Explosion of 2 heavy fuel oil tanks

10 March 1992

Verdun – [Meuse]

France

Explosion
Fire
Boiler
Heavy fuel oil storage
Heating pin, heating coil
Vents

THE FACILITY CONCERNED

Site:

The suburban residential area in the heart of the Verdun metropolitan area houses the Mirabel district where the barracks are located. In the barracks is installed a central boiler room at less than 3m from its enclosure wall and a road with individual and collective housing units.

The unit in question:

The boiler room was completely refurbished in 1978 and has been working without any significant modification since then. It is installed in a 20 x 10 m masonry with a metal covering and houses three 1.45 MW boilers, each of which is supplied with both heavy and domestic fuel oil. The masonry also houses a 20m high free standing chimney in steel. The heavy fuel oil is stored in two 100 m³ vertical overhead metal tanks and the domestic fuel oil is stored in a 10 m³ underground tank. The two heavy fuel oil tanks are placed in a 10.60 x 5.80 m and 2020m deep leak-proof dike strapped-on to the gable of the building. The tanks are equipped with a float gauge and lined with a rock wool lagging protected by aluminium sheets. The fitted tank weighs approximately 5 tonnes.

For each tank, the heating of the heavy fuel oil for its storage, transfer and spraying is carried out by:

1 water coil in a steel tube placed 40 cm deep whose temperature is regulated by a motorised three-way control valve that maintains the temperature of the preheating water at 80℃.

Two 4.5 kW electric exhaust heaters located on either sides of the suction strainer. The heaters are controlled by sensors that measure the fuel oil temperature at the feed point to the tanks and operate if heating with water is insufficient. Electric heating is interrupted when the temperature of the fuel oil reaches 80℃.

Heat plotters that maintain an appropriate temperature throughout the feeding process.

Administrative situation:

Due to its power and storage capacity (more than 150m³), the facility comes under the category of facilities to be declared within the framework of regulations governing classified facilities (ex section 153 bis and 253D).

THE ACCIDENT, ITS COURSE, EFFECTS AND CONSEQUENCES

Accident:

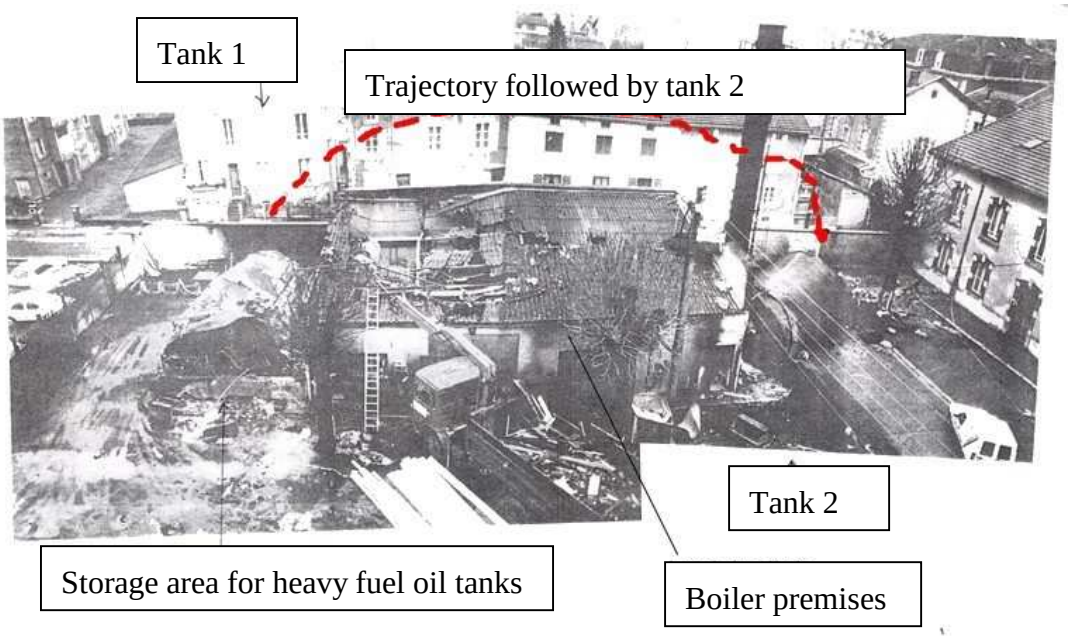
On the morning of 10 March, the two boilers were functional while the third served as back-up. The quantity of heavy fuel oil in tank no. 1 was 7m³ and in the reserve tank no. 2 was 51 m³ and was kept heated to immediately take over from tank no. 1.

Around 5h00, a resident of the district heard a boiling noise from the storage unit without paying much heed.

At 6h00, the roundsman, during his visit to the boiler room did not observe anything abnormal.

At 6h07, tank no. 1 explodes. The seam weld between the shell and the bottom had completely ruptured. The tank was thrown not very high off the ground and landed on the building of the boiler room. The fuel oil in the tank spilled on to the dike and caught fire.

Thirty seconds later, the second tank exploded. It was detached from its bottom the same way and took off like a "rocket" to a height of 50m according to some witnesses. After hitting the upper portion of the chimney, it landed on the other side of the building and spilled its content.



Source: D.R.

Consequently, the dike also collected the fuel oil spilled on to the courtyard. The equipment in front of the building was destroyed (fire extinguishers, electric cabinets, waste bins, etc.). The rescue services arrived at around 6h15 on the site and initially focused on protecting the residences and vehicles in the vicinity of the boiler. The firemen used foam gun and quickly put out the flames in 10 minutes.

Consequences:

There was no human casualty but considerable material damage caused: destruction of fuel oil storage and a part of the boiler feeding system, internal damage to the buildings, electric circuit and chimney, and external damage to vehicles parked outside the enclosure wall of the barracks and residences (roof damaged due to fall of debris, window and windshield glass shattered, smoke stains and dirt inside homes, etc.). The renovation of the facility is estimated at 1 million Francs 1992 (191,120 € 2006) and damage to third parties at 300,000 Francs 1992 (57,336 € 2006).

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:

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

Level 1 is attributed to the dangerous materials released (Q2 parameter) since the accident corresponds to an explosion with an equivalent TNT mass less than 100 kg (glass shattered within a radius of 330m).

Lastly the damage caused to the boiler and to third-parties estimated at 1 million Francs 1992 (0.156 M€ ECU 1993) and 300,000 Francs 1992 (0.047 M€ ECU 1993) respectively justify level 1 for the 'economic consequences' parameter (parameters €15 and €17).

ORIGIN, CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

The various investigations conducted brought to light the following facts:

The fuel oil level in tank no. 1 was very low and must have reached the level of the suction strainer.

The exhaust heater of tank no. 1, that ought to have been immersed at all times, was initially raised or during a maintenance operation with an offset of ¼ a turn from its normal position. This allowed an electric pin to protrude from the fuel oil when it was at its lowest level in the tank.

The line heater that was not functional had been removed. To compensate for the loss of heat during the transfer, the heating temperature of the tank has been raised.

The electric pin protruding from the fuel oil was found with strong traces coking, which proved that very high temperatures had been reached.

The two tanks were not fitted with a flame arrestor at the vents.

Explosion of tank no. 1

The cold night coupled with the low thermal inertia of the fuel oil lead to a massive heating requirement by the control system and to the frequent activation of the electric heating system. The electric resistance temperature very close to the fuel oil surface increased due to poor heat exchange (metal-gas contact instead of metal-liquid). This caused the parts of the surface of the fuel oil to over heat and boil with a beginning of coking born out by the presence of pitch on the electrical resistance. In these conditions, the air-hydrocarbon vapour mixture on the surface is too rich to cause the tank to explode. When the electric back-up system was stopped, the convection effect caused the air to enter into the tank via the vent creating explosive conditions. When the system was switched on, the resistance was far enough from the fuel oil level to rapidly heat up and reach the self-combustion temperature in a mixture conducive to combustion and thus resulting in an explosion.

Explosion of tank no. 2

The control system common to the two tanks caused the second tank to overheat. The air in the second tank was rich in inflammable vapours. The fiery projectiles coming from tank no. 1 could enter tank no. 2 through the unprotected vent or set fire to the vapours escaping through the vent resulting in the second explosion.

The accident highlights:

An initial flaw in the design of the facility and inadequate analysis of its safety: there was no safety system insulating the electric pins in case of very low fuel oil levels. The vents were not protected by flame arrestors;

An abrupt modification in the facility (removal of line heater) and operating conditions incompliant (heater overload) with the design specifications without an adequate risk analysis.

Poor running, monitoring and quality control of maintenance operations: the heating pin was not properly assembled, the boiler room manual not kept up to date, the tri-annual inspection by certified experts within the framework of the order dated 5 July 1977 on the visits and detailed and regular inspections of facilities consuming thermal energy were not carried out.

ACTION TAKEN

The operating guidelines of all boilers in the barracks were made more clear. They require a minimum level of fuel oil in the tanks to keep the resistances always submerged and display of safety guidelines in the premises where the operating staff work.

The electric heating of the strainer was removed from all places where there was no strict requirement. Lastly, flame arresters were installed on the vents of each tank. All operating units were also reminded that the cloudy sky above the tanks could contain inflammable vapours.

LESSONS LEARNT

The “exposure” of heating pins is frequent reason behind overheating and explosion of tanks containing hydrocarbons and organic matter. The level of the substance in the tank can be constantly maintained above the pin by making design adjustments (suction strainer level, level control device, controlling heating, etc.).

On the organisational level, any modification, even of a trivial nature, in a technical facility with respect to the construction plan is likely to have serious environmental, material and human consequences. Moreover, it is also advisable to ensure compliance with the facility design and maintenance operations by performing checks and validations at each stage of construction.

Moreover, if human errors can be easily identified, they must not dissimulate any organisational setbacks that may strongly call into question any habitual practise (operating guidelines, scheduling inspections in the time frames stipulated by regulations, drafting procedures for taking action, etc.)

The human consequences of these two explosions could have been dramatic. However, at the time of accident nobody was in the vicinity or in the adjoining residential area. Setting up facilities in urban areas, which seems rather ordinary (petrol pumps, fixed storage of a boiler, etc.) requires taking into account the risk of accidents and especially the gravity of the possible effects on persons likely to be exposed in the neighbourhood (respecting the minimum distance between the facility and enclosure).

Similar accidents:

Accidentology has recorded several cases of explosion of tanks involving the heating system of the content.

Annonay accident in 1983 (Aria 546)

Ambes accident in 1993 (Aria 4587)

Sommesous accident in 1998 (Aria 12675)

Bar-Sur-Aube accident in 2005 (Aria 29128)

Givors accident in 2006 (Aria 31604)