

Fire in hydrocarbons depot

14th June, 1991

Saint Ouen - [Seine-Saint-Denis]

France

Fire

Flammable liquids
farm

Valve

Gasoline

Works

Victims

Difficulties of
intervention

THE INSTALLATIONS IN QUESTION

The context

The hydrocarbons depot, designed in 1912, is bisected by a road, completely isolating the two sites from each other. Only one of these sites was affected by the incident. The depot is surrounded by a 3 metre high curtain wall and borders on:

- ✓ to the East: by a railway network originating in the docks and serving a hangar (3 000 m²) belonging to a paper recycling company, situated at 30 m from the wall. The RER railway passes, at its closest point, at 50 m.
- ✓ to the West: by the road which bisects the site on which are 2 buildings close to the wall ;
- ✓ to the North: by a number of single story industrial buildings;
- ✓ to the South: by a road and a block of buildings housing public works material.

The site

The depot is subjected to authorisation and consists of 37 fuel tanks (gasoline, diesel fuel and domestic fuel oil). It is supplied in hydrocarbons by a conduit with 3 buried pipes, by barges, by tank trucks and by cistern wagons.

For the last 20 years, the pipes have been equipped at several points with 3 inch t-flange purges positioned outside the bund, sealed with orifice plates with 4 bolts and enclosed in an open sump.

The depot has internal means of defence comprising :

- ✓ A network of 13 fire hydrants (of which 10 are on the accidented side, branching from a single 250mm pipe with a flow of 480 m³/h at 10 bars which can be increased to 12 bars by two pressure booster pumps ;
- ✓ A foam producing station on the same conduit, with 5 110 mm nozzles fed by 2000 l of water + emulsifier in reserve in the conduits and 6 000 l of emulsifier in a rechargeable tank ;
- ✓ An emulsifier truck of 14 000 l capacity ;
- ✓ A cistern of 2 000 l of synthetic emulsifier of the A3F type (Agent forming a floating film) ;
- ✓ 22 barrels of 200 l of emulsifier ;
- ✓ 3 foam cannons.

Additionally, there is an inter-oil company agreement between the depot and the neighbouring depots to supply emulsifier in case of need. The personnel of the depot, 6 on the day in question, is in charge of deploying all these means.

The circumstances

Starting several days previously, the depot operator had been running a programme of measurements, throughout the site, of the closure times of the motorised valves at the foot of the tanks.

In parallel, work has to be started on June 14th to refurbish the supply network for tank N°2 as from the transport terminal manifold. In preparation for this, tank N°2 (4500 m³ of super grade gasoline), linked with tank N°1 (14 480 m³ of super grade gasoline), was emptied and de-gassed ; the 14 inch feed pipe to the tank in question was isolated by a "saucepan handle" (sealing plug). The tank and the isolated part of the piping were emptied and de-gassed. The other part of the network (feed to tank N°1) was simply purged after closure of the valve at the foot of tank N°1, at that time filled with 9,000 m³ of super grade gasoline.

Having obtained the fire permits countersigned by their hierarchical superior, 3 operators from an outside specialised company, commenced acetylene welding on the "firemen's way" outside the bunds close to one of the purge inspection points. Although their work was undertaken outside high risk zones, they placed powder extinguishers close by and an explosive atmosphere audible warning device set to 30 % of the lower limit of explosiveness.

THE ACCIDENT, ITS BEHAVIOUR AND CONSEQUENCES



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The accident

Friday 14th June at 11h15, a flash followed by a fire in a sheet of gasoline on the ground suddenly occurred close to the operators. Surprised, the workers turned around and saw their generator surrounded by flames. They immediately attempted to extinguish the fire with their extinguishers but it became too violent and spread rapidly over 100 m² of the ground. On being informed, the manager of the depot initiated the "POI" (Internal Operation Plan): he alerted the fire brigade on a direct line and initiated the emergency stop which commands the closure of all motorised valves in the depot in between 45 and 60 seconds, also cutting the general electricity supply. He also warned the depots in the Paris region, in the framework of the inter-oil company agreement, so that they could place at his disposal a part of their specific fire-fighting facilities, (essentially consisting of fire-hoses and reserves of emulsifier). Simultaneously, the 10 men present in the depot set up a water cannon and turned on the pressure booster pump of the internal fire network.

Intervention of the fire brigade

As from 11h27, even before their arrival at the site, the firemen saw a dense cloud of smoke rising from the fuel depot and requested the despatch of a second echelon as reinforcements. Thus some twenty additional fire engines set out towards the fire. Arriving at 11h30, the firemen were immediately committed in assisting the personnel of the depot. "The "firemen's way" was already submerged under a layer of burning hydrocarbons.

From 11h30 to 12h26, external support continued to arrive in successive waves bringing into play major means. Medical teams from the fire brigades and the "SAMU" (emergency ambulance service) were despatched to the site to provide medical cover for the fire-fighters. The businesses and habitations in the surroundings were evacuated or spontaneously deserted, intensifying the vehicle traffic which burst fire-hoses when running over them. After 30 minutes, 4 foam cannons and 2 water cannons, including a high-power water cannon, were in action. However the intensity of the fire did not diminish. 3 times, the depot manager confirmed that the fire could not be fed as, according to him, all the valves had been closed. A violent hydrocarbon fire developed between 3 tanks: tank N°2, empty and degassed being beside the site of the works, tank N°93, containing 4,527m³ of fuel and finally tank N°75 practically empty but not de-gassed. This latter fortunately had a heat-resistant coating, reducing the risk of explosion by over-pressure.

From 12h27 to 13h00, while the fire was still extending, the firemen saw a flaming leak, a vertical jet, 2 to 3 metres high, squirting from the ground on the access way running along the bund of tank N°2. However the depot operators still could not explain the origin. Unburned hydrocarbons were flowing towards the railway and feeding an intense fire which was threatening 3 parked wagons as well as 2 other tanks in the depot. A few metres behind, the cladding walls of the paper warehouse were blackening. The bursting of numerous hoses created serious difficulties in the water supply. Consequently, to limit the traffic, the Police, set up roadblocks around a radius of 600 m around the depot.

13h01 : 12 fire-hoses were in action ; the emergency services became certain that the fire is being fed but still without knowing from what source.

13h05 : the emergency services had to fight against the extension of the burning sheet of fuel and, although almost the total supply of emulsifier from the neighbouring depots has been requested by the depot operator, the fire-brigade decided to bring in its own reserve stock.

13h12 : the depot management made another inspection tour to check all the valves, without discovering the origin of the leak. The wagons parked on the railway were now under direct threat and the firemen had to take precautions to avoid the neighbouring warehouse catching fire.

14h13 : volunteer firemen in protective clothing, went in their turn to check the valves at the foot of the most exposed tanks ; they reported that they were all closed.

From 14h16 to 15h00 : a front end loader belonging to the depot operator was placed at the disposal of the fire-brigade and, despite the risks of the machine catching fire, a fireman and then a driver from the brigade proceeded to tip three loads of sand.

15h00 and 15h53 : on two occasions, following the passage of vehicles, the breaking of the power supply to a foam generator provoked the re-inflammation of a sheet of super gasoline floating on the water from the fire pumps ; 11 firemen suffered burns of whom 4 seriously. The 2 acetylene cylinders left on the work site exploded, slightly wounding another fireman.

15h33 : a barge arrived to support the firemen and the engineer is given the mission of surveillance of the SEINE with a view to preventing any pollution.

15h53 : while the operation of suffocating the fire was starting to show results, it was observed that the valve at the foot of tank N°1, containing super grade gasoline, was open . It led to a conduit of which the purging orifice, precisely positioned at the spot from which the flaming leak emerged, was open. As soon as this valve was closed, the fire suddenly calmed down and only a fire of low intensity persisted at the level of the conduit in the bund of tank N°2. The director of the depot declared that this conduit should have been water-filled, given that welding work was in progress on the "firemen's way" and that, for this reason, it was not part of the check-list for valve closures nor on the control panel check.

16h11 : roughly 15 minutes after the closing of the valve, the fire had been mastered. The impressive material committed or in reserve was progressively withdrawn as the cooling of the overheated metal parts continued.

19h12 : the director of the emergency services announces that the fire had been extinguished. A surveillance contingent provided support for the depot's teams who remained on standby and protection duties. A foam projector from the depot maintained the foam carpet throughout the night and two big fire hoses continued with the cooling of the metallic structures. A secondary residual gasoline leak was neutralised using internal emergency facilities.

22h55 : A walk round check was made and no new problem was detected.

From midnight to 17h45 on 15th June : regular relief of the services and walk round checks of the site.

From 15th June 10 h until 16th June 17h45 : the depot operator pumped the extinction water and fuel filling the bunds and proceeded to fill the hydrocarbon distribution conduits with water.

16th June at 17h45 : The intervention of the emergency services was completed.

The consequences

This intervention, mobilised 472 firemen and required the use of 20 fire-hoses, 10 km of hosing and the consumption, practically at a total loss, of 3,000 m³ of water and 42,000 l of emulsifier out of 77,000 l available. (54,000 l. supplied by the depot and its suppliers and 23,000 l by the fire brigade).

The services, whose planned access to the installations, according to the Internal Operations Plan, was cut ("Firemen's Way" on fire) and who were misinformed by the operator as to the origin of the fire and the status of the installations, took very serious risks. 4 firemen were badly burned and 11 others were injured during this operation.

One person from the public was also slightly injured by the bursting of a fire hose.

The fire consumed 620 m³ (flow rate: 150 m³/h) and partially, 50 m³ of fuel. Damage to the installations is however relatively light : one tank destroyed and 2 others deformed. On the exterior, four railway lines were damaged and a train of 3 wagons destroyed. A large amount of fire-fighting material was also degraded.

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							
Human and social consequences							
Environmental consequences							
Economic consequences							

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 3 indicated as the index relating to dangerous substances (in terms of the SEVESO directive) characterises the quantity of super grade gasoline released during the fire (Q1, 620 m³ of gasoline released for a SEVESO threshold of 25 000 t : 1,87%).

With 4 firemen seriously burned and 11 other injured, the index of social and human consequences reached a level 2 (parameters H4 et H5).

The cost of material damage is estimated at 2.7 M€, that is to say an index 3 for the criterion "economic consequences" (parameter €15).

Finally, this accident did not generate any known environmental consequences.

ORIGIN, CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

There exist buried conduits at a depth of approximately 2 m, to the right of the starting point of the fire. They serve to supply the tanks from the manifold of the transport terminal, situated at the entry to the depot and to feed from the tanks the loading points for the tanker-trucks. Considering several low points on these conduits, they are equipped with maintenance purge points used when work is required on the tanks or the piping and which allow for pumping with a gland pump any remaining liquids. There are around 15 inspection hatches (section : 50 cm x 50 cm) enclosing these maintenance purge points close

to the point of the fire and situated outside the bunds. These maintenance purge points consist of a pipe ending some thirty centimetres below ground level and sealed with a liquid proof orifice plate, retained by 4 bolts.

The product escaped through one of these purge points which was badly closed, (only 1 bolt tightened of the 4 bolts). The leak was of super grade gasoline (flow-rate : 150 m³/h) from tank N°1 which the bottom valve remained open despite the remotely controlled emergency shut-down.

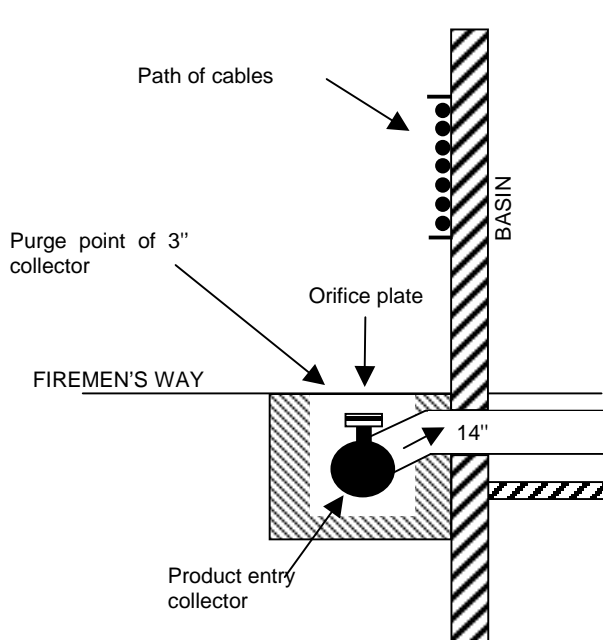
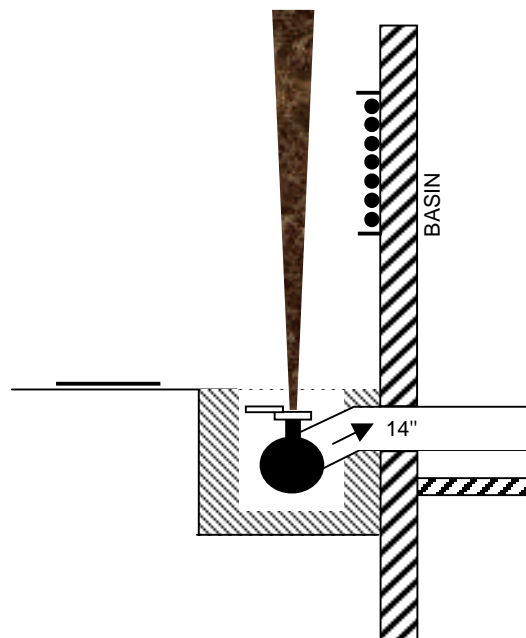
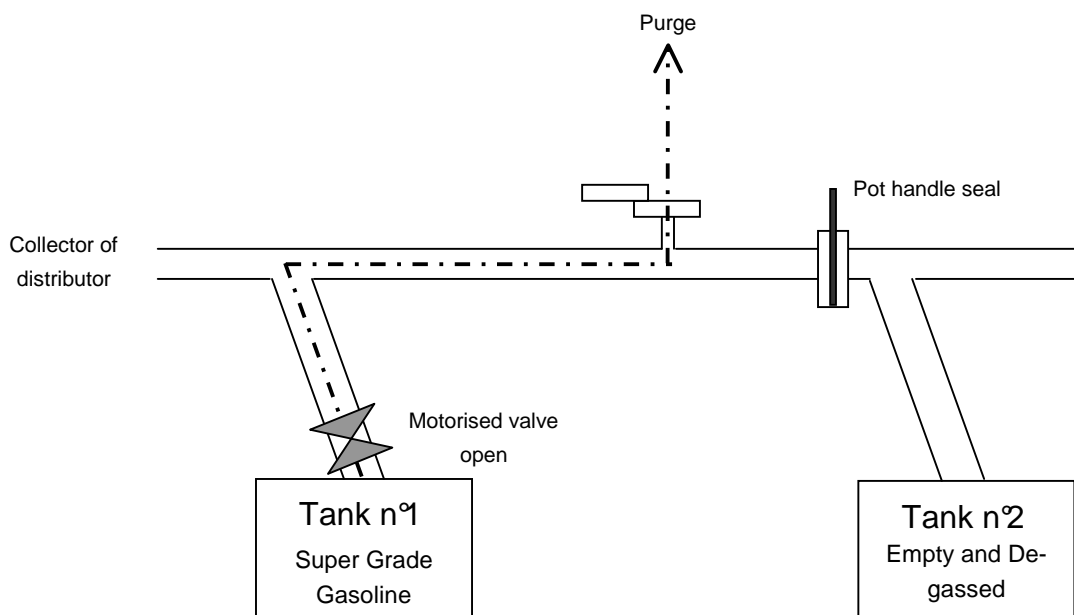


Diagram of purge

Under normal conditions



During the incident



Piping diagram

The following hypothesis has been retained: on Thursday evening, at the end of the day's work, the closing seal of a maintenance purge point was put back into place but only one bolt was used. On the 14th, the entry valve to tank 1 was found open for an unknown reason. The gasoline contained in the tank flows at a rate of 150 m³/h and the pressure causes the orifice plate of the purge point to pivot. The gasoline then squirted out and its vapour was ignited by a spark generated by the welding work in progress near by.

Two hypotheses have been expressed concerning the opening of the tank bottom valve:

- ✓ The opening of the valve from the remote control centre is the most probable hypothesis in the view of the operator (unconfirmed human error).
- ✓ The presence of petrol vapours in the piping of the maintenance purge point (which was empty but not de-gassed) which ignited, causing the deterioration of the electrical cables and provoking the opening of the valve.

It appears that a second valve, damaged by the fire, also allowed some fuel to escape.

Detailed examination of the accident revealed other anomalies which aggravated the incident:

- ✓ As regards the design of the site:
 - Following the cut-off of the general electrical supply on the emergency shut-down, the control table view of the installation's conduits, with no back-up, was unavailable (indicators of valve positions, electrical supply to valve motors at the foot of the tank...).
 - The motorised valves had no hand operated security backup.
 - The electrical supply cables to the valves had very poor fire resistance, less than 3 minutes.
 - The installation and the localisation of the purge points for the buried conduits had no retention vessel and ran along the access provided for the emergency services.
- ✓ From an organization standpoint, the conduit which fed the leak should have been flooded with water on account of the welding work in progress on the "firemen's way" and did not therefore figure on the valve closing check list nor on the control panel.

The difficulties encountered during intervention

The fire brigade met numerous difficulties during their intervention:

- ✓ Lack of electrical backup for the control panel overview and the lack, or absence, of information supplied by the operator concerning the nature and the origin of the burning product made it extremely difficult to prepare an effective strategy to combat the fire. This applied particularly to the use of sand which could not be effective against a leak fed by such a powerful flow.
- ✓ Considerable delays in finding out the origin of the leak and thus in closing it off.
- ✓ The existence of the depot in a built-up area, the only possible access to the fire, the "firemen's way" in flames and, the distance from the water risers required the use of flexible hose pipes over long distances, crossing roads with vehicle traffic and thus resulting in the bursting of a number of them. The explosion of acetylene cylinders used for the maintenance work in progress prior to the accident, under the heat of the flames, placed the firemen in additional danger.
- ✓ The extension of the fire beyond the boundaries of the depot towards the railway line necessitated the use of additional means under difficult conditions.
- ✓ The perilous conditions for the firemen who were working with their feet in a mixture of water and hydrocarbons.

ACTIONS TAKEN

Following the accident, the following measures have been taken:

- ✓ Modification of the purge points (manual valve with visualisation of position, bunds, position above ground);
- ✓ 15 minute backup for control panel;
- ✓ Minimum fire-resistance of cables supplying power to valve motors increased 10 min;
- ✓ Backup of motorised valves by fuse operated shutters;
- ✓ Additional emergency shut-down buttons dispersed throughout the installation;
- ✓ Installation of 3 additional fire hydrants;
- ✓ Installation of a fixed conduit around the depot to avoid the requirement for numerous flexible hoses in the event of fire;
- ✓ Increase of the flow of water for fire-fighting (either by a pipe from the SEINE or a renewable reserve or any other means...);
- ✓ Revision of the Plant Operating Plan to take into account 5 additional accident scenarios.

The fire-fighting water and the hydrocarbons on the site have been pumped away and treated.

LESSONS LEARNT

Numerous lessons can be learned from this accident

Firstly, as regards the design of the site, this major fire leads to the institution of the following precautions:

- ✓ Every orifice, valve etc., must be linked to a bund;
- ✓ The motorised valves must be fail-safe and backed up by remotely controlled manual valves;
- ✓ The electrical cabling of the valves must be sufficiently fire-resistant to permit the secure shut-down of the installations;
- ✓ The general control panel must be operational in the event of emergency shut-down in order to identify the original failure or failures which could aggravate the incident;
- ✓ Access to the site for the fire brigade must be designed to allow for easy intervention.

The scale of the accident can essentially be blamed on an error of judgement concerning the motorised valve at the foot of the tank which, supposedly closed, was considered to be 100% sealed against liquids or vapours.

These mistakes reveal weaknesses in the general organization and demonstrate, in particular:

- ✓ Poor appreciation of the parameters of equipment important for safety (power supply to valves and the control panel);
- ✓ Insufficient operator training (poor knowledge of danger sources);
- ✓ Sub-standard application of safety rules (re-installation of orifice plate);
- ✓ Inadequate quality control of work completed and of the strict application of safety rules (fire permit delivered without complete check of prior security measures).