

A series of explosions on alcohol tanks at a distillery

3 September, 2001

Lillers (Nord-Pas-de-Calais)

France

Explosion
Sugar refinery /
Distillery
Storage tanks
Alcohol / Ethanol
Potassium
permanganate
Explosive
atmosphere
Internal
contingency plan

THE INSTALLATIONS IN QUESTION

Since 1925, the company has been located on approximately 65 ha of property situated between a primarily rural and the urbanized zone of the city of LILLERS. The company processes approximately 1,000,000 tons of beets per year and operates an associated distillery with a processing capacity of 2,500 hl/day of alcohol.

The alcohol storage area, an installation attached to the distillery, consists of 9 tanks having the following characteristics :

Bund	Tank	Capacity	Volume contained during the accident
A	R1	2500 m ³	Empty
	R2	2500 m ³	825 m ³
B	R8	1500 m ³	Empty
	R9	540 m ³	470 m ³
	J5	115 m ³	Empty
	J6	115 m ³	Empty
	J7	115 m ³	Empty
	F10	1500 m ³	13 m ³
	MG11	540 m ³	Empty

As regards the regulations, on the day of the accident the establishment was operating under the authority of a prefectural order dated January 6, 1999 relating to the global update of the regulations imposed on the site. It comes under the Ministerial Order of May 10, 2000 (SEVESO 2) for the storage of flammable liquids (quantity stocked > 5,000 tons).

The installation in question was in-status and had formed the subject of a prefectural order, dated June 8, 1993, concerning additional requirements relative to the application of the ministerial technical order, dated November 9, 1989, relative to the existing old stocks of flammable liquids and specifically on the reinforcement of fire prevention and fire fighting facilities.

THE ACCIDENT, ITS BEHAVIOUR, ITS EFFECTS AND CONSEQUENCES

The accident

On September 3, 2001 at roughly **4 pm**, the distillery personnel were performing a cleaning and alcohol transfer test operation into tank F10 (1,500 m³) which was empty and degassed for this purpose. 50 kg of potassium permanganate in powder form was dispersed into the bottom of the tank and approximately 15 m³ of alcohol was gravity fed into the tank. Once this operation was completed, the personnel left the storage facility at roughly **4.35 pm**.

At 4.42 pm (t = 0), tank F10 exploded projecting its roof more than 10 m into the air. The roof fell onto the roof of tank R8. Bund B and tank F10 caught fire.



Photo : DRIRE Nord - Pas - de - Calais

At 4.52 pm (t = + 10 min.) – explosion of tank MG11. The roof was blown off and landed roughly thirty meters on a nearby stock of limestone.

The distillery's security staff, alerted by the initial explosions, went to the fire pumping station to engage the fixed extinguishing means :

- ✓ **Foam monitor of the alcohol storage facility in open position,**
- ✓ **Water spraying rings on the neighbouring silos opened,**
- ✓ **The fixed water spray rings** on the alcohol storage tanks were opened as required with foam or water from the distribution stations located near the bunds.

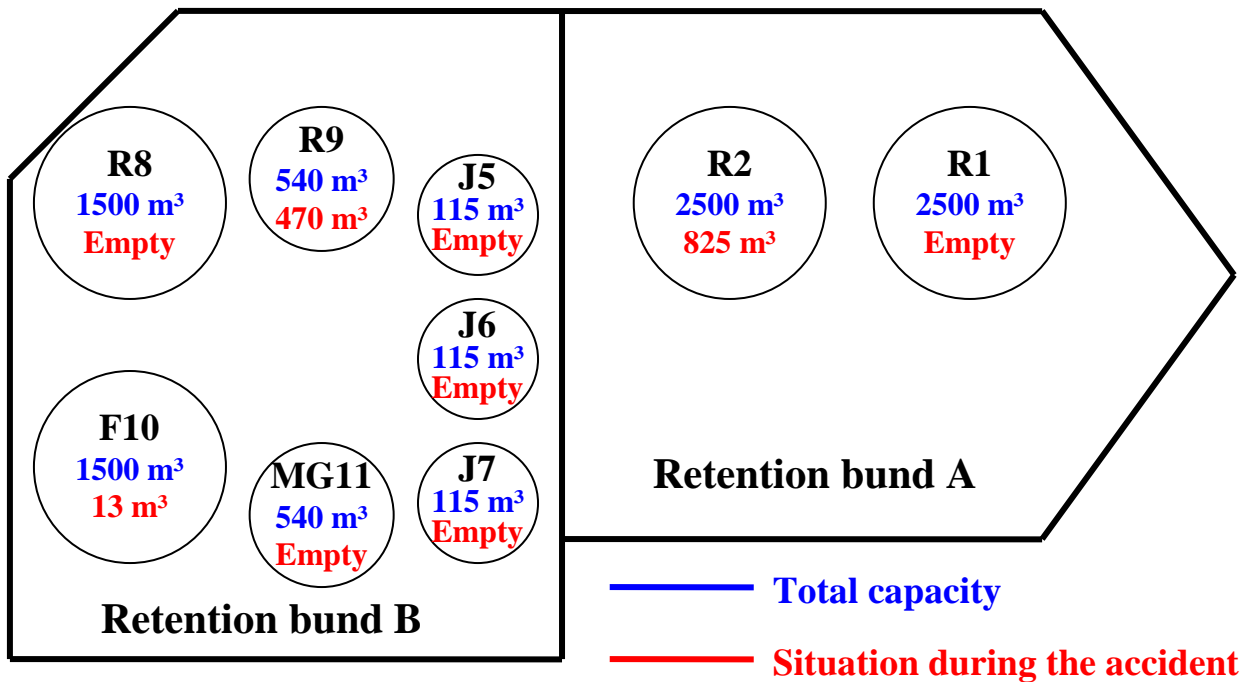
At 4.55 pm (t = + 13 min.), while the fixed extinguishing installations started to be implemented, tanks J6 and J7 exploded ripping off at roof level.

The last explosion occurred while the fixed installations were being started; fortunately no one was injured.

From 4.49 to 4.58 pm (t = + 16 min.), calls from the company and eye witnesses arrived at the CODIS 62 (Centre Opérationnel Départemental d'Incendie et de Secours, departmental fire and rescue centre) reporting " an explosion followed by flame at the Lillers distillery".

At 5.01 pm (t = + 19 min.), the plant manager put the internal contingency plan into action. The rescue services on site (firemen) reinforced the fixed extinguishing means to prevent the fire from spreading to bund A.

At 5.10 pm (t = + 28 min.), the operator's command centre was set up and began to seek foam concentrate assistance (from neighbouring manufacturers and suppliers).



Scheme : DRIRE Nord - Pas - de - Calais

The company personnel was counted: no-one was missing.

The action of the fixed extinguishing means on bund B began to take effect. The flames started to recede.

At 5.15 pm (t = + 33 min.), arrival of the fire chief and contact made with the plant manager at the internal contingency plan centre (POI). While the fire had been surrounded, the layer of foam is pierced by numerous outbreaks of flame.

At 5.35 pm (t = + 53 min.), the CODIS 62 engages the 2nd echelon.

The fixed extinguishing means and firemen were adjusted to reserve the foam concentrate for bund B and to switch to water to protect the other installations. The amount of water being pumped at this time is approximately 800 m³/h, not counting the fixed water spray rings of the storage facility and neighbouring installations.

At 5.40 pm (t = + 58 min.), four 1,000-liter containers of foam concentrate are transferred into the 30 m³ fire storage tank which is dropping rapidly.

At 5.54 pm (t = + 1 h 12 min.), the situation is assessed in the operator's command centre, then on site.

The layer of foam is stable; there is no more visible fire re-ignition, and it can be considered that at 5.55 pm (t = + 1 h 13 min.), the fire was brought under control.

The monitors are readjusted to cool down the collapsed tanks and the full tank R9. Foaming operations are reduced. Bund B is 50% full.

At 6.30 pm (t = + 1 h 48 min.) – spraying down of the neighbouring installations is stopped.

At 6.40 pm (t = + 1 h 58 min.) – the fire is out – the tanks are cooled intermittently to avoid prevent the catchpit from overflowing.

A thermal imaging camera is used to monitor the cool down of the structures.

At 6.55 pm (t = + 2 h 13 min.), the foam concentrate tank is empty. Two 1,000-liter containers from neighbouring manufacturers are pumped over.

At 7.15 pm (t = + 2 h 33 min.), a situation report is conducted between the plant manager, the CODIS and the DRIRE concerning further actions:

- ✓ immediate replenishing of the foam concentrate tank and the company's water reserve,
- ✓ monitoring of the cool down throughout the night,
- ✓ a meeting the next day to plan the unloading operations.

At 7.30 pm (t = + 2 h 48 min.), the operator's command centre is shut down.

A detachment of firemen and plant personnel will monitor the site until **8 am** the next day.

Consequences

Operating losses are evaluated at 2.13 million Euros and property damage at 2 million Euros: 1,500 m³ tank (F10) (structure collapsed) and 540 m³ tank (MG11) (roof blown off) destroyed, and the roofs of three 115 m³ tanks ripped open.

The 2,000 m³ of firefighting water were recovered in the storage tanks' bund and processed in the plant's treatment facilities (lagoon system).







15 m³ of ethanol burnt. By domino effect, the consequences of the accident were worsened by the damages caused on tanks MG11, J5, J6 and J7.



Photo : DRIRE Nord - Pas - de - Calais

European scale of industrial accidents

By applying the rating rules of the 18 parameters of the scale made official in February 1994 by the Committee of Competent Authorities of the Member States which oversees the application of the 'SEVESO' directive, the accident can be characterised by the following 4 indices, based on the information available.

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

The parameters that comprise these indices and the corresponding rating method are available at the following address : <http://www.aria.ecologie.gouv.fr>.

The level 1 of the index concerning the quantity of dangerous materials released (in the meaning of the SEVESO Directive) expresses the quantity of ethanol (15m³) and potassium permanganate (50 kg) that burnt during the fire (parameter Q1).

The level 3 given to the economic consequences is due to the cost of the material damages the company have to face with (parameter €15).

Finally, there is not any noticeable consequence regarding the human, social and environmental consequences.

ORIGIN, CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

At the request of the Classified Installations Inspectorate, the company called upon a independent expert to determine the causes of the accident.

According to the subsequent expert evaluation, it appears that the explosion of tank F10 was due to the ignition of an explosive atmosphere (ATEX) made up of alcohol vapours and air, present in the void of tank F10. The ignition was caused by a strongly exothermic reaction between a surplus of oxidizing agent, the potassium permanganate (KMnO₄), and the aqueous ethanol solution at 96%. Owing to the domino effect, the consequences of the accident were worsened by the damage caused to the other tanks.

The expert assessment was based primarily on the results of a laboratory test showing the exothermic character of the heterogeneous mixture (KMnO₄ + ethanol) in the proportions used causing the explosive air/ethanol atmosphere above the mixture of products to ignite. This permanganate mixture, which had been made since the storage facility was created (1980) without any incident, is designed to neutralize the trace of sulphur-containing components present in the alcohol.

The compliance of the installation with the instruction dated November 9, 1989, realised in 1994, and particularly the fire fighting measures (fire protection piping system, water and foam canon, containers of foam concentrate), enabled a rapid and efficient reaction of the personnel awaiting the firefighters. In addition, the Internal contingency plan realized by the company before the accident contributed to limit the damages.

The foam concentrate made available by other manufacturers located near the plant were incompatible, not enabling them to be used in the refinery's installations for flammable polar liquids (alcohols).

Moreover, positive security valves at the bottom of the tank enabled to save the 470 m³ of alcohol contained by tank R9 and thus to limit the damages.

ACTIONS TAKEN

The identical reconstruction of the tank farms was subjected to request for préfectoral authorization. The measures imposed to the operator are the following:

- Installation of a fog screen between the bunds;
- Installation of a fire detection coupled with the activation of the spray rings and of the spraying system with alarm report in the guardhouse;
- Installation of alcohol and fuel detectors alarm report of the alarm thresholds in the control room ;
- Reconstruction of the tanks with ventable roofs;
- The solid permanganate was replaced by diluted liquid permanganate liquid after the process was validated.
- Installation of foam pourer on each bund;
- Inertage of the tanks with nitrogen.

LESSONS LEARNT

On the basis of this accident, the lessons that could be learnt and worth to be highlighted are:

- ✓ Establish or improve the assistance agreement between operators and consider the different types of foam concentrate used by the neighbouring sites;
- ✓ Installation of automatic prevention systems to compensate for the absence of personnel in the immediate proximity of the installations (cooling of the installations, etc.).