Fire on a stainless steel production line

23 December 2012

Gueugnon (Saône-et-Loire)
France

Metallurgical industry
Fire
Stripping
Fire detection
Fire extinguishing
Lockout
Maintenance
Hot spot
Backup power supply

THE FACILITIES INVOLVED

The site:

This metallurgical facility is located in the centre of the town of Gueugnon on a 34-ha site along the riverbank. The specific spot had been occupied by an activity dating as far back as 1724. The current company was founded at the end of 2010 out of the Group's desire to create a spinoff relying solely on its stainless steel alloy activities.

The Gueugnon site receives stainless steel rolls, proceeds with the lamination step and, in certain cases, finishing work. The plant itself employs a workforce of just over 800 people and comprises:

- chains dedicated to the annealing, shot blasting and stripping of the steel rolls;
- furnaces;
- production trains;
- annealing stations including rolling mills;
- finishing units (cut-outs, and sheet, disc or tight reel finishes).

The site was responsible for producing the hydrogen, nitrogen and oxygen required for the particular combustion conditions in the annealing furnaces thanks to an Air Liquide station set up on-site.

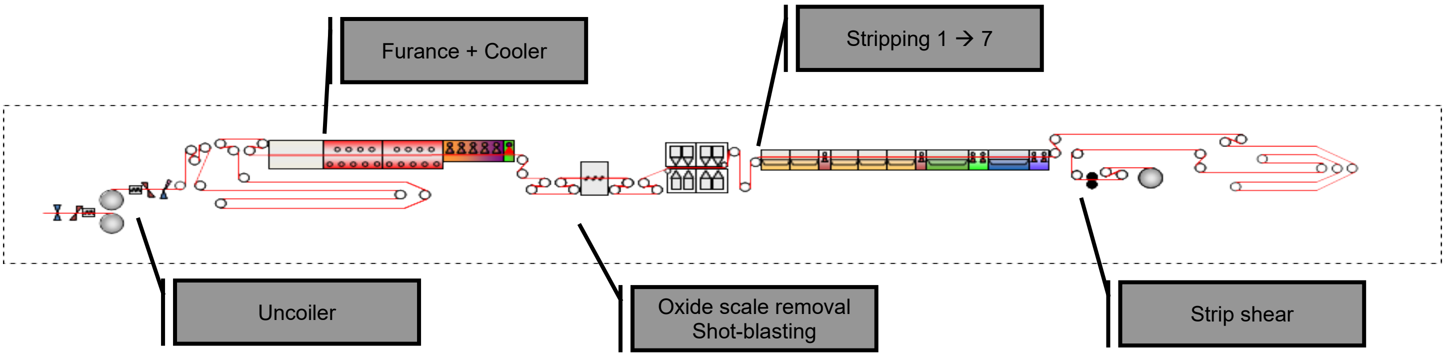
The stripping operation requires large amounts of hydrofluoric acid (HF) to be stored, which triggered the upper-tier SEVESO classification.

The specific unit involved:

The machinery placed on the new RD79 annealing-stripping line had been introduced during the production preparation phase lasting several weeks, but it had not yet been officially accepted.

The RD79 line is composed of:

- an input section with an uncoiler and an accumulator;
- a furnace + cooler section;
- a section for removing oxide scale and shot-blasting;
- a stripping section containing 7 polypropylene PPM tanks:
  - 5 hydrochloric acid tanks (numbered 1 through 5);
  - 1 hydrofluoric acid (HF) tank UG3P (No. 6);
  - 1 nitric acid tank (no. 7).
- an output section with an accumulator, a strip shear and a winding reel.



Moreover, the line contains ancillary technical premises, some of which are located on the mezzanine level, as well as electrical substations, tanks for collecting used acid liquor and mist washer jets.

Status of fire detection and protection devices on the RD79 line prior to the incident

• Existing detection and protection devices:

Since 16 October 2012, the RD79 line had been equipped with the following detection and protection features at the stripping station:

Smoke detectors:

– acid supply pumps on tanks 1 and 2;
– acid supply pumps on tanks 6 and 7;
– eastern stripping premises.

Flame detectors:

– stripping tanks 1 through 7.

Heat detectors:

– ducts and washers in unit named UGCO;
– ducts and washers on tanks 6 and 7.

Automated sprinkler system with a fuse head either underwater or by immersion:

– stripping tanks 3 through 6 (extinction by immersion);
– UGCO ducts and washers on tanks 3, 4 and 5 (extinction by immersion);
– washers on tanks 6 and 7 (extinction by immersion);
– Eastern sector stripping premises (extinction by sprinklers with a fuse head exposed to air).

Protection by means of a fire hose cabinet was operational at the entrance to the shot-blasting station on the Western wall.

All alarms were relayed into the line's input and output booth on an alarm annunciator, indicating the target zone. They were also relayed onto fire-fighters' beepers at the guard station, to the Operations and Maintenance Department and on the RD79 station manager's cordless phone.

• The following zone protections were on order or being installed:

Automatic extinction by immersion:

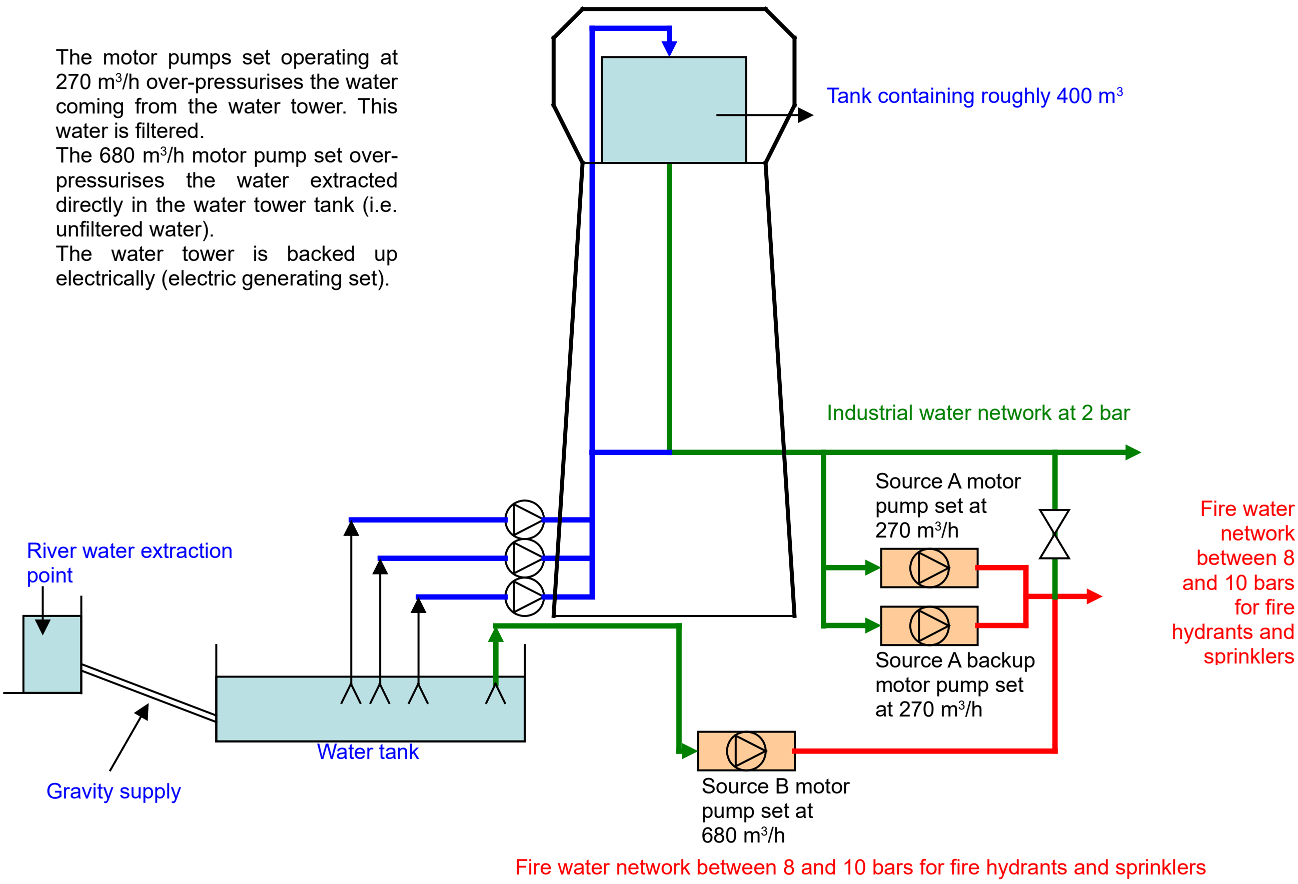
– stripping tanks 1 and 7;
– UGCO ducts and washers on tanks 1 and 2;
– ducts on tanks 6 and 7.

Planned extension of the Southern fire hose network after dismantling of the GD09 line.

Status of fire water supply facilities

In order to supply, as a priority, the fire water network and sprinkler type installations, the site had been equipped with:

– a source A motor pump set operating at 270 m^3/hour and its backup also running at 270 m^3/hour,
– a source B motor pump set operating at 680 m^3/hour.



The 680 m³/hour motor pump set directly draws water into the reserve located below the water tower. The 2 motor pumps running at 270 m³/hour were fed via the water tower and industrial water network. The combination of these sets of pumps supplied the sprinkler protection system as well as the site's 23 fire hydrants and a portion of the fire hose cabinets.

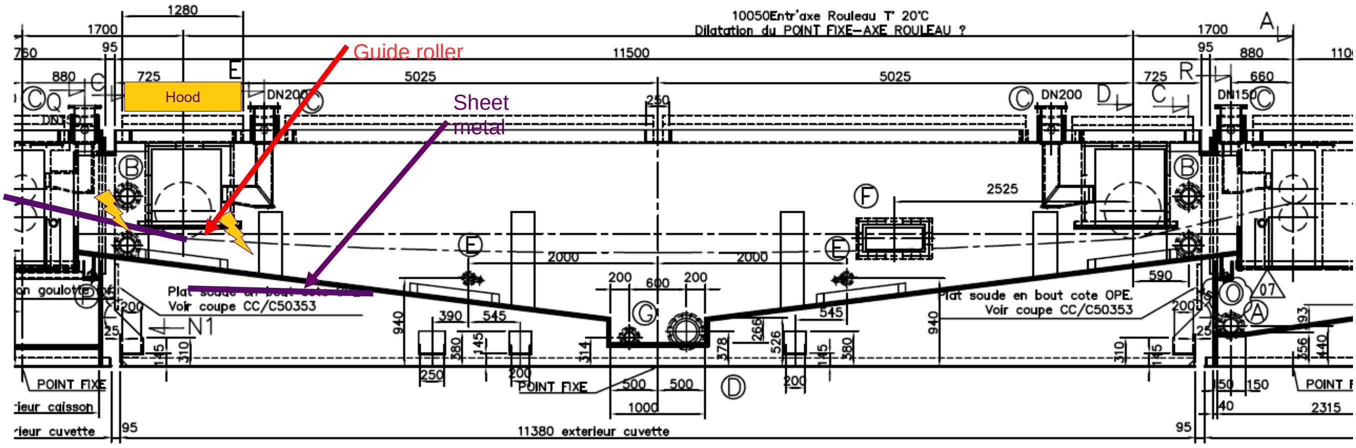
On the day the fire broke out, both A motor pump sets at 270 m³/hour had been operational, while the B motor pump set (680 m³/hour) was down subsequent to a major malfunction that had occurred in July 2012 while treatment was underway.

THE ACCIDENT, ITS CHRONOLOGY, EFFECTS AND CONSEQUENCES

The accident:

The 450 m long RD79 line is composed of several sheet metal treatment stations. This accident mainly affected the stripping installations. Investigations indicated that the most likely source of the ignition point was a welding operation taking place on a strip of sheet metal, which is typical in the process (occurring roughly once a month) and supervised by a specific procedure.

Less customary however was the fact that this operation had been carried out using a sheet metal strip guide roller, in a particularly narrow spot, which required the operator to wear both a head lamp and a mask.



The tests performed by the plant operator revealed that the material surrounding the roller, i.e. EPDM (ethylene propylene diene monomer) rubber, only required a small amount of energy to ignite. Placing a match in immediate proximity would cause it to slowly burn and be consumed entirely.

Upon completing the welding operation, the personnel began to reactivate the line in order to remove the belt without first reconnecting the fire detection system:

– gradual filling of stripping tanks, which had been drained in preparation of the welding operation;

– reactivation of the acid vapour exhaust hood.

Turning the hood back on most likely fanned the hot spot.

The flame was thus able to spread to the polypropylene lid on the closest stripping tank. The thicker tank walls liquefied and in turn also ignited.

These tests actually proved that the input of a high amount of energy was necessary to cause the polypropylene to burn.

Moreover, the line's compressed air pipes, made of a plastic material, melted while allowing a large quantity of air to escape, which undoubtedly contributed to fanning the fire.

Given the workshop's acidic atmosphere, much of the line's equipment had been designed and built using plastic: stripping tanks, honeycomb platform, acid vapour suction pipes, compressed air pipes, etc. These items, engulfed in the fire, generated a very significant combustible potential.

Chronology of the tripping of fire detection devices:

As a result of the RD79 line's fire detection lockout, the first information was conveyed by a sensor installed in a room adjacent to the RD79 line; known as UGCO. This room stored the buffer reserve of concentrated hydrofluoric acid used to supply the stripping tanks and moreover featured a smoke detector that transmitted an alarm to fire-fighters. The multiple and repeated detections then activated sprinkling within this room once the sprinkler heads had melted.

Next, the heat detectors present in the acid vapour suction duct relayed the information and triggered sprinkling inside this duct.

Lastly, the site's in-house fire-fighters manually activated sprinkling of the tanks.

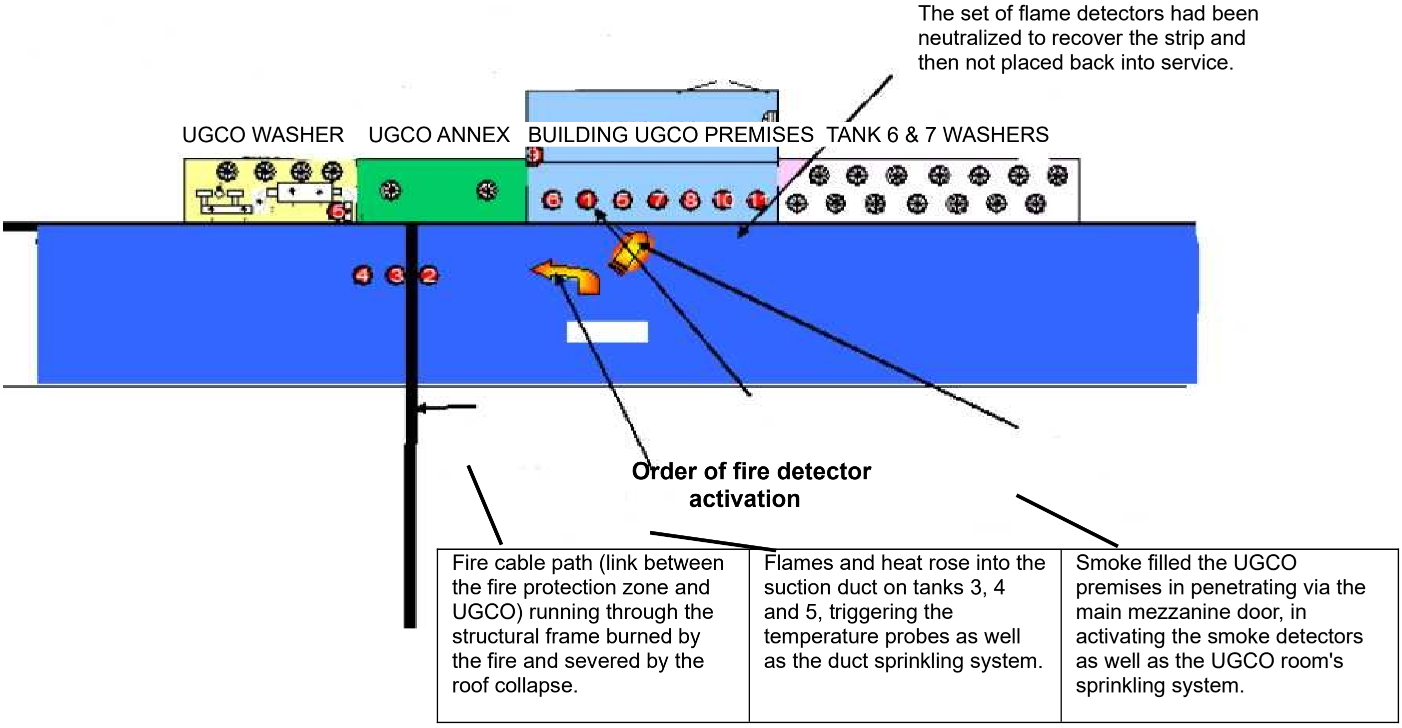
This violent fire could not be brought under control by the extinction resources at hand. Consequently, less than 30 minutes after onset of the blaze, the building roof partially collapsed, causing widespread electricity outages throughout the site, plunging the facility into total darkness.

Moreover, this collapse incapacitated the sprinkling network, thereby generating a tremendous water flow around the set of motor pumps. The 270 m^3/h set (source A) had to be placed in a secure operating mode. Manual intervention by site staff proved necessary to deploy the 270-m^3/h backup pump set.

Since source B was not operational, the automatic start-up function had been idled for several weeks.

Diagram depicting the chronological order of fire detection activation (source: operator)

1 - P73 smoke detector on the mezzanine level of the UGCO premises - fire-fighter's beeper alarm.
2-3-4-5 - UGCO duct temperature probes - sprinkler activation in the ducts of tanks 3, 4 and 5.
6 through 11 - smoke detectors on the mezzanine level and on the UGCO premises - sprinkler activation after melting of the sprinkler head on the mezzanine level.
Cut-off of the connection between the fire protection zone and the stripping detection after destruction of the cable path through the structural frame.
Manual tripping of the sprinkler system in the structural frame of tanks 3, 4 and 5, followed by roof collapse, causing the sprinkler network to fall.



Consequences of this accident:

The consequences of this fire were first and foremost physical. No injuries were reported.

The stripping baths, which had been undergoing filling with diluted acid, were drained by gravity flow by plant personnel just a few minutes after receiving information from the fire detection system:

- in the retention basins located under the RD79 line for tanks 1, 2, 6 and 7;
- in the remote tanks placed in the adjacent room for tanks 3, 4 and 5.

No environmental damage was thus recorded, given that no hazardous substances were directly at risk during the fire and moreover the extinction water could be confined on-site, primarily in the remote basin and then overflowing to the treatment plant. The retention basins on tanks 6 and 7, both made of polypropylene, melted during the fire. Nonetheless, it should be noted that these tanks only contained highly-diluted acids (less than 3% HF in tank 6 and less than 10% HNO_3 in tank 7).

The main physical consequences of this outbreak were:

- complete destruction of tanks 3 through 7 and their supporting structures;
- complete destruction of the recycling basins on tanks 6 and 7;
- destruction of the vapour extraction systems on tanks 3, 4 and 5 (UGCO washer);
- destruction of the building over a 120 m length;
- partial damage of the asbestos cement roof located on the eastern lean-to of building 37;
- damage to overhead travelling crane 114.

The presence of fire walls around the UGCO room helped protect the buffer tanks of concentrated hydrofluoric acid from the fire.

As an initial estimation, the amount of damage and operating losses rose to several tens of millions of euros.

External emergency rescue teams placed great emphasis on establishing efficient cooperation with on-site (fire-fighting) personnel throughout the crisis management and response period.


Source : operator (ARR)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European scale of industrial accidents:

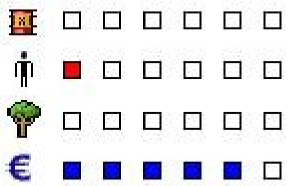
By applying the rating rules applicable to the 18 parameters of the scale officially adopted in February 1994 by the Member States' Competent Authority Committee for implementing the 'SEVESO' Directive on handling hazardous substances and in light of available information, this accident can be characterised by the four following indices:

Hazardous substances released

Human and social consequences

Environmental consequences

Economic consequences



The parameters composing these indices and their corresponding rating protocol are available from the following Website: http://www.aria.developpement-durable.gouv.fr

THE ORIGIN, CAUSES AND CIRCUMSTANCES OF THIS ACCIDENT

Upon studying the chronology of the facts underlying the fire outbreak and observing the subsequently damaged equipment (especially the rollers), the addition to the analyses and testing conducted on-site on the materials present at the time, the following scenario was determined to reflect the cause of this accident:

1/ During the welding operation, following spattering and/or the presence of heat, fire began to smoulder underneath the dipping roller, which was covered with an easily-flammable EPDM material that burned slowly with only limited smoke release. The technicians therefore did not notice this combustion.

2/ When capping the tanks with their lids, the active fire ventilation (the UGCO mist washer was still operable), the flames started to rise.

3/ Flames climbed to the tank lid and immediately heated it: since the lid was not as thick as the tank sidewalls, it began to melt (dripping plastic) and the ensuing liquid (highly flammable) stoked the fire and caused extremely hot flames. Tests conducted in-house after the blaze revealed that the temperature of these flames was capable of reaching 650 degrees celcius.

4/ The fire also spread by footbridges constituting the platform in front of the stripping tanks (plastic plates with an easily flammable honeycomb structure).

5/ The observation was also made that spraying water (using fire hoses) without any foam additive onto the liquid plastic only served to stoke the flames.

ACTIONS TAKEN

The operator implemented an action plan aimed to introduce several improvement measures in rebuilding the annealing-stripping line, as prescribed in a Prefectural decree issued in August 2013.

Design of the annealing-stripping line building:

- Installation of a roof composed of rock wool sandwich panels along with non-combustible lighting strips and including smoke venting, smoke exhaust equipment connected to the outside and structural openings to allow for natural ventilation;
- Protection of the hydrofluoric and nitric bath recycling tanks on those premises equipped with the REI120 fire walls separated from the main building;
- Protection of the mist washers in both the hydrochloric and hydrofluoric/nitric baths on premises equipped with the REI120 fire walls separated from the recycling tanks;
- Installation of a 100% retention basin for each recycling tank.

Choice of less combustible materials for the annealing-stripping line:

- Installation of a platform, in alignment with the stripping station, composed of class A2 materials (combustible, yet not flammable);
- Use of class A1 materials (non-combustible) for the platform, in front of each brushing machine, for the brushing machine box section and the mist suction ducts;
- Use of a roller lining made of relatively inflammable materials.

Networks and piping:

- Creation of a dedicated above-ground rack for the hydrofluoric acid pipes;
- Creation of another dedicated rack above the building roof line for both the hydrochloric acid and hydrogen peroxide pipes.

Water and foam supply:

- Increased supply of emulsifier, to better protect the stripping tanks and utility rooms;
- Installation of a separate structure independent of the sprinkling network support system.

Fire detection and protection:

- Relay of fire alarms into booths along the line as well as onto the portable device carried by line personnel;
- Installation of manual extinction system actuators in both the booths and the stripping zone;
- Implementation of an operational management procedure requiring restriction of the fire detection system;
- In each of the 7 stripping tanks and vapour suction ducts, installation of a double heat detection servo-controlled to:
  - shutoff of the suction device,
  - opening of the fire control valves prior to the washers,
  - triggering of CO_2 extinction from the bottom, the ducts and the washers.
- In the stripping zone, layout of detection zones, each equipped with 2 flame detectors, servo-controlled to:

- extinction within the given zone,
- cut-off of the vapour suction fans,
- closure of check valves on the vapour washers,
- tripping of the CO_2 extinction in the washer ducts.

- Installation of a double flame and smoke detection device automatically servo-controlled to the extinction (water + emulsifier) in the premises dedicated to hydrochloric, hydrofluoric and nitric stripping as well as in the washer room;
- The utility ducts and electrical rooms were equipped with a smoke detector priming the water supply to the automatic extinction system;
- In the water recycling room, installation of a fire detector automatically servo-controlled to the room's fire extinction resources (water-activated).

LESSONS LEARNT

Welding procedure:

The existing specific welding procedure was extremely tersely written. Its content was not commensurate with the importance of this delicate operation. Moreover, the existing hot spot working protocol was not being applied for this type of internal operation, even though the risk of hot spots was indeed a reality.

The welding location, in a particularly narrow and dark space, combined with the mandatory wearing of a mask owing to the acidic atmosphere undermined the chances of detecting the hot spot (by its glimmer, smoke release, etc.).

Acid vapour suction:

The lack of servo-control of acid vapour washer operations to fire detection was a factor contributing to this outbreak. Moreover, the design of acid vapour suction ducts using plastic material appears to be an ill-advised choice.

Along the same lines, the inability to control acid vapour extraction flow rates (with the destruction of some suction points having mechanically increased the suction flow rate of other points) fanned this fire. It should also be considered that the molten compressed air pipes strengthened the fire.

Fire detection lockout and lockout removal:

Given its sensitivity, the detection technology in place above the tanks (infrared) imposed their lockout in the case of welding tasks. It turned out that the line had been placed back into operations in order to release the sheet metal strip without removing the fire detection lockout first.

When questioned on this point, the plant operator indicated that in practice, employees wait to release the metal strip until the fire detection lockout has been removed, given the possibility of successive breakage (which would impose having to repeat the set of lockout procedure steps).

Fire protection resources:

The absence of fire protection zones on the platform, especially between the stripping tanks, seriously complicated the fire response. This observation was coupled with the apparent relative inefficiency of the sprinkling facility along the stripping line compared to a preventive action introduced perpendicular to the line.

The roof collapse, with a metal structural frame, caused several pipes to burst, including the sprinkling pipe.

Once melted, plastics exhibited the behaviour of flammable liquids, for which the use of water proves inefficient and may even tend to promote spreading of the fire due to the effects of spattering. This site had not been equipped with a sufficient quantity of emulsifier to successfully battle a fire outbreak of this type (i.e. like a "hydrocarbon" fire).

The automatic start-up of the 680 m^3/h motor pump set (source B) had been inoperable since July 2012 (even though several actions had been undertaken by the operator to repair the start-up mechanism during its idle period).

The site's pump wagon was incapacitated by the blaze. This equipment had neared the end of its useful life, but the operator had not allocated the budget for its replacement.

Management of the site's backup electricity supply:

The severing of an electrical cable, caused by the roof collapse, triggered a cut-off of the entire facility's electricity supply. Several electric generating sets were present on-site, but the most strategic elements on the circuit had not been backed up, namely:

– lighting;
– the TE02 treatment plant;
– the external emergency plan siren (even though this plan had not been activated during the accident).

Emergency plan:

The current internal emergency plan did not provide a satisfactory quantity of information relative to the water pollution management steps to be implemented in the event of such an incident.

This plan's recipients were only given an electronic version. The circulation of a print version would seem to be absolutely necessary.