2. UPDATE ON THE SPANISH CAMPSITE DISASTER

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2.1 INTRODUCTION

On the 11th July 1978 an overfilled and dangerously stressed road tanker, carrying propylene, suffered a loss of containment of its cargo alongside a Spanish campsite, see Figure 2.1. An initial flash fire and a BLEVE*-induced fireball caused an ultimate death toll of 210 persons. Given the prehistory of the use of the tanker, the appalling laxity over its loading and the irresistible build-up of hydraulic pressure the initiating release was hardly surprising.

FIGURE 2.1 Baffle from lorry near caravanette

The combined likelihood of the incident, involving such vulnerable exposees in large numbers at a spot presenting an exposed length of only 1.3×10^{-3} of the intended tanker journey, must be regarded as extremely low.

Recently unearthed photographic evidence together with the Spanish judicial findings have shed light on the pattern of events leading up to the tragedy.

2.2 THE VEHICLE

The tanker, hauled by an owner-driven traction unit, was primarily used to carry propylene from the Empetrol refinery at Tarragona to Puertotollano 450 km away. It is believed that, on occasion the returning vehicle had been loaded with anhydrous liquid ammonia, a cargo having a detrimental effect on the integrity of the high tensile steel tank. There was no pressure relief device on the tanker.

The maximum load of propylene ought to have been approximately 19 tonnes which would have left a substantial voidage to accommodate thermal expansion.

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* Boiling Liquid Expanding Vapour Explosion

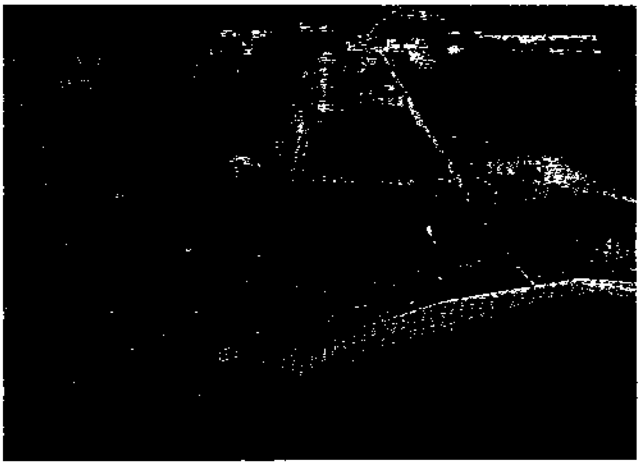


Figure 2.3 Aerial view of campsite taken from over the sea looking North.

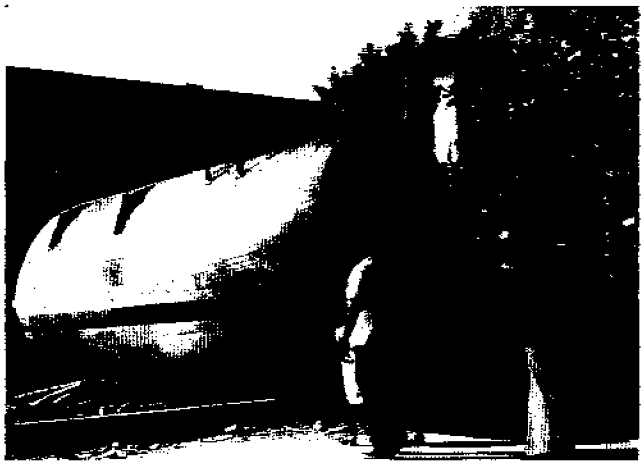


Figure 2.4(a) Rear end of tanker which rocketed 300m to the North.

Figure 2.4(b) Typical shot showing tent frames taken from road.

Figure 2.4(c) Mid section of tanker, rectangular sample taken for analysis.

Figure 2.4(d) Burned out shells of cars.

Figure 2.4(e) Set of rear wheels embedded in wall of campsite.

2.3 THE FINAL JOURNEY

The tanker was loaded in a haphazard way,[1] there was no metering device nor any mechanism to prevent overfilling, the driver had however to sign his acceptance of the cargo before he left the filling point. Only at the company exit weighbridge would the driver learn how much propylene his vehicle was carrying. If he was unhappy that the tank was overfull the driver could burn off the excess with a device like a flame thrower.

On this occasion the tanker held 23 tonnes. The excess payload was not 'flamed off' and the driver set off with the usual toll (equivalent to £7) for the autopista (motorway). This route was merely 'recommended', and instead the driver took the four-laned N340 coastal road.

Three and a half hours after leaving the refinery the tanker reached the 'Los Alfaques' (The Sandbars) campsite.

2.4 THE RELEASE

There is some uncertainty as to what happened just prior to the disaster but the photographic evidence, see Figures 2(a) to 2(c), points to an initial partial loss of the propylene into the campsite. Now it is known[2] that at the time a "light to moderate breeze" was blowing 'from the sea', thus this initial release must have been squirted upwind as a flashing liquid. The following circumstantial evidence supports this scenario:

a) The almost nonchalant demeanour of the campers in the photographs, see Figures 2(a) to 2(c). The mid section of the tanker was found in the vicinity of these persons and had the major event (complete failure of the tanker) happened before the photos were taken, then they would have been more than acutely aware of it.

b) The amateur photographer's statements that he, unlike those persons in the photographs, survived because he moved away towards the camp entrance in order to take more shots of the fire, whose basis was not visible to him. He also confirmed that after a small number of minutes the tanker violently ruptured.

c) The evidence from a Swedish chemical engineer who stated, before his eventual death from burns, that he and his family were inside their caravan near to the road when he heard a sharp report and smelled 'gas'. He opened the caravan door, observed the enveloping cloud and yelled to his family to get out immediately.

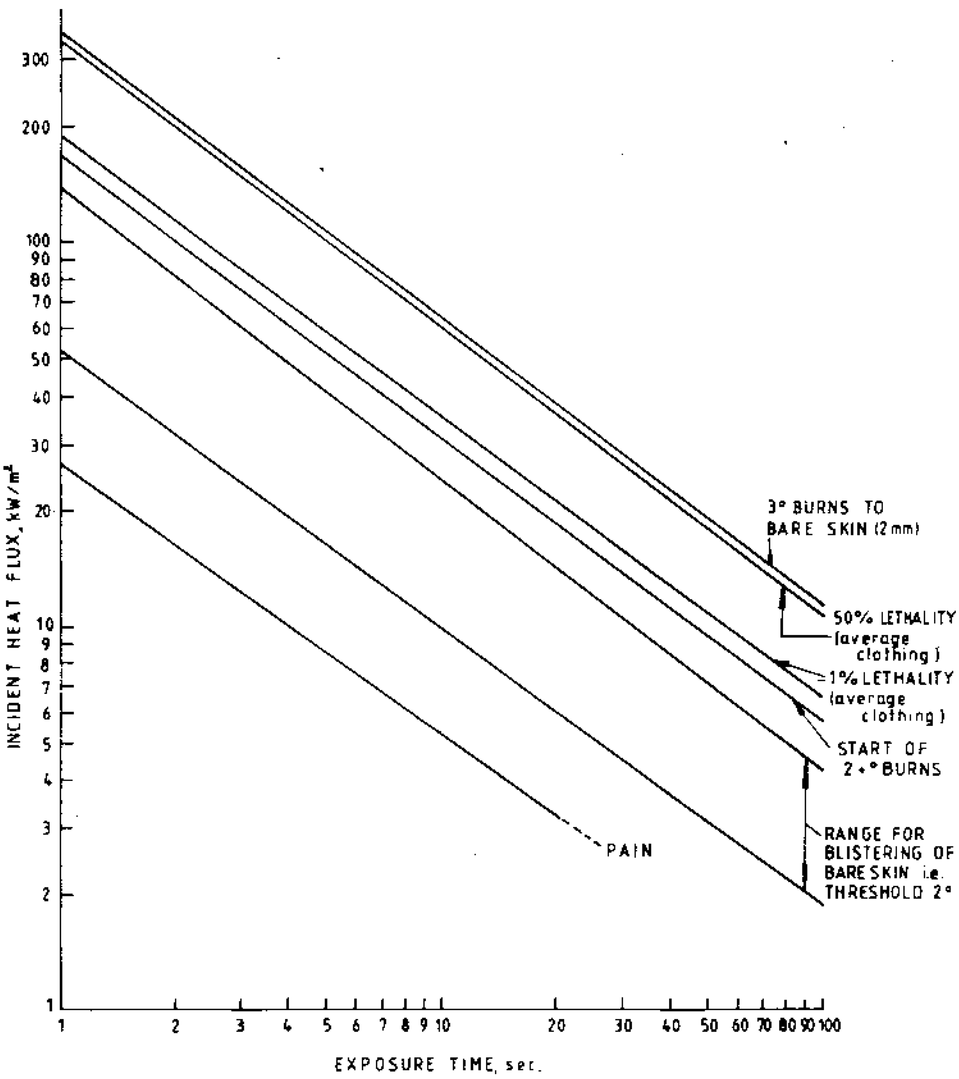
d) Aerial photographs show, (see Figure 2.3) and the report of HM Explosives Inspector mentions, a localised heavily burned zone which intruded into the site from the presumed point of release.

It appears then that there was a small scale deflagration or flash fire which travelled back to the leaking tanker and which burned there for a short time before the weakened vessel BLEVE'd. The vehicle was torn into four main pieces. The rear portion of the tank rocketted to the NW and on crashing back down, sledged and bumped along until finally lodging in a wall of a restaurant 350 m distant. A tubular length of the mid section of the tank shot sideways into the site probably demolishing part of the boundary wall. The nose cap of the tanker still fastened to the cab by the 'fifth' wheel flew down the SSW axis of the road. The tractor unit became detached en route and came to rest at 60 m whilst the endcap carried on for another 100 m shedding the 'fifth' wheel and an antisurge baffle on the way. Photographs showing missiles from the tanker are shown in Figure 2.4(a) to 2.4(e). The ejected vapour/aerosol produced a fireball.

2.5 THE CONSEQUENCES

Assuming 20 te of the payload went into the fireball the latter would be expected to have a ground level hemispherical radius of about 90 m[3,4].

The relationship between the incident heat flux F(kW/m^2) and exposure time t(sec) for various levels of burn injury is shown in Figure 2.4(f).



TOLERANCE TIMES TO BURN INJURY LEVELS
FOR VARIOUS INCIDENT HEAT FLUXES

FIGURE 2.4(f)

% body area burned	Age(yr.)																
	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80+
93+	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
88-92	.9	.9	.9	.9	1	1	1	1	1	1	1	1	1	1	1	1	1
83-87	.9	.9	.9	.9	.9	.9	1	1	1	1	1	1	1	1	1	1	1
78-82	.8	.8	.8	.8	.9	.9	.9	.9	1	1	1	1	1	1	1	1	1
73-77	.7	.7	.8	.8	.8	.8	.9	.9	.9	1	1	1	1	1	1	1	1
68-72	.6	.6	.7	.7	.7	.8	.8	.8	.9	.9	.9	1	1	1	1	1	1
63-67	.5	.5	.6	.6	.6	.7	.7	.8	.8	.9	.9	1	1	1	1	1	1
58-62	.4	.4	.4	.5	.5	.6	.6	.7	.7	.8	.9	.9	1	1	1	1	1
53-57	.3	.3	.3	.4	.4	.5	.5	.6	.7	.7	.8	.9	1	1	1	1	1
48-52	.2	.2	.3	.3	.3	.3	.4	.5	.6	.6	.7	.8	.9	1	1	1	1
43-47	.2	.2	.2	.2	.2	.3	.3	.4	.4	.5	.6	.7	.8	1	1	1	1
38-42	.1	.1	.1	.1	.2	.2	.2	.3	.3	.4	.5	.6	.8	.9	1	1	1
33-37	.1	.1	.1	.1	.1	.1	.2	.2	.3	.3	.4	.5	.7	.8	.9	1	1
28-32	0	0	0	0	.1	.1	.1	.1	.2	.2	.3	.4	.6	.7	.9	1	1
23-27	0	0	0	0	0	0	.1	.1	.1	.2	.2	.3	.4	.6	.7	.9	1
18-22	0	0	0	0	0	0	0	.1	.1	.1	.1	.2	.3	.4	.6	.8	.9
13-17	0	0	0	0	0	0	0	0	0	.1	.1	.1	.2	.3	.5	.6	.7
8-12	0	0	0	0	0	0	0	0	0	0	.1	.1	.1	.2	.3	.5	.5
3- 7	0	0	0	0	0	0	0	0	0	0	0	0	.1	.1	.2	.3	.4
0- 2	0	0	0	0	0	0	0	0	0	0	0	0	0	.1	.1	.2	.2

FIGURE 2.5 MORTALITY PROBABILITY CHART (1965-1970)

FIGURE 2.6 PARTLY SHIELDED TENTS

Let $F^{\alpha}t$ = thermal dose for one of the specified levels of injury in Figure 2.4, where F = incident heat flux in kW/m^2 and t = exposure time in seconds. Then from the slope of the log F versus log t graph we find that $\alpha = 4/3$ and the injurious thermal dose has units of $\left(\frac{kW}{m^2}\right)^{4/3}$ seconds.

A thermal dose of ca. 2600 units is required to just autoignite or melt most everyday clothing and happens also to be capable of inflicting severe second or third degree burns to bare skin.[4] Thus clothed or not if a large area of the body were exposed to such a dose the probability of death would be close to unity as Figure 2.5 implies.

From the rationale outlined in reference 4 it can be shown that pessimistic assumptions are not required to predict a high number of casualties from this incident.

For example, the case where the radiative fraction of the heat of combustion of the fuel = 0.3 and where a significant proportion of the thermal radiation is scattered by a smoky atmosphere this dose of 2600 units would obtain up to 140 m from the notional centre of the fireball. Since the tanker ruptured about halfway along the 200 m long frontage of the site this would subject everyone on the site to a high probability of death given no shielding. At the extremes of the site and for the small number of people in the sea, some injuries were non fatal thanks to the shielding of successive broadleaved trees and even the odd part-shielded tent survived, see Figure 2.6.

2.6 THE LESSONS FOR THE SPANISH AUTHORITIES

Manufacturers and users of tankers should be mindful of how transport conditions and nature of cargoes can have a deleterious effect on the vessel. 'Minimal consequence' routes should be planned by discussions between supplier, transporter, receiver, and emergency services. Proper loading/unloading and transport procedures, including sensible filling precautions with accurate metering and check weighing are basic essentials for safety, particularly for LPGs.

2.7 THE LESSONS FOR US ALL

The logistical problems of getting emergency services to, and extricating large numbers of serious casualties from such a catastrophe, in a relatively remote area are very often underestimated.

The desirability of having primary medical treatment both for minimising suffering and significantly improving the prognoses of casualties was tragically underlined in this incident.

Transporters of hazardous materials have responsibilities for safe working.

REFERENCES

1. Findings of the Spanish Court of Inquiry.

2. Meteorological report for 11th July 1978 from Barcelona.

3. Roberts A.F. 'The Effect of Conditions Prior to Loss of Containment on Fireball Behaviour'. IChemE Symposium No. 71, Manchester, April 1982.

4. Hymes I. 'Physiological and Pathological Effects of Thermal Radiation', SRD Report, R275, September 1983.

5. Bull J.P. The Lancet, November 1971, p1133.