

Fires and BLEVE of LPG tanker lorries

7 May 2007

Dagneux (Ain)

FRANCE

Explosion
Transport compagny
Projections
Propane
Tanker truck
Ill will

THE FACILITIES INVOLVED

The site:

A company specialised in maintaining road shoulders sublet a portion of its parcel to a hazardous substance transport firm interested in parking its fleet of tanker vehicles. This site was located in an industrial zone 200 m from the A42 motorway, 450 m from the Lyon-Geneva railway line and 350 m from the nearest dwellings (though a single-family home was just 200 m away). No fixed LPG storage or gas transfer station had ever been installed on this site. A 2-m high bund wall had been erected to the east and south of the tanker lorry parking zone. This parcel was fenced but not guarded.

The regulations in effect relative to lorry traffic and use of public parking facilities when transporting hazardous substances did not in fact apply to this "private" depot; the same was true for classified facilities legislation.



Parking zone used by tanker lorries (red dot)

The specific unit involved:

On the evening of the accident, three small lorries carrying propane were parked in a parallel position spaced approx. 2 m apart, with the lorry cabs facing the site exit. The first lorry, with a 15-m³ capacity, contained 480 kg of propane while the second, positioned in the middle and capable of carrying 20.4 m³, was emptied but not degassed; the third lorry (also with a 20.4-m³ capacity) contained 2.5 tonnes of LPG.

THE ACCIDENT, ITS CHRONOLOGY, EFFECTS AND CONSEQUENCES

The accident:

On 7 May at 8:24 pm, a passer-by, in observing that the cabs on 3 of the tanker vehicles had ignited, notified emergency services. Local fire-fighters and gendarme officers were at the scene about 15 min later and deployed their fire extinction equipment in establishing a 500-m safety perimeter. Alerted by the owner of the parcel used as a parking lot, first responders attempted a massive cooling of the blaze using a high-pressure hose while remaining at a safe distance, since they were aware of the possible risk of a BLEVE.

At 9 pm that evening, the fire began to intensify and a flare, combined with a loud whistle, was perceptible above the tankers, according to the witness accounts collected (several witnesses even filmed the accident sequence). The explosion occurred at 9:06 pm, accompanied by a fireball; 3 fire-fighters positioned at the site entrance were knocked down by the ensuing blast. Two fire outbreaks, identified in a tyre storage depot 100 m away and on a conifer hedge at approx. 250 m, were rapidly brought under control.

Around 10:30 pm, road and rail traffic was stopped on the motorway and railway. A half-hour later, emergency services were fighting 3 distinct blazes:

- ✓ 500 m² burning on the LPG lorry parking lot,
- ✓ spreading of the original fire to a textile company some 100 m away,
- ✓ workshops in flames at a robotics firm located about 50 meters from the epicentre.

All fires were contained by 12:40 am and fully extinguished at around 2 am.

Consequences of this accident:

Two of the three tankers exploded by shattering, whereas the third was projected onto a neighbouring building. A single explosion with a fireball was seen and heard by witnesses, and this account was corroborated by the recorded footage. In all likelihood, both vehicles had exploded at nearly the same time. This accident caused thermal effects and a pressure surge, along with ejected fragments.



15-m³ tanker projected 60 m - Source: INERIS

✓ Human toll:

No serious injuries were reported; 3 fire-fighters and 2 gendarmes were slightly hurt by the blast during the explosion.

✓ Property damage:

An inventory of damage and the corresponding estimations were produced by an independent, third-party body commissioned by the Ministry of Sustainable Development.

- **Thermal effects**

The characteristics of this fireball could be estimated based on available film footage; from an initial duration of approx. 9 sec and 80-m max ground spread, the fireball rose to a height of 80 m (as measured from its centre). The 2-m high bund wall installed to the east and west of the company's premises was obviously unable to offer any protection from the thermal radiation generated. No radiation effects were detected however on building structures (e.g. chipped or blistered paint). Only burned vegetation could be observed: grass, hedges and deciduous trees were heavily scorched out to an 80-m radius south-east of the site. The independent body estimated that the thermal doses received were on the order of 600 to 1,000 (kW/m²)^{4/3}.s and furthermore concluded that the distance over which heat radiation exceeded the human health threshold (1,000 (kW/m²)^{4/3}.s) had certainly not reached beyond 80 m.

The damage caused by fires due to projections of incandescent fragments was severe: the LPG tanker lorry parking lot and farm machinery owned by the leasing company, a textile warehouse located at 150 m and a robotics firm 50 m away were all destroyed. 100 m from the explosion, a tyre storage depot ignited, with fire spreading to the building before its containment; moreover, a conifer hedge was consumed by flames 250 m from the point of explosion.

- **Pressure effects**

Pressure effects were mainly witnessed west of the site, with some damage also recorded to the north and south. Lack of damage to the east might be explained by this sector's lower building density. In general, these effects were reflected by quite serious damage to lightweight structural elements: cladding, windows, doors. Adjacent to the explosion, wall cracks could still be detected. Shattered glass panes were observed as far as 400 m. The 50-mbar threshold was estimated at 50 to 100 m, and the 20-mbar threshold at 150-200 m. According to the independent body, the 2-m high bund wall built to the east and south of the parking zone appeared only to exert a minor influence on pressure wave propagation, when given the tank height (> 3 m); the screening effect in the "shadow" of the bund wall on the primary pressure wave propagation direction would not have extended beyond about 10 metres (i.e. 4 to 5 times its height).

- **Material projections**

The 15-m³ tank, weighing an estimated 3 tonnes, was ejected 60 m onto the roof of an adjacent company. Both the 20-m³ cisterns burst into multiple fragments; 13 pieces of tank were counted, though without being able to ascribe each piece to a particular origin, along with considerable debris projected out to 300 m; the materials sprayed included sheet metal, parts of lorry chassis and cabs, sun visors. Only the 13 pieces of tank and the intact vessel could be inspected with precision, yet smaller elements might have gone unidentified; 10 fragments (with a mass of between 50 kg and 750 kg) were ejected up to 250 m away, with 3 pieces (masses: 100 kg to 1,000 kg) falling at distances from 400 m to 900 m.

The alignment of these projections was, for the most part, perpendicular to the vehicle parking arrangement, except for 2 fragments, the larger of which (weighing 1 tonne) was found to the north-west 400 m from the point of explosion while the other (100 kg) crossed the roof of a dwelling 700 m north-east. Eleven of the 14 inventoried impacts, including the 15-m³ tank, were recorded west of the parking lot. Several industrial facilities were also damaged by these impacts.

The maximum height reached by these debris projectiles during their trajectory could not be discerned, though video recordings revealed that some may have soared to between 50 m and 100 m.



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" directive on handling hazardous substances, and in light of 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 checked="" type="checkbox"/>	<input checked="" 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" assigned to the "Hazardous substances released" index reflects the 2.98 tonnes of propane involved in the accident; this gas is specifically addressed in Appendix 1 of the "SEVESO" Directive.

The blast from the explosion slightly injured 5 onsite workers; the "4" score on the "Human and social consequences" index is due to job losses for some 30 employees with neighbouring firms destroyed in this accident.

"Economic consequences" (i.e. parameters €16 and €15) could not be characterised given that no damage estimate had been conducted. Some media reports however cited several million euros worth of damage, in which case level "5" on this index may have been attained, or even exceeded.

THE ORIGIN, CAUSES AND CIRCUMSTANCES SURROUNDING THIS ACCIDENT

The tank break, combined with formation of a fireball, propagation of a pressure wave and projection of fragments over large distances, characterises a BLEVE. The progression of the fire had not been known with any precision, but at 8:30 pm the 3 lorry cabs were all in flames and the fire was able to spread via the vehicle's combustibles, namely the fuel tank, tyres, rubber hoses and wood beams supporting the cistern, and perhaps via gas leaks resulting from the deterioration of joints and destruction of distribution hoses. Paint on the cistern had completely disappeared from view, and the independent body conjectured that the lorries had been engulfed in flames shortly before the explosion.

Since the cisterns had not been equipped with a safety valve, the flare observed around 9 pm might have been due to either the opening in a tank ferrule or a break in a tap (perhaps the one on the liquid recovery line on the tank's top part).

It could not be determined whether the simultaneous break of both cisterns represented a random occurrence, or whether instead the bursting of one had caused the other to subsequently break, e.g. by a fragment perforating the shell.

ACTIONS TAKEN

An administrative investigation was carried out and legal proceedings were initiated in order to determine the origin of the fire. Malicious intent was considered the most plausible lead. All 6 of the lorry's doors were found open even though the drivers claimed to have locked them; since the vehicles had not been charged electrically, except for the chronotachographs, the batteries had been cut.

In conjunction with these initiatives, the Ministry of Sustainable Development commissioned a third party to establish a record and analyse the effects produced by heat, pressure and fragment projection as a result of this explosion.

The "simple" parking of vehicles containing LPG does not constitute in and of itself an activity considered under the jurisdiction of legislation specific to facilities classified for environmental protection purposes.

LESSONS LEARNT

This accident illustrates the inherent risks involved in parking vehicles transporting hazardous substances, especially LPG, on private zones lying outside the scope of safety-related regulations, given the quantities of propane contained in the cisterns (i.e. < 10 tonnes). A strategic assessment, leading to a change in regulations for such sites (particularly as regards site supervision and fire-fighting resources), would seem to be an appropriate course of action.

This BLEVE of tanker lorries triggered the standard impacts (i.e. pressure surge, thermal effects and projections) associated with such a phenomenon. The direction most commonly taken by projectiles was perpendicular to tank alignment and moreover the number of fragments ejected was very high (on average 6 per cistern), which is quite infrequent compared with feedback available for this type of event. Even though 75% of the fragments were projected within a 250-m radius (which on the whole is in accordance with feedback), 3 elements weighing 1 tonne, 100 kg and 200 kg were respectively found at distances of 400 m, 700 m and 900 m from the point of explosion. Some of these "hot" missiles caused fires as far as 250 m away. This accident thus highlights the difficulties encountered when incorporating the effects of fragment projections into the risk evaluation of a hazardous facility.