into three shifts: A, B, and C. Each shift is assigned a captain and two firefighters. Shifts operate on a 24-hour schedule. The fire department also consists of a fire chief, deputy chief, chief of training, chief of EMS, an administrative assistant, a fire department mechanic, and three volunteer captains.

Training, Education, and Professional Development

The fire department maintains qualification requirements for all full-time firefighting positions. At minimum, a full-time career firefighter is required to obtain Fire Fighter I, Fire Fighter II, Fire Apparatus Driver/Operator, and Emergency Medical Technician within the first 24 months from their hiring date. The fire department also provides a two-week orientation which includes information on apparatus checks and how to report mechanical issues.

Firefighter 4 (deceased firefighter) was hired by the fire department in 2019. He maintained numerous International Fire Services Accreditation Congress (IFSAC) certifications such as Fire Fighter I, Fire Fighter II, Fire and Emergency Services Instructor I, Fire Officer I, Fire Apparatus Driver/Operator – Pumper, Hazmat Awareness, and Hazmat Operations. Between January 2020 and December 2021, he attended 163 in-house professional development trainings consisting of 305 hours on various topics such

as jurisdiction familiarization, driver training, EMS protocols, and firefighting equipment. This also included knowledge and skills assessments on preventative maintenance of apparatus such as checking tires for pressure and wear.

Apparatus, Maintenance, and Tire

On December 18, 2021, firefighter 4 was assigned to Station 4. This station maintained an engine, tanker, brush truck, and a squad. Firefighter 4 was performing vehicle maintenance on Engine 4 at the time of the incident (**See Photo 2**). Engine 4 is a 2009 Spartan Furion Chassis with a 1,250-gallon water tank and a 1,250 gallon per minute pump. This apparatus underwent a Rosenbauer upfit in 2011 which updated various components and equipment of the cab. Engine 4 has two tires in the front and four tires in the rear of the vehicle in a dual configuration. Engine 4 is only used to respond to major incidents and accumulated 2,974 miles during 2021.

Photo 2. Engine 4 with tire off the rim.
(Courtesy of the fire department)

Maintenance

The fire department in this incident requires firefighters to perform apparatus checks at the beginning of each shift. These checks are recorded using an electronic checklist. Additionally, fire department SOPs require drivers to complete a walk around of apparatus before departing the station or scene. This includes a visual inspection of tires. The checklist for Engine 4 included requirements for a visual tire inspection and verification that the tires maintained an inflation pressure above 95 psi. The fire department trains firefighters to verify that tires for large vehicles, such as engines and tankers, are at 100 psi. If less than 100 psi, this can be marked in red on the checklist and turned into the deputy chief and fire department mechanic. According to fire department records, Engine 4 had been routinely checked once per week for the year of 2021 up to the date of the incident. None of the checklists detail issues or discrepancies with the tire in this incident.

Tire

According to fire department maintenance records, Engine 4 received four new rear tires on March 30, 2021. These tires were purchased from and mounted by a local tire and mechanic service business. Engine 4 was equipped with Firestone FD663 Radial 12R 22.5 16PR tires whose manufacturer information recommends an inflation pressure of 120 psi and a maximum load capacity of 6,780 lbs. for a dual configuration [Firestone 2017]. At the time of the incident, firefighter 4 noted that the outer tire on the driver's side rear had a pressure of 50 psi. He decided to inflate the tire to the required pressure of 95 psi or greater per the departments checklist using the fire department's cascade system at Station 1.

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The tire that came off the rim in this incident was the outer dual configuration wheel on the driver's side rear of Engine 4 (**See Photos 1 and 3**). This wheel had a single piece rim with a decorative aluminum simulator/hubcap that covered the entirety of the rim over where the tire beads are seated (**See Photo 4**). After the tire incident, it was discovered that the wheel had sustained damage believed to be from either running over a curb or an object on a roadway. Specifically, the rubber of the tire had multiple scuff marks, and the metal rim had a significant deformation. The latter is believed to be what caused the tire pressure to leak. The simulator/hubcap would have covered and hidden the rim deformation from being discovered during a visual inspection. When firefighter 4 attempted to inflate the tire, the rim deformation allowed the tire bead to slip past the wheel rim, causing a zipper effect where the entire bead let go. Some combination of the outward motion of the tire and the sudden outburst of air from the tire, launched the wheel simulator/hubcap as a projectile.

Photos 3 and 4. Apparatus tire that came off showing rim deformation and simulator/hubcap from passenger side of Engine 4.
(Courtesy of the fire department)

Investigation

On December 18, 2021, firefighter 4 (deceased firefighter) was assigned to Station 4. He began his shift by performing apparatus checks. During a check of Engine 4, he checked and inflated the tires to ensure they were all above 95 psi. At 08:30 hours, firefighter 4 called the shift captain to notify him that he was bringing Engine 4 to Station 1 to check and inflate the tires. Upon arriving, he parked Engine 4 in front of bay 1. Firefighter 4 connected a pre-connected 100 ft airline from the external fill port of the station's cascade system to the tires. The regulator for the cascade was set to just above 100 psi. Firefighter 4 also secured a manual tire gauge and an air chuck. The air chuck was connected to the air line.

The shift captain arrived to assist in checking and inflating the tires. The captain started inflating the front passenger side tire. Firefighter 4 then took over inflating the passenger side rear tires. During inflation, each tire was checked with the manual tire gauge to ensure each was above 95 psi. Both firefighters moved to the driver's side tires after completing the passenger side tires. Upon checking the outer dual configuration tire on the driver's side rear, firefighter 4 noted that the pressure was only 50 psi. He began to inflate the tire by sitting on the ground directly in front of it and holding the air chuck onto the tire valve stem.

After a short amount of time inflating, the tire bead came off the wheel rim with great force which launched the simulator/hubcap as a projectile hitting firefighter 4 in the head. Firefighter 4 was thrown back about 30 ft from Engine 4. Upon witnessing the incident, the shift captain promptly contacted the parish public safety answering point and requested a medic unit and a medical helicopter be dispatched to their location. The captain and another firefighter rendered medical aid to firefighter 4 who was unconscious and bleeding from the head. Firefighter 4 was transported to a local hospital and pronounced deceased.

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 in this incident:

- Procedure and equipment for inspecting and inflating apparatus tires
- Training on daily/weekly visual and operational checks of apparatus

Cause of Death

According to the Coroner's Office report, firefighter 4's cause of death was multiple blunt force head injuries. The examination noted shattering fractures of the front of the skull that embedded pieces of bone in the brain. Additionally, the examination noted a partial amputation of the right hand. The investigation determined that firefighter 4 was using his right hand to hold the air chuck onto the tire valve stem during inflation. According to the sheriff's office report, the manual tire gauge displayed 90 psi upon inspection after the incident. A third party tested the cascade system's regulator to confirm it did not contribute to the incident.

Recommendations

For fire departments:

Recommendation #1: Ensure that firefighters have access to and use appropriate equipment and safe operating procedures to inspect and inflate apparatus tires.

Discussion: At this incident, the fire department maintained a checklist for Engine 4 that included a section requiring a visual tire inspection and verification that the tires maintained an inflation pressure above 95 psi. This visual inspection did not require firefighters to remove the simulator/hubcap and inspect the condition of the rim prior to inflation. While inflating the tire, firefighter 4 sat on the ground

directly in front of the tire. The fire department utilized a cascade system to inflate apparatus tires. These systems are designed to fill self-contained breathing apparatus cylinders to pressures of up to 4,500 psi.

The NIOSH Fatality Assessment and Control Evaluation™ (FACE) Program has investigated several incidents of worker fatalities involving tire explosions while workers were inflating tires. For each incident, FACE reports recommended that workers use best safety practices and appropriate equipment when performing tire maintenance and service. This includes ensuring workers properly inspect tires before inflation, never position themselves in front of or in the trajectory of tires during inflation or servicing and use the necessary tools and equipment for safely servicing tires [NIOSH 2004; NIOSH 2004; NIOSH 2018a; NIOSH 2018b]. Additionally, the FFFIPP has recommended in previous reports that fire departments ensure proper tire inspection and inflation according to the manufacturer's instructions as part of a vehicle maintenance program [NIOSH 2005; NIOSH 2010].

Fire departments can follow industry best practices and federal regulations listed under 29 CFR 1910.177, Servicing Multi-Piece and Single Piece Rim Wheels, when establishing procedures for inspecting and inflating apparatus tires. Safe practices and appropriate equipment that fire departments can adopt in procedures include [MSHA 1996; MSHA 2006; USPS 2008; OSHA 2011]:

- **Inspection:**
  - Visually inspect tire and rim for any damage, defects, or fatigue such as wear, cracks, broken or bent components, rubber separation, and excessive corrosion or rust.
    - Remove simulators/hubcaps to fully inspect rims.
  - Have a tire service provider remove and inspect any tire that has been run flat or under inflated less than 80% of its recommended pressure.
- **Inflation:**
  - Verify the manufacturer's recommended tire inflation pressure and the maximum load capacity relative to the fire apparatus.
  - Check the tire's pressure when tires when the vehicle has been parked for a while.
  - Use eye and hearing protection.
  - Ensure tire is secure in a restraining device (e.g., safety cage) if not connected to apparatus or is bolted onto apparatus with lug nuts fully tightened.
  - Remove simulators/hubcaps before inflation so they do not become projectiles.
  - Use the appropriate, commercially available equipment. The assembly has three critical components:
    - Clip-on air chuck or stand-off inflation device.
    - In-line valve with a pressure gauge or regulator that can be preset.
    - Sufficient hose (i.e., six to nine feet) to allow firefighters to stand clear of the tire's trajectory during inflation.
      - This tire inflation assembly allows the operator to position themselves outside of the trajectory zone in front of the tire they are inflating.
      - Trajectory is any potential path or route that a tire, rim, or component may travel during an explosive separation or sudden release of air pressure.

- Only use stationary or mobile air compressors whose manufacturer's instructions explicitly state they can be used for inflating tires.
- Inflate the tire only to the minimum pressure necessary to force the tire bead onto the rim ledge and create an airtight seal.

Recommendation #2: Ensure firefighters are trained on how to conduct daily/weekly visual and operational checks of apparatus.

Discussion: The fire department in this incident maintained an electronic checklist for firefighters to perform weekly visual and operational checks of apparatus. At the beginning of each shift, firefighters would complete the checklists and email them noting any issues or deficiencies to the deputy chief and fire department mechanic.

Per NFPA 1910 [2024], Standard for the Inspection, Maintenance, Refurbishment, Testing, and Retirement of In-Service Emergency Vehicles and Marine Firefighting Vessels, fire departments should train driver/operators on how to perform visual and operational checks of apparatus. This includes visual checks of components such as tire condition and air pressure and operational checks of systems such as warning lights and documentation of these checks. Additionally, NFPA 1910 recommends fire departments develop and implement a procedure for reporting defects and removing apparatus from service based upon out-of-service criteria. Relative to wheels, a bent or improperly seated rim is a deficiency that would cause a vehicle to be taken out of service. One tool that fire departments can utilize for performing daily/weekly visual and operational checks of apparatus is the sample check sheet in Annex C of NFPA 1910 [NFPA 2024].

The NFPA Fire Apparatus Committee could consider adding wheel simulator requirements to NFPA 1900 that would assure wheel simulators can be easily removed for inspection. This may include the permanent removal of wheel simulators that cannot be easily removed for inspection or replacement with versions that can be easily removed for in-service apparatus.

Additionally, for fire service training organizations and fire academies (federal, state, regional/county, and local):

Recommendation #3: Add information about tire explosion hazards and provide hands-on training for safe inspection and inflation of apparatus tires in driver/operator and maintenance training programs and publications.

Discussion: The fire department in this incident required firefighters to attend an 80-hour training and achieve IFSAC certification as a Fire Apparatus Driver/Operator – Pumper through the Louisiana State University. This training and certification only included a skills assessment of checking tires for pressure and wear.

Inflated tires are a pressure vessel. Handling and servicing tires and rims expose workers to a variety of potential hazards such as explosions and being struck by flying parts [MSHA 2006]. Both OSHA [2011] and MSHA [1996] recommend that no employee service a tire and rim unless they have been trained and instructed in the correct procedures. It is important for firefighters to understand potential hazards of tire

explosions; the necessity of standing outside the trajectory during inflation; how to inflate the tire when a rim wheel is mounted on a vehicle or secured in a restraining device; and what equipment to use during these activities.

Fire service training organizations and fire academies can develop and incorporate training in driver/operator maintenance programs that includes hands-on practice of how to inspect and inflate a tire. Such training that focuses on tactile experiences could also be considered for certification as a Fire Apparatus Driver/Operator and Emergency Vehicle Technician [NFPA 1010; NFPA 1910] and included in training publications for these certifications.

Post-Incident Fire Department Prevention Actions

After this incident, the fire department implemented changes to vehicle maintenance operations. These changes were based on the department's internal assessment of the incident on December 18, 2021.

- **Improved Tire Inspections, Inflation, and Maintenance Procedures**
  The fire department has removed all wheel simulators/hubcaps from all apparatus in their fleet. They have purchased and provided firefighters at stations 1 and 4 with tire inflators with gauges that have a six ft hose with a locking valve stem connection. Their updated procedures mandate firefighters to report any abnormal strike of apparatus tire (e.g. curb or object in the road) to the fire department mechanic or chief officer. The procedures also include a mandate that if apparatus tires are lower than 90% of the desired pressure, the apparatus shall be pulled from service with the fire department mechanic or chief officer being notified to resolve the issue.

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Investigator Information

This incident was investigated by Karis Kline (former), 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, WV. This investigation report was authored by Dr. Wesley R. Attwood, Investigator and Program Advisor, and Jeff Funke, MS, CSP, Team Lead, with the Fire Fighter Fatality Investigation and Prevention Program, Surveillance and Field Investigations Branch, Division of Safety Research, NIOSH located in Morgantown, WV.

J. Roger Lackore, PE, CSP, of the Fire Apparatus Manufacturers' Association (FAMA) provided an expert review of the investigation report. A subject matter expert review was provided by William

Adams of Metal Township Fire Department, Pennsylvania. The NFPA Emergency Response & Responder Safety Division and Kyla Hagan-Haynes, NIOSH Center for Motor Vehicle Safety, also provided a technical review.

Additional Information

Fire Apparatus Manufacturers' Association (FAMA)
FAMA works closely with national and international organizations within the fire industry including apparatus manufacturers. FAMA assists in the development of fire truck safety and performance standard, programs and objectives for improving fire apparatus and equipment safety, as well as fostering the highest possible industry standards. Access to resources from these efforts can be found at https://www.fama.org/fire-service-resources-list/.

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.