GREEN SHEET

Informational Summary Report of
County of Los Angeles Fire Department (LAC)
Serious or Near Serious Injuries, Illnesses, and Accidents

Firefighter Line of Duty Death

June 14, 2024

Unnamed Truck/RV Fire

Incident Number LAC 24-203895

This Informational Summary Report is intended to enhance safety and training, aid in preventing future occurrences, and to inform interested parties. Because the report is published in a short time frame, the information contained herein is subject to revision as further investigation is conducted and/or additional information is discovered.

SUMMARY

On Friday, June 14, 2024, at 1356 hours a Truck/RV Fire response was dispatched to a sand and gravel quarry in the City of Palmdale. The first engine arrived at 1406 hours, deployed two hand lines, and began applying water on a burning wheel loader. The left-rear wheel loader tire exploded 2 minutes and 19 seconds after fire department arrival. One firefighter suffered fatal blast injuries and a second firefighter was transported and evaluated at the nearest trauma center as a precaution.

CONDITIONS

The incident occurred within a sand and gravel quarry in the City of Palmdale, California.

Looking south at the quarry from the access road.

Location:

- 3500 East Avenue T, Palmdale.
- The wheel loader was located approximately 2,000 feet south of Avenue T.
- The wheel loader was accessed via dirt roads with a total travel length of approximately 4,000 feet from the entry gate.
- The incident occurred 90 feet below the surrounding grade.
- The wheel loader was located between two sand piles.

Weather:

- Temperature: 96° Fahrenheit
- Relative Humidity: 16 percent
- Winds: NNW 7MPH gusting to 15MPH.

Fire Conditions:

- Fire was first discovered by quarry personnel in the engine compartment of the wheel loader located at the rear of the vehicle.
- Burning material fell to the ground below the engine compartment.
- The burning material ignited the right-rear and then the left-rear tires.

Make/Model of Equipment:

- The vehicle involved was a diesel-powered 2015 Caterpillar 988K Wheel Loader.
    - Engine: 541 hp, 18 L, CAT C18 ACERT™
    - Dimensions: 40 feet long, 13.7 feet high, and 12.7 feet wide
    - Operating weight: 112,574 lbs.
    - Rated payload: 16 tons for loose material

Right side of wheel loader

- The wheel loader tires were Bridgestone V-Steel N-Traction (VSNT) 35/65R33 radial tires.
    - The front tires were inflated with compressed ambient air to 100 psi.
    - The rear tires were inflated with compressed ambient air to 90 psi; no water was added for ballast.
    - The overall tire diameter was 81.7 inches, and the overall tire width was 35.6 inches.

Left-front tire with 6.1-foot tall firefighter for height comparison.

SEQUENCE OF EVENTS

On Friday, June 14, 2024, the operator of wheel loader at a sand and gravel quarry was alerted to a fire at the rear of the vehicle. The operator discharged a 20 lb. dry chemical fire extinguisher into the engine compartment and exited the vehicle.

Fire in engine compartment

Fire was visible burning in the engine compartment and on the ground around the rear tires by 1338 hours. Quarry personnel attempted to extinguish the fire utilizing the quarry's 3000 gallon water tender beginning at 1346 hours. The fire was not extinguished, and all quarry personnel were evacuated to approximately 120 feet from the wheel loader.

Fire extending to the right-rear tire at 1441 hours.

A VEHL (TRUCK/RV FIRE) response consisting of Engine 93 (E93), Engine 79 (E79), and Patrol 79 (P79) was dispatched at 1356 hours with the text "LOADER ON FIRE." The jurisdictional engine company, Engine 92 (E92), became available at 1400 hours and was placed on the response.

At 1402 hours, four minutes before the fire department arrived, the right-rear tire exploded. The blast broke the passenger side windshield of a quarry vehicle located approximately 120 feet away from the tire, but no facility personnel were injured. After the explosion, quarry personnel and equipment were relocated 200 feet away from the wheel loader.

Right rear tire (left photo) and right-front tire (right photo)

Right-rear tire explosion prior to FD arrival. The windshield of the white truck was broken during the blast.

E93 arrived on-scene at 1406 hours. Firefighter one (FF1) was seated on the right side of the engine. FF1 wore full personal protective equipment (PPE), including self-contained breathing apparatus (SCBA) facepiece and hood, and was on air prior to exiting the engine and while engaging in fire attack. FF1 deployed and operated the right-side one-inch reel line to attack the fire on the left side of the wheel loader.

Firefighter two (FF2) was seated on the left side of the engine. FF2 wore full PPE, including SCBA facepiece and hood, and was on air prior to exiting the engine and while engaging in fire attack. FF2 deployed and operated the left-side one-inch reel line to attack the fire on the right side of the wheel loader.

FF1 and FF2 began applying water to the burning engine compartment and rear tires of the wheel loader at 1407 hours. E93 captain (CA1) went to the left side of the wheel loader to evaluate FF1's progress and then repositioned to the right side of the wheel loader to evaluate FF2's progress.

E92 arrived on-scene at 1408 hours, and personnel began exiting the vehicle to assist with fire attack and water supply.

Overhead view. Some photos have been edited out of respect.

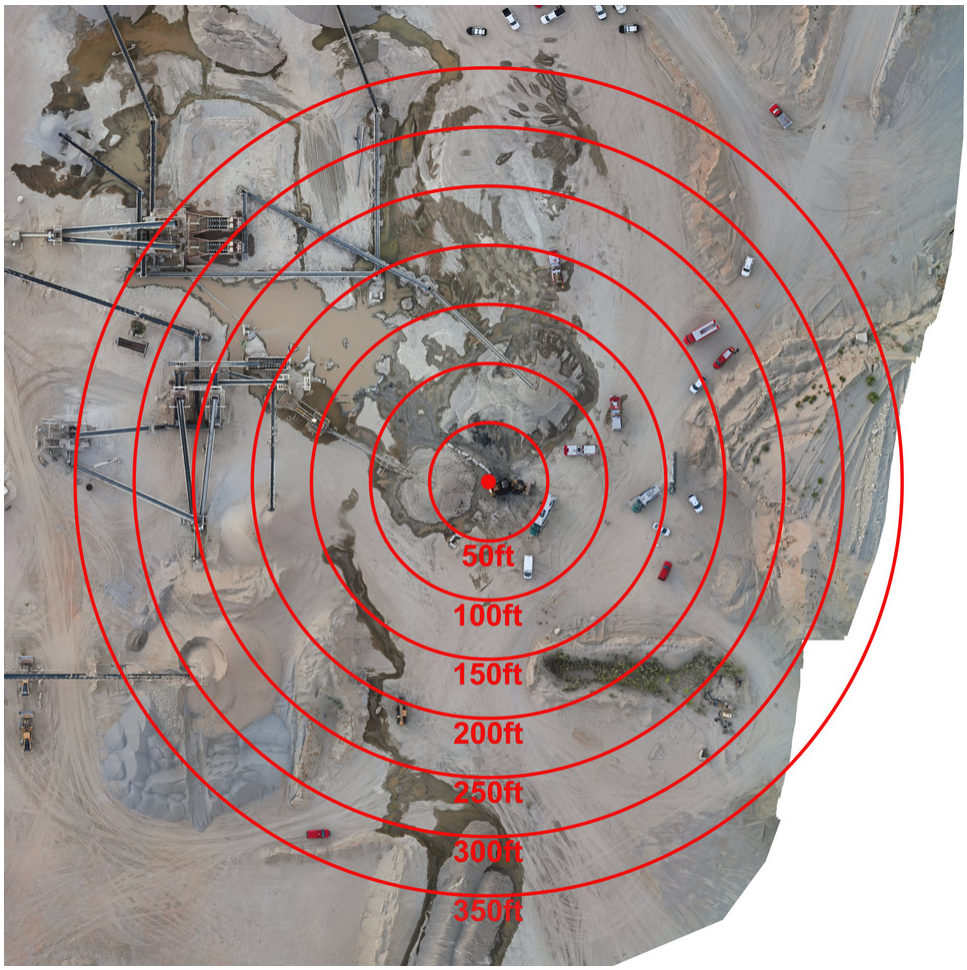
Looking west (note that E92 moved after the explosion).

The left-rear tire exploded at 1408 hours. This explosion occurred:

- At least 30 minutes after the fire started within the wheel loader.
- 6 minutes and 38 seconds after the right-rear tire explosion.
- 2 minutes and 19 seconds after Engine 93 arrived.

The force of the explosion expelled debris up to 350 feet from the left-rear tire. The left-rear tire explosion was more powerful than the right-rear tire explosion. Only the rubber and steel cord components of both tire's sidewalls were expelled during the explosion; the multi-piece rim assemblies remained intact.

Left rear tire (left photo) and left-front tire (right photo)



Scaled overhead photo illustrating maximum distribution of debris.

FF1 was positioned near the left-rear tire at the time of the explosion. CA1 and FF2 were on the right side of the wheel loader and were shielded from the blast.

E92 captain (CA2) requested a squad, ambulance, and an air squad at 1409 hours, less than one minute after the left-rear tire exploded.

CA1 located FF1 at 1409 hours and determined death in accordance with the County of Los Angeles Department of Health Services Reference Number 814, “Determination / Pronouncement of Death in the Field.” CA2 canceled the air squad at 1410 hours based on the report from CA1.

CA2 requested the battalion chief (BC) at 1410 hours via radio and then notified the BC of the situation via cell phone. BC advised the chain of command and ordered the American flag from the fire station be brought to the incident scene.

E79 and P79 arrived on scene at 1413 hours. Squad 92 arrived at 1415 hours, and FF2 was transported to the closest trauma center at 1427 hours.

Engine 37, Water Tender 80, and Water Tender 117 responded to relieve E92 and E93. E92 and E93 personnel were relieved and transported back to the fire station.

E79, P79, and E37 established an 80’ exclusion zone and defensive operation consisting of one 2 ½-inch hose line with a smooth bore nozzle and two BlitzForce® portable monitors. The water tenders shuttled water to support the firefighting operation.

Left rear of loader just prior to full extinguishment.

After the bulk of the fire was knocked down, a 1 ¾-inch handline was utilized along with FireIce® powder to extinguish the remaining fire around the left-rear tire. Full extinguishment was achieved at approximately 1915 hours.

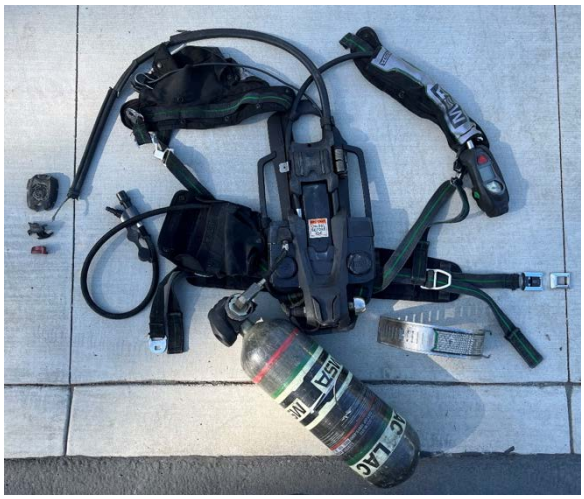
INJURIES/DAMAGE

Injuries:

- FF1 suffered fatal blast injuries per the preliminary Los Angeles County Medical Examiner's report.
- FF2 was evaluated at the closest trauma center and released.

Damage:

- FF1's personal protective equipment, including radio and SCBA, were destroyed.
- One 1-inch reel line was destroyed.
- One 1-inch 10/40 gpm dual gallonage nozzle was destroyed.
- E93's engineer side windshield was broken.



FF1's SCBA

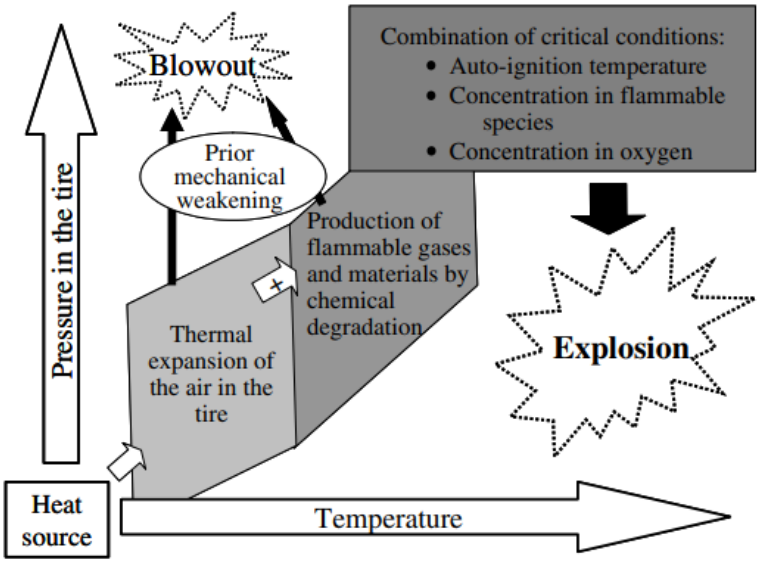
FF1's radio

1-inch hose and nozzle

Broken windshield

LESSONS LEARNED

The Serious Incident Review Team (SIRT) researched information regarding the hazard of large vehicle tires exposed to fire. Although the hazard of large vehicle tires during installation, inflation, and service is known within the vehicle maintenance industry, very little information was available from fire service sources regarding the effects of fire on this class of tires. The following information was obtained from academic journals and vehicle maintenance safety documents.



Processes leading to tire blowout or explosion (Dolez et al., 2007)

According to “Exploring the chemical aspects of truck tire blowouts and explosions” (Dolez et al., 2007), there is a distinction between a tire blowout and a tire explosion. A blowout is associated with the mechanical failure of the tire or rim assembly. Blowouts occurring while the vehicle is in motion typically generate pressures around 145 psi. A tire exposed to fire may blowout prior to explosion when the internal pressure increase exposes a mechanical defect within the tire or rim assembly. An explosion is a much more violent event involving flammable gases and is a result of the process discussed below.

There are three phases of the process that may lead to the explosion of tires exposed to heat. First, the air pressure inside the tire will increase as the temperature rises. The pressure of a tire inflated to 90 psi will rise to approximately 235 psi. Unless there is a mechanical defect within the tire or rim assembly, the pressure increase due to the expansion of the air inside the tire will not typically lead to failure (blowout).

Second, when the rubber of the tire reaches 365º Fahrenheit, it will undergo thermo-chemical degradation reactions and release gases within the tire. The gases released are added to the quantity of air already inside, increasing the pressure within the tire. There are two important things to note regarding these thermo-chemical degradation reactions:

- The reactions are exothermic, meaning they can continue inside the tire even if the external heat source is removed. Extinguishing a fire exposing or involving the tire may not stop the reactions and prevent a tire explosion.

- The gases produced inside the tire are flammable with a heat release comparable to that of natural gas.

Third, an explosion will occur when the oxygen concentration is at least 5.5 percent and the flammable gases reach their lower explosive limit and auto-ignition temperature. The explosion will generate shock waves and pressures over 1000 psi, projecting fragments outward at high velocity that travel great distances.

As a reminder, this explosive process can occur within tires inflated with ambient air regardless of the presence of a rim assembly.

“Methodology for assessing safe distances in case of explosions of dump truck tires in an open pit” (Kobylkin and Arzhanov, 2021) identifies the safe pressure for a person in front of a shock wave at 1.5 psi or less. Pressures exceeding this value will cause injury. Once the shockwave pressure reaches 14.5 psi fatal outcomes are possible, and a fatal injury is 100 percent likely at pressures of 43.5 psi or more.

The document provides methods to use specific tire dimensions to calculate explosive energy, safe distance from air blast effects, and the maximum distance wheel fragments may travel. These calculations were utilized to develop the explosive hazard zones discussed in the next section.

SAFETY ISSUES FOR REVIEW

The explosive danger of large vehicle tires is one of many potential hazards fire department personnel may face when operating at a large vehicle fire. Knowledge of the explosive hazard of tires enables company officers to perform a more thorough hazard assessment.

The risk management process (RMP) below provides a framework to mitigate large vehicle fire incidents safely and effectively.

- Situation Awareness: Upon recognizing a fire involving a large vehicle, determine which hazards are present from a safe location. Establish the incident priority: life, environment, or property.

- Hazard Assessment: Assess the conditions to determine which hazard(s) (compressed natural gas, liquified natural gas, hydrogen, lithium-ion batteries, tires exposed to fire, etc.) are present. Information sources include placards, fire conditions, reports from vehicle operators, etc.

- Hazard Control: Develop your plan by determining the appropriate and available hazard control(s) (distance, approach angle, etc.) and mitigation strategies. The incident priority, specifically life, will dictate the appropriate level of risk.

- Decision Point: Validate the plan, brief personnel, and engage.

- Evaluate: Observe progress and changes and reassess strategy if necessary.

The diagrams at the end of this section identify the explosive hazard zones around tractor-trailer and heavy equipment tires. These zones assist with the completion of an accurate hazard assessment and the implementation of the hazard control(s) of time, distance, and/or shielding. The tire explosive hazard zones are:

- The “Exclusion Zone” represents the area where potentially lethal pressure waves will be generated in a tire explosion. This area shall be treated as an exclusion zone as PPE does not provide protection from pressure waves. Only robust shielding (buildings, large vehicles, etc.) will mitigate the hazard in this zone. Consider the use of tools to reach victims within the exclusion zone.

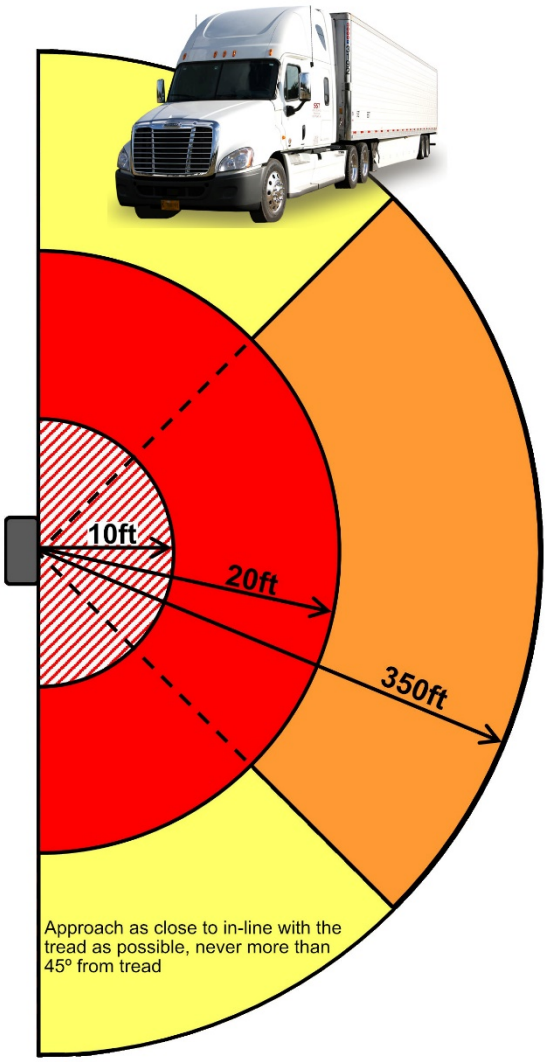
- The “Immediate Rescue Only Zone” represents the area where pressure waves are likely to cause injury. Personnel shall only operate in this zone for immediate rescue, as PPE does not provide protection from pressure waves. Robust shielding will mitigate the hazard in this zone. In situations where a savable victim is within the zone, limiting time in the area and performing an immediate extraction of the victim may be an acceptable hazard control or strategy.

- The “Rescue Only Zone” represents the material dispersal area where tire fragments may be thrown. Personnel shall only operate in this zone to perform rescue. The intensity of impact from tire fragments will vary within this zone based on distance and angle of the blast. On tractor-trailers or other vehicles with dual tires, the explosion of the inner dual may expel the outer dual out from the vehicle in line with the axle. Full PPE may provide some protection from the tire fragments depending on their size and velocity. Shielding will mitigate the hazard in this zone.

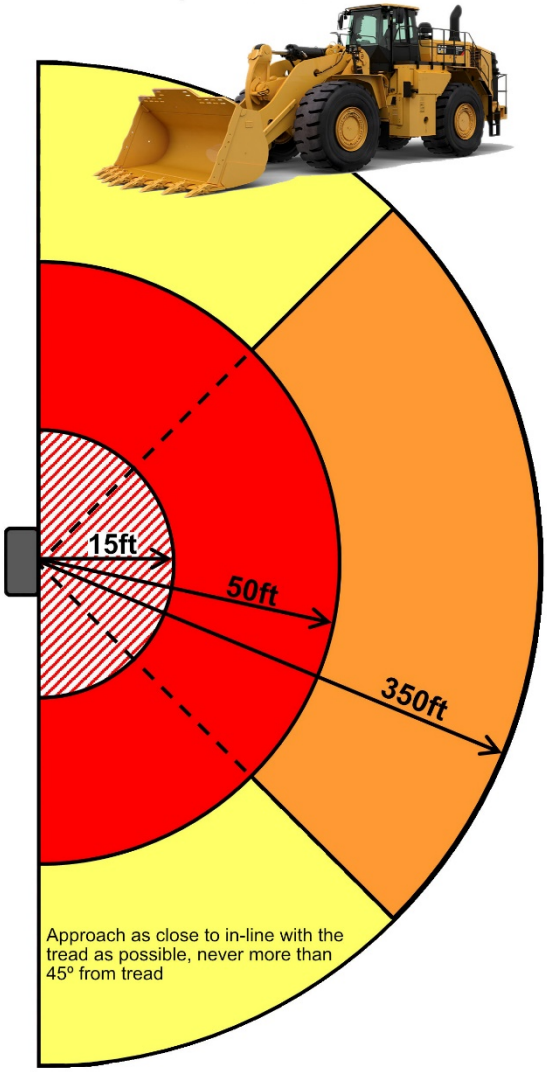
- The “Limited Operation Zone” is within the material dispersal area where tire fragments may be thrown. The hazard of material dispersal is reduced, but not eliminated if operations are aligned with the tire treads at the greatest distance from the tire as possible. Personnel shall only operate in this zone if the incident priorities dictate, for example, to perform a rescue or prevent extension to other tires or vehicles. Consider unstaffed hose streams to reduce the time personnel are in this zone.

When the incident priorities do not require operation within any of the explosive hazard zones, personnel shall be kept a minimum of 350 feet away from the tire. As discussed in the previous section, extinguishing the fire exposing or burning the outside of the tire may not stop the exothermic reactions inside the tire and an explosion may still occur. Personnel and civilians shall be aware and not immediately approach a tire which has been exposed to significant heat.

Tractor-Trailer Tire Explosive Hazard Zones



Heavy Equipment Tire Explosive Hazard Zones



Exclusion Zone: Lethal pressure waves will be generated in a tire explosion. Do not enter unless robust shielding (building, large vehicle, etc.) is present as PPE does not protect from pressure waves. Consider the use of tools to reach victims within the exclusion zone.

Immediate Rescue Only Zone: Pressure waves are likely to cause injury. Only operate in this zone for immediate victim rescue to limit exposure time unless robust shielding is present as PPE does not provide protection from pressure waves.

Rescue Only Zone: Only operate in this zone to perform a rescue as projectiles may be expelled into this area. On vehicles with dual tires, the explosion of the inner dual can expel the outer dual out from the vehicle in line with the axle. Full PPE may provide some protection from projectiles and shielding may mitigate the hazard in this zone.

Limited Operation Zone: The hazard of projectiles is reduced, but not eliminated if operations are aligned with the tire treads at the greatest distance from the tire possible. Only operate in this zone if the incident priorities dictate (rescue, prevent extension to other tires or vehicles, etc.). Consider unstaffed hose streams to reduce the time personnel are in this zone. Shielding may mitigate the hazard.