

Fires and BLEVE on LPG tanker lorries

27 July 2010

Port-la-Nouvelle (Aude)

France

Explosion / BLEVE
Transport of hazardous
materials
Projections
Propane
Mobile storages

THE FACILITIES INVOLVED

The site:

This accident occurred at a site engaged in logistics, maintenance and parking specifically for tanker lorries transporting hazardous substances (primarily LPG and hydrocarbons). The company also uses the site for the storage of a small quantity of LPG cylinders, declared under the type 1412 of the French Regulation on Classified Industrial Facilities: « storage of liquefied flammable gases in manufactured containers », with a maximum of 6 to 50 tonnes of gas present at the same time.

The installation was located in the vicinity of the Port-la-Nouvelle harbour. The environment immediately adjacent to the company's premises was relatively unencumbered, especially given the presence of salt marshes to the north-west. A grain silo occupied a site 200 m to the south, a hydrocarbon storage facility (lower-tier Seveso) 300 m to the south-east and an LPG filling station (upper-tier Seveso) 500 m to the east. The closest dwellings lie on the other side of a channel some 400 m to the south of the company's parcel.

The regulations in effect relative to infrastructure for transporting hazardous substances specific to public parking zones (Articles R.551-1 and following of the Environmental Code) did not apply to this private "depot". Similarly, the "simple" act of parking vehicles carrying LPG does not, in and of itself, constitute an activity that falls under the jurisdiction of classified facilities legislation.



Precise accident location (red dot)

The unit involved:

On the day of the accident, eleven vehicles were parked at the designated LPG tanker lorry zone:

- two empty vehicles dedicated to the transport of liquid hydrocarbons,
- eight vehicles dedicated to LPG transport,
- abutting the repair shop, another vehicle (filled at 64% capacity with propane) that had undergone a mechanical inspection during the afternoon.



THE ACCIDENT, ITS CHRONOLOGY, EFFECTS AND CONSEQUENCES

The accident:

During the afternoon of 27 July, the driver of a tanker lorry, whose 13.5-m³ capacity was filled at 64% with propane subsequent to a product pickup order at a client's site, decided to return early to the base after noticing that the "overheated engine" indicator light had come on. Upon arriving at 6:20 pm, the indicator light turned off. Parked away from the other vehicles, his lorry was scheduled for repairs at the shop the next day. Between 6:30 and 11:20 that evening, despite a number of site entries and external patrol rounds, nothing out of the ordinary was reported. At 11:40 pm, the alarm was sounded by a safety officer who witnessed a glow on his control screen and received reports of a burning smell downwind to the east. At 11:58, the industrial park guard saw flames around the vehicle's bumper below the engine. Fire started to engulf the lorry, closing in on the cistern. A crew of 12 fire-fighters were at the scene 12 minutes past midnight and observed an ignited leak in back of the cistern, perhaps near the manhole; they sprinkled the entire vehicle.



Photograph of a fire-fighter arriving at the scene of the accident

In attempting to cool the cistern while remaining 100 m away, due to the inherent BLEVE risk, responders heard a whistling noise at 12:16 am and retreated to safety just before the BLEVE explosion of the tanker lorry and the ensuing "fireball" observed by eyewitnesses.

The BLEVE effects caused fire to spread to 2 buildings (the repair shop and the maintenance shop, built alongside the company's administrative offices) as well as to 2 empty hydrocarbon tankers parked nearby. Two gas bottles present in the repair shop also exploded.

Throughout their response effort, which lasted all night, fire-fighters protected the other LPG vehicles in order to avoid subsequent BLEVE explosions. The fire was ultimately contained during the morning of 28 July.

While fighting the blaze, the emergency response team encountered difficulties in accessing the site's water resources, which were needed for their cooling operation; they had to rely on the fire-fighting reservoir made available by a nearby hydrocarbon storage facility.

Consequences of the accident:

Some of this site's tanker vehicles were quite seriously damaged and nearly all vehicle windows and windscreens were destroyed:

- The 2 empty vehicles dedicated to hydrocarbon transport parked at the targeted zone were destroyed by fire and the walls of their cisterns completely torn apart;
- Among the 8 vehicles for LPG transport, 4 were partially destroyed by the blaze (mainly the cab area, as the cisterns could be spared by spraying water on their walls). Three of these lorries were empty but not yet degassed (displaying a residual pressure of 7 bar), and the fourth was filled with LPG to 82%, under pressure exceeding 7 bar.

Only the cistern on the vehicle responsible for the accident actually exploded. The administrative buildings also sustained damage due to the power of the blast.

Less severe damage was caused beyond the site boundary: shattered windows, hangar cladding deterioration, vents on the neighbouring silo blown off, brush fires in the salt marshes separating the company premises from the LPG filling station.

As typically noted during such accidents, thermal and mechanical effects were both induced.



Source DREAL Languedoc-Roussillon

Administrative offices and maintenance shop: concrete structure shifted due to the blast



Source DREAL Languedoc-Roussillon

Zone occupied by gas tanker vehicles: burned lorries

➤ Human toll:

No serious injuries were reported; one of the company's drivers sustained cuts to his hand due to the broken windscreen on the lorry he was removing from the parking lot as the fire was spreading; 12 fire-fighters complained of headaches and/or hearing problems (resulting from the blast effect). No one at the scene required hospitalisation.

➤ Property damage:

Recordings of damage and their corresponding valuations were logged by a third-party body, commissioned by the Ministry for Sustainable Development.

✓ Thermal effects:

According to witness accounts, the BLEVE explosion created an ignited cloud with an elongated shape, rather than spherical, rising to considerable heights. The film recorded by an adjacent site's monitoring camera revealed the violence of the explosion, though the maximum size of the ensuing fireball could not be estimated.

No heat effect due to radiation was detected on structures located within tens of metres of the lorry explosion, e.g. no scaling or blistering effect on the paint could be ascribed to radiation from the fireball.

The only thermal effects observed were related to the intense fire, which lasted several hours and led to the destruction of a number of tanker lorries.

✓ **Pressure effects:**

The tanker lorry exposed to this BLEVE was destroyed by both the explosion and fire. The only part remaining on the ground was its engine, as the cistern was found "flattened" on the roof of the repair shop's metal building structure.

Pressure effects were reflected by damages of varied intensity to lightweight building structures: cladding, windows, doors, glass panes. Adjacent to the explosion, a concrete wall was also damaged.

Outside the site, many glass showcases and windows on facades directly exposed to the BLEVE pressure wave were destroyed. According to testimonies collected, some of the windows located on non-exposed facades also sustained damage. Shattered windows were reported up to 700 m from the ignited lorry.



Wrecked tanker lorry after exposure to the BLEVE



"Flattened" cistern thrown onto a roof

✓ **Debris projections:**

The 13.5-m³ cistern burst into several fragments, with projections mainly in the direction of the tanks' alignment.

Four large pieces of the tank were catalogued:

- the largest fragment, comprising most of the shell of the "flattened" cistern, was thrown onto the roof of the repair shop's metal building;
- two pieces were identified outside the site at 20 m and 70 m in front of the lorry, along its alignment;
- a bottom piece (steel flange) was projected in the opposite direction from the previous fragments, beyond the site boundary 150 m from the ignited vehicle.

Cladding was also projected outside the site, at distances in the range of 50-100 m from the tanker lorry.

The European scale of industrial accidents:

By applying the rating rules applicable to the 18 parameters of the scale officially adopted in February 1994 by the Member States' Competent Authority Committee for implementing the 'SEVESO II' directive on handling hazardous substances, and in light of the information available, this accident can be characterised by the four following indices:

Dangerous materials released		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Human and social consequences		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Environmental consequences		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Economic consequences		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

The parameters composing these indices and their corresponding rating protocol are available from the following Website: <http://www.aria.developpement-durable.gouv.fr>

The level 3 rating of the "hazardous substances released" index reflects the 4.2 t of propane involved in the accident.

The 2 score assigned to the "human and social consequences" index is due to the one site employee and 12 fire-fighters injured (though not hospitalised).

Given the lack of any damage estimate, the "economic consequences" (parameters €16 and €15) could not be rated.

THE ORIGIN, CAUSES AND CIRCUMSTANCES SURROUNDING THE ACCIDENT

This accident occurred on a tanker lorry that had returned to the base earlier than scheduled subsequent to activation of the "engine overheating" indicator light. As a result, the lorry was parked with product in its cistern adjacent to the repair shop, where it had been scheduled for inspection the next day. This parking spot did not correspond to a normal designated space at the depot site. The vehicle had been placed in a temporary position directly above a drainage pit that possibly contained oil. These circumstances however could not be singled out with certainty as the cause of the fire outbreak. It turned out that by the time the lorry had returned to the depot, the indicator light was no longer on; moreover, the fire started several hours after the lorry had come to a complete stop without any anomaly observed in the meantime.

The shared use of parking facilities by lorries carrying liquid hydrocarbons and LPG might have helped spread this fire, though this overlapping use was not responsible for other BLEVE.

This BLEVE occurred following an audible whistling sound. Since the cisterns had not been fitted with valves, such a sound could have been created by a loss of seal just a few moments prior to the explosion, e.g. around the joint on the manhole whose flange wound up being ejected 150 m.

ACTIONS TAKEN

An administrative investigation was conducted in order to determine the origin of the fire. Following a Classified Facilities Inspectorate site visit during the morning of 28 July, the Inspectorate proposed for the Aude County's Prefect to sign a Prefecture order imposing the adoption of emergency measures in application of Article L.512-20 of the Environmental Code, requesting that the site operator ensure the safety within 48 hours of the 4 LPG vehicles already partially damaged by the fire, by means of degassing the 3 empty lorries and draining the vehicle that had remained full.

The possibility of malicious intent could not be ruled out, as an opening in the fencing was remarked after the accident.

At the same time, the Ministry for Sustainable Development commissioned a third-party body to establish a record and analyse the thermal effects, pressure effects and flying fragments generated by the explosion.

LESSONS LEARNT

This accident illustrates the risks inherent in parking vehicles designated for transporting hazardous substances, especially LPG, on private lots. A review to enhance recognition of these risks, focusing on site supervision and fire-fighting resources (inadequate in the present case), was one approach that could be envisaged.

The BLEVE of a tanker lorry had typical effects (pressure surges, thermal effects and projections) associated with such a phenomenon.

No heat radiation effect could be detected on any of the structures. According to theoretical models for estimating thermal effects, if the cistern had actually been filled to 64% of its capacity at the time it burst, then a thermal load of $1,800 \text{ (kW/m}^2\text{)}^{4/3}$ would have been reached at a distance of about 50 m to 60 m. These differences might be explained by the fact that, according to testimony, the explosion gave rise to a high-altitude and elongated (rather than spherical) "fireball", whereas the theoretical model had assumed a spherical expansion. Moreover, it is entirely possible that a portion of the liquid initially present had leaked prior to bursting, as suggested by the whistling sound heard by fire-fighters. This leak may have stemmed from the onset of a crack, a broken tap or else a compromised seal around the joint on the manhole whose flange had been ejected 150 m.

An analysis of damage, as measured against the tables of typical damage, showed the 140-mbar threshold at between 30 m and 50 m, and the 50-mbar threshold between 50 and 200 m. These distances associated with blast effects fit overall with expected values. The effect distance for the 20-mbar threshold could not be located precisely (somewhere between 100 and 700 m). The few shattered window panes observed at 700 m by far exceed the distance corresponding to the 20-mbar threshold described in the regulations (180 m for a 6-tonne tanker lorry), yet they remind us that this threshold corresponds to a rate of broken windows equal to at least 10%.

Both the direction (along the cistern alignment) and the maximum observed distance of projected debris are consistent with feedback available on this type of BLEVE.

This accident also recalls the very short period of time required for a BLEVE to occur: less than 20 minutes between the observation of fire and the explosion. Nonetheless, the occurrence interval remains difficult to predict, since it depends on a whole array of parameters (e.g. fire intensity, quantity of liquid present in the cistern, tank shell specifications). The more reduced the volume of the liquid phase is and the denser the fire surrounding the tank grows, the shorter the time lapse will get. The benefit of installing valves on the cisterns merits discussion (as a means of delaying the BLEVE occurrence and reducing the quantity of LPG involved), especially as regards the risks of additional leaks and associated consequences in cases where the lorry overturns during a road accident.

Lastly, the clustering of (curious) onlookers trying to catch a glimpse of the growing fire, unaware of the risks created by such an incident, more broadly raises the recurring issue of informing the local population (in particular summer tourists at resort locations).