Abridged Investigation Report

Ammonium Nitrate Explosion

Angellala Creek, Charleville Queensland Australia on 5th September 2014

Queensland Government

The incident

Just before 9:00pm on Friday 5 September 2014, a vehicle carrying 52.8 tonnes of ammonium nitrate was involved in a single vehicle incident. The vehicle was transporting 44 bags of ammonium nitrate, each bag weighing 1.2 tonnes.

The vehicle left the road on approach to the road bridge over Angellala Creek on the Mitchell Highway, approximately 30 km south of Charleville. It came to rest in the creek bed adjacent to the road bridge. The prime mover caught fire. A local man driving south from Charleville arrived at the crash scene soon after the incident and rendered assistance to the injured driver.

A truck driver arrived from the south soon after and provided assistance to the injured driver. The local man left the crash scene to contact emergency services at a nearby farm. A short time later another truck driver arrived from the north and rendered assistance to the injured driver.

Queensland Fire and Emergency Services, Queensland Police Service and Queensland Ambulance Service from Charleville responded. The first fire truck arrived at the incident scene at approximately 10:00pm with two fire officers. They administered first aid to the injured driver and assessed the vehicle fire. A second fire truck arrived at about 10:10pm with two fire officers followed by a police car with one police officer. The police car parked approximately 200 metres north of the incident site.

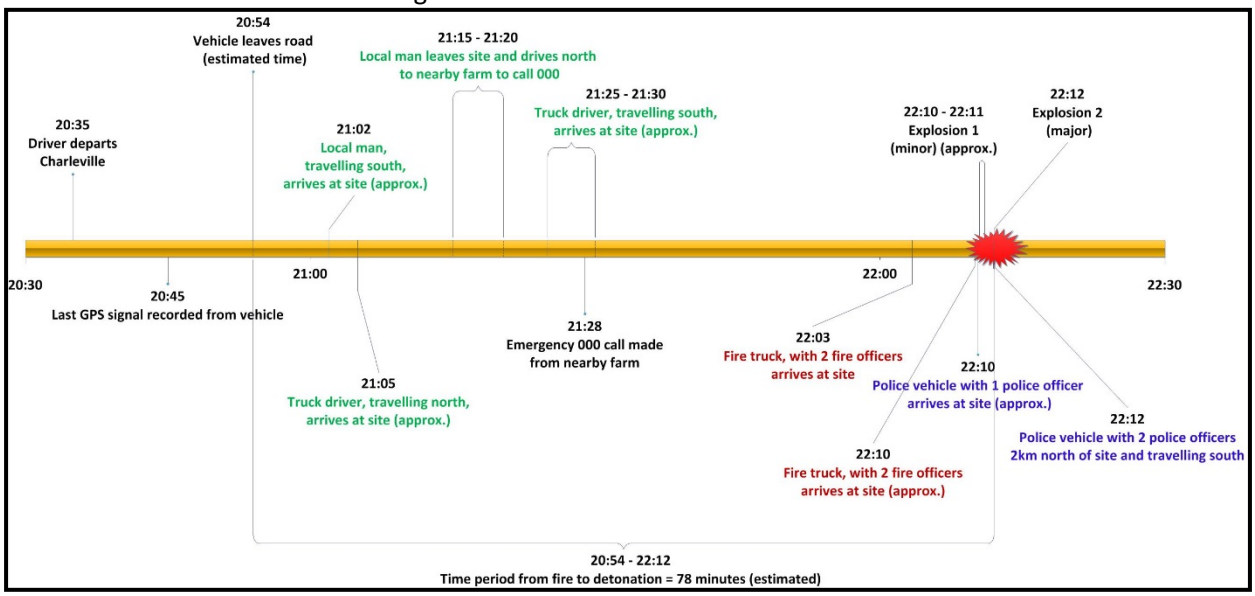
Soon after the arrival of the second fire truck and police car, an explosion occurred. Witnesses describe this explosion as large with no overpressure and a “firework” type effect of white sparks falling from the sky. The fire officers decided to evacuate. At 10:12pm a larger explosion occurred while the fire officers were in the process of evacuating the area. A second police car with two police officers was driving south from Charleville at the time of the second explosion and were just out of range of the incident site. The first ambulance arrived on site after the second explosion.

There were no fatalities; however eight people were injured, some seriously. The injuries included burns, lacerations, internal bruising, bleeding of organs, eardrum perforation and bleeding from the ears.

The vehicle transporting ammonium nitrate, two fire vehicles, a police car and both the rail and road bridges over Angellala Creek were either destroyed or sustained significant structural damage. All of the blast injuries and infrastructure damage was a result of the second explosion.

Geosciences Australia detected a seismic event at the site measuring 2.1 on the Richter scale at 10:12pm as a result of the second explosion. The size of the explosion was estimated to be equivalent to 10 – 15 tonnes of trinitrotoluene (TNT). No link could be found between the first and second explosions.

Brief timeline of the incident at Angellala Creek.



Role of the Explosives Inspectorate

The Explosives Inspectorate had two main roles during and following the incident:

1. Provide technical advice to emergency services during the incident, including the explosive properties of ammonium nitrate, evacuation of the site and safe exclusion distances.
2. Once the site was declared safe, investigate the cause of the fire and explosion following the traffic crash.

Properties of ammonium nitrate

Ammonium nitrate is regulated in Queensland as a security sensitive ammonium nitrate (SSAN). The ammonium nitrate in the incident was intended for use at a mine in South Australia for the manufacture of bulk explosives. This ammonium nitrate was not a fertiliser for agricultural use.

The ammonium nitrate was classified as a dangerous good (UN Number 1942), a Division 5.1 oxidising substance regulated in Queensland under the Explosives Act 1999. It is considered to be relatively insensitive and safe for transport in its solid prill form.

Ammonium nitrate is incompatible with a number of substances, including combustible material and certain metals. When ammonium nitrate is mixed with these incompatible substances and heated in a fire, an explosion may occur.

Cause of vehicle crash

The vehicle crash was part of the police investigation that concluded the cause of the vehicle leaving the road could not be determined.

Cause of vehicle fire

There was no conclusive determination on what caused the initial fire, or at what location or time, on the vehicle. Witness accounts indicate the fire was large, consuming the prime mover and first trailer. The fire burned for approximately one hour and twenty minutes prior to the explosion. Immediately prior to the explosion the fire had reduced to a small fire on the prime mover. The most probable scenarios for the initiation of the fire on the vehicle include:

1. Spilt fuel contacting the hot engine exhaust and igniting;
2. An electrical arc igniting the leaking fuel;

Cause of first explosion

The cause of the first explosion could not be clearly determined. This explosion had no overpressure or significant projections and did not cause any structural damage. The probable scenarios leading to this first explosion following the fire include:

1. A pressurised piece of equipment (for example a tyre or air tank reservoir) has burst possibly as a result of fire;
2. A gas or thermal explosion from the decomposition of ammonium nitrate as a result of heating has caused a low order explosion;
3. Molten aluminium contacting either a water source or molten ammonium nitrate causing a violent reaction.

Cause of second explosion

The cause of the initiation of the second explosion could not be clearly determined. The probable scenarios leading to this second explosion following the fire include:

1. Thermal explosion (cook off);
2. Deflagration under pressure (heat conduction and chemical reaction);
3. Detonation (shock wave driven) – either direct shock detonation transition or deflagration detonation transition; or
4. Water hammer / concerted void collapse (i.e. hot spot).

Key findings

- The vehicle was mechanically sound and regularly maintained.
- The prime mover contained a large amount of combustible material, including diesel fuel, oils, fibreglass, rubber and plastic.
- A diesel fuel injector line has failed and ruptured during the fire event after the crash.
- The GSM phone signal from the prime mover was lost approximately 15 km north of the incident site and the satellite signal had not been acquired at the time of the incident. The crash occurred approximately 10 minutes after the GSM signal was lost.

- Some ammonium nitrate bags were dislodged from the trailers during the crash and scattered along the vehicle pathway from the northern bank of the creek to the resting point of the prime mover on the southern bank.
- There was a diesel spill from the vehicle across the site from the north bank to the south bank of the creek that would have contributed to the fire.
- Ammonium nitrate samples from the site showed the appearance of being molten and contaminated with organic substances and metals.
- Following the crash the fire burned for over one hour, engulfing the prime mover, first trailer and a quantity of the load before reducing to a small fire on the prime mover immediately prior to the explosion.
- There were hot surfaces, particularly the engine exhaust in close proximity to where spilled diesel would be found as a result of the crash.
- An electrical arc has occurred from the battery electrical cabling for the starter motor circuit.
- Molten ammonium nitrate and molten aluminium and copper were found at the site, indicating an intense fire in excess of 1000^{o}C.
- The first explosion occurred approximately one hour and fifteen minutes after the estimated time of the vehicle crash.
- The first explosion did not appear to have a significant blast overpressure or projections and caused no structural damage.
- A second explosion occurred approximately one hour and seventeen minutes following the estimated time of the vehicle crash.
- Post blast analysis estimated the size of the explosion equivalent to 10 – 15 tonnes of TNT.
- Debris from the vehicle and other infrastructure was found up to one kilometre away from the site of the vehicle crash.
- Eight people were injured in the explosion, some seriously.
- The vehicle crash rendered the driver semi-conscious and unable to take control of the incident site. He was able to convey some emergency response information to external parties.
- The manifest, emergency procedure guide (EPG), placards and Emergency Information Panel's (EIPs) were destroyed by the fire, preventing communication of the hazards to first responders.
- There was no phone signal at the site for people to call and alert emergency services of the incident.
- Guide 50 in SAA/SNZ HB76:2010 *Dangerous Goods – Initial Emergency Response Guide* (HB76) for response to an ammonium nitrate incident is not specific in some cases, for example when to respond and when to evacuate an ammonium nitrate incident involving a fire and the safe evacuation distances.
- At the time of the incident, the Hazchem Code in the *Australian Code for the Transport of Dangerous Goods by Road and Rail 7th Edition (*ADGC) for ammonium nitrate was 1Z and did not address the explosion risk of ammonium nitrate.

Fire mitigation and response

All of the previous incidents worldwide where an explosion has occurred on a vehicle transporting ammonium nitrate have been following an intense fire that has involved the ammonium nitrate and have occurred on 'flat deck' type trailers. If the risk of fire is eliminated, controlled or isolated, the chance of an explosion of ammonium nitrate during transport operations is negligible.

To reduce the likelihood of this type of incident occurring again there is a need to:

1. Minimise the likelihood of a fire occurring on transport vehicles by improving the safety design and including fire mitigation controls for if and when a fire does occur.
2. Segregate ammonium nitrate from the prime mover and other large sources of contamination and heat through effective risk management practices.
3. Ensure first responders to an incident site can quickly identify and treat incident according to the hazards present.

Recommendations

1. A steel vertical and horizontal firescreen be fitted to flat deck trailers transporting ammonium nitrate to isolate the ammonium nitrate load from a fire on the vehicle.
2. Reduce the quantity of combustible material on a vehicle, particularly in proximity to ignition sources.
3. Regulators and industry representatives to develop appropriate design criteria for vehicles transporting ammonium nitrate that includes safety design features to prevent, reduce and isolate a fire.
4. Increase the fire extinguisher capacity and provide additional water and firefighting foam on vehicles transporting ammonium nitrate to respond adequately to an initial fire scenario.
5. Review the appropriate hazard information on vehicles, including documentation and vehicle marking, and systems to alert external parties to an incident involving ammonium nitrate.
6. Communicate ammonium nitrate transport routes to emergency services and remote communities for pre-planning of emergency response.
7. Update the initial emergency response guide SAA/SNZ HB76:2010 *Dangerous Goods – Initial Emergency Response Guide* (HB76) to reflect the appropriate initial response and evacuation response to an ammonium nitrate fire.
8. Conduct further research into the causes of initiation of an ammonium nitrate explosion in a transport incident, particularly the interaction of molten metals with molten ammonium nitrate in large loads.