Flooding of a glassworks factory

30 May 2016

Bagneaux-sur-Loing (Seine-et-Marne) France

Natural hazards / floods
Intervention
Safety procedure
Water damage
Restarting

THE FACILITIES INVOLVED

The site:

The group that owns the glassworks has been located in Bagneaux-sur-Loing since 1992. The site specialises in the manufacture of vitro-ceramic plates used in the manufacture of electric household appliances and fireplace inserts. The company operates two glass kilns, each with a production capacity of 85 and 120 tonnes per day. A third kiln is scheduled to be commissioned in 2017. The site in Bagneaux-sur-Loing, France, employs approximately 240 people.

Geographic location:

The site extends over 6.5 ha along the base of a valley. It is located roughly one hundred metres from the Loing Canal which forms the junction between the Seine river basin and the Loire. The Loing is located 200 m from the site.

Geographic location of the factory - All rights reserved

The facilities:

The site is made of up several units, including:

- two buildings, each containing a glass kiln;
- storage facilities for finished products and hazardous materials (arsenic).

The buildings housing the kilns are made up of several floors. The inverters, the various electrical panels and the fuel oil tanks supplying the generator sets are located on the ground floor.

The utilities are supplied by:

- a network of buried steel or polyethylene natural gas pipes;
- piping to convey water to the kilns for cooling purposes. Electric pumps are used to draw water from the water table. A 400 m^3 water tower completes the system, as required;
- electricity is supplied by a set of sheathed underground cables. The site's main power station is co-managed with another plant operator and thus supplies power to a neighbouring factory. The generator sets are installed in each kiln building and are supplied by fuel oil tanks. Some of the generator sets are used to supply electrical power to the arsenic storage facility's automatic fire extinguishing system.
- a buried steel oxygen pipe which passes through a concrete sleeve;
- a compressed air network.

The fibre optic telecommunication network is backed up by a copper cable network (ADSL link). A GSM antenna, located at a high point in the vicinity of the site, provides mobile phone communication.

The installations are managed by a computerised industrial control system which enables manual intervention by the personnel as needed. The computer cables and automation elements/sensors are routed overhead in service ducts. The computer rooms, containing the servers needed to run the system, are protected from exposure to water.

The hazardous material storage facilities (arsenic) are equipped with a deluge-type automatic fire extinguishing system. This device (sensor, central processing unit controller) is inspected and maintained by two specialised companies.

Regulatory situation:

The establishment is classified as “high-level SEVESO” due to sections 4707 and 4708 of the classified installations nomenclature:

Sections	Products concerned
4707	Arsenic pentoxide, arsenic(V) acid and/or salts thereof
4708	Arsenic trioxide, arsenic(III) and/or salts thereof

Condition of the site before the flood

At the time of the flood, a kiln was being rebuilt at the site. However, no trenching was underway. Deliveries were cancelled when word was received concerning the rising waters.

Flood risk:

The site is located in the area of the Loing Valley's flood risk prevention plan (PPRI) which is designated in light blue (i.e. an area subject to limited conditions for the reference high water level on which new construction may be authorised under certain conditions). The groundwater is also very shallow which favours upwelling.

Except for the historic flooding of 1910, the site had never been flooded. The flood of May/June 2016 was thus the first time that the operator had to face this risk. No specific procedure with regard to this natural risk was specified in the company's internal contingency plan.

The weather warnings are distributed internally via e-mail based on the current situation, although the monitoring of these warnings is not formalised and systematic. The operator uses the Vigicrues site (flood warning system), in particular.

THE ACCIDENT, ITS CHRONOLOGY, EFFECTS AND CONSEQUENCES

The flood:

Chronology:

30/05 — 3:30 p.m.: The Vigicrues bulletin announced that the warning level along the Loing (upstream) had risen to orange (orange = risk of significant flooding). This information was disseminated internally via e-mail.

31/05 — 11 a.m.: a telephone call from the Classified Facilities Inspection authorities warned the operator of the flood risk and ordered that the site to be secured;

5:30 p.m.: the operator set up a crisis unit, and assessed the vulnerability of its establishment. The unit was made up of 15 people belong to a trade sub-unit (power, maintenance, communication, purchasing, IT, etc.). The unit met every 3 hours until 04/06;

Given the risk of rising water in a kiln building and the loss of the generator associated with this furnace due to its low position, the electric power to one of the kilns was “bypassed” by cable routed between this kiln's distribution substation and the electrical substation of another kiln. The connection was made above ground and at height, passing through the existing galleries between the buildings (passageway).

01/06 — 8 p.m.: A Vigicrues bulletin announced that the warning level along the Loing (upstream) had risen to red (red = major risk of flooding).

10:00 a.m.: the operator initiated its internal contingency plan;

The first upwellings were observed as water began to rise from the manhole covers located between the kiln buildings: The storm water network flowing into the Loing Canal was itself being flooded. Water was then detected in the technical ducts.

The operator decided to evacuate the site. There were 30 people present at the site at that time (175 people during normal operations on 31/05). The personnel rotate every 8 hours.

2:22 p.m.: main electrical power was lost, followed by the switch to the generator sets.

6:40 p.m.: the special intervention plan siren began blaring inadvertently (sound of a “drowned siren”).

02/06 at 8:00 a.m.: Flood peak. The maximum height reached to the site's lowest point was approximately a metre in the site's southern area (construction site base camp area). Water reached a maximum height of approximately 40 cm in the lower levels of the kilns, 30 cm in the arsenic storage cases and 20 to 30 cm in the composition workshop.

10:00 a.m.: The flood begins to recede. Generally speaking, water rises faster than it recedes.

The flooded installation - source: operator

04/06 6:43 p.m.: Power restored to the substations supplying a kiln. The electrical cabinets remained under water for 2-3 days.

06/06 Electrical power restored to the other kiln.

07/06 A significant amount of water was still present in southern part of the site. Special means were brought in (motor-driven pumps) by the civil defence services. Pumping operations were completed in the late afternoon and traffic was suspended in order to pass the drain lines over the roadway.

Water pumping operations - source: operator

08/06 End of clean-up and disinfection of the cooling towers.

15/06 The special intervention plan siren was returned to operation but in downgraded mode.

The operator had to deal with the following difficulties during and following the flood:

- **Maintain production equipment in good condition** (the glass kilns must be maintained at a specific temperature to prevent damage, particularly to the refractory elements). This notably requires that the utilities be maintained, such as gas, electricity, oxygen, fuel oil for the generator sets, and cooling water;
- **Ensure site security** given the unavailability of the security systems or access difficulties: The gas detection sensors (oxygen, natural gas), and the automatic fire extinguishing system protecting the storage facilities

were inoperative. Physical access to the facilities was complicated at some locations due to the water levels (1 m at the base camp in the site's southern area, between 10 cm and 50 cm of water in the basements of kiln buildings);

Water level reached on the site - source: operator

- **Maintain the internal and external communication**: as the site's telephone exchange was without power, mobile telephones (GSM network) were used to communicate. Internet access, however, was available during the flood (as the computer network router is independent of the telephone exchange). The switched telephone line (PSTN) at the guard station was operational (these premises remained above water during the flood). The exchange of information between the site's personnel and the outside (journalists, authorities) had to be maintained. Lastly, the utility suppliers (electricity and gas utilities, and the oxygen supplier) were regularly updated regarding the situation.
- **Quickly resume activity:** beyond the financial constraints, the operator had to ensure the following:
    - the procurement of specific equipment from suppliers (inverters, machine filters, etc.);
    - inspection of the installations following a damage assessment. Land subsidence and a rupture of storm water basin sheeting were observed when the floodwaters receded.

Consequences of this accident:

Neither significant environmental impact, nor human and social consequences were observed as a result of the flooding of the site. Lastly, the operator did not detect any anomalous signals (alarms, measured values, etc.) when the installations were put back into service.

The economic consequences were evaluated at several million euros, and were primarily associated with operating losses. Property damage was much lower in comparison. A partial shutdown period was observed which affected 78 employees. The donation of leave or overtime hours by workers nevertheless made it possible to limit the impact on those affected. Site personnel were also largely involved in the clean-up operations.

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 for hazardous substances and in light of available information, this accident can be characterised by the following four indices:

Dangerous materials released		□	□	□	□	□	□
Human and social consequences		□	□	□	□	□	□
Environmental consequences		□	□	□	□	□	□
Economic consequences	€	■	■	■	□	□	□

The parameters associated with these indices and their rating scale are available on the website: http://www.aria.developpement-durable.gouv.fr.

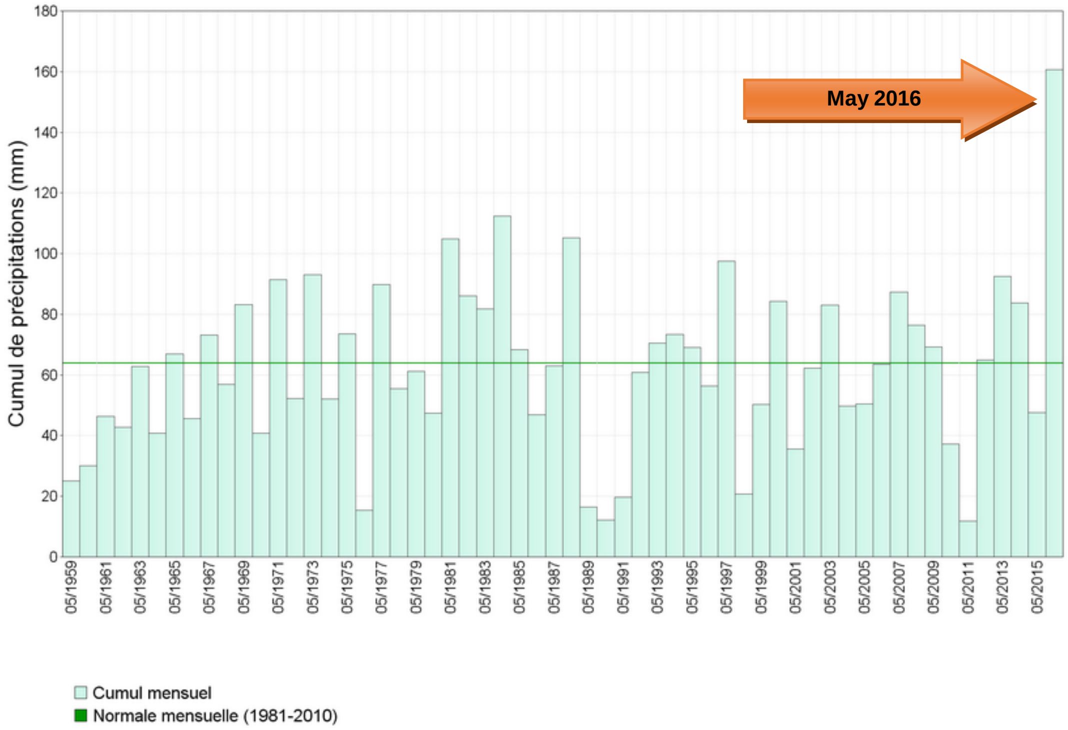
THE ORIGIN, CAUSES AND CIRCUMSTANCES SURROUNDING THIS ACCIDENT

The peak rise of the SEINE in Paris was equivalent to that of 1982 (6.10 m vs. 6.18 m), but the flooding of some of its tributaries reached levels above that observed in 1910 (notably for the LOING).

The rising water was attributed to an exceptional level of rainfall throughout the month of May (the greatest amount ever recorded), with, since the weekend of 28-29 May, a significant stormy period followed by several days of intense precipitation.

The flooding of the site was characterised by a rise in the water table combined with the overflow of the LOING Canal. The water then stagnated on the site. There was, therefore, no current that was capable of transporting log jams and debris that could damage the facilities.

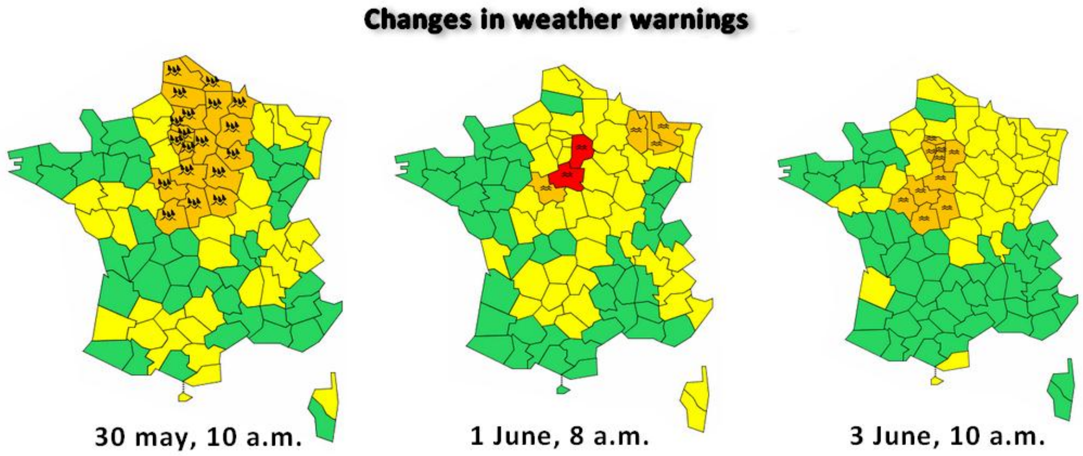
Monthly accumulation of aggregated precipitation in Ile de France from May 1959 to May 2016



Source: Météo France

Weather warnings

The Seine-et-Marne department was under an 'orange' rain-flood warning on 30 May at 10:00 a.m. The warning was raised to its maximum level (red: flood alert) on 1st June at 8 a.m. until 3 June at 10:00 a.m. Weather warnings were also issued specifically for the LOING on the Vigicrues website (www.vigicrues.gouv.fr).



Source: Météo France

ACTIONS TAKEN

Owing to the difficulties faced, the operator has undertaken the following actions:

Functions to be ensured	Triggering event	Measures taken
Maintain production equipment in good condition	Upon receiving the alert (after the first meeting of the crisis unit of 31/05 at 5 p.m.). The operations to secure the site ended in the afternoon of 01/06. These operations thus lasted 24 hours.	• Placement of hazardous material drums and storage facilities at a higher elevation; • Placement of cement blocks in front of the electrical rooms; • Anticipating the need for utilities (delivery of oxygen by truck, contact with the gas utility); • Opening of access routes to the site and electric doors between workshops to avoid any possible access difficulties in case of a power failure; • Creation of a multi-trade crisis unit; • Anticipation of a power outage (blackout): “bypass” of electrical substations between the kiln buildings (the electrical installations of a kiln are in a flood zone); • Kiln on standby; • Interrupt the ongoing operations on the other kiln in order stabilise it at a specific temperature level; • Shutdown of the site's various the workshops; • Ensure that the combustion dust recovery bags from the kilns' pollution control unit are protected from water and then turn off the kilns; • Securing of construction equipment at the kiln construction site.
Ensure site security given the unavailability of the security systems or access difficulties	During the flood	• Anticipate the utility supply difficulties (oxygen, natural gas, fuel oil for the generators). For this purpose, regular meetings with the suppliers should be held; • The kilns are cooled in an open circuit with the site's fire prevention and extinguishing network which pumps water from the LOING Canal, • Monitoring of water height within the site (measurements every half hour); • Rounds conducted to secure the premises and explosimetry control at sensors; • Provide appropriate lighting means in workshops to deal with the lack of lighting; • Prohibit access to flooded areas and use of a paper logbook to know who is on the site; • Use of a boat to get around in certain areas of the site; • Preserve computer data (use of virtual server type technology, redundancy of data backup systems).
Communication	During the flood	• Create a limited-access account on social networks to communicate with employees who stay at home; • Organisation of a meeting with members of the Health and Safety Committee (HSC); • Request for mobile telephones to ensure communication between people on the site. The landline telephone network was not working (telephone exchange out of order).

Resumption of operations	After the flood	• Inventory and inspection of equipment and electrical ducts in contact with water. The inspections were conducted by a specialised company whose details were sent by the operator's insurance company; • Inspection of all fire safety and gas detection systems; • Drying and cleaning of electrical components by a specialised company. These operations took one week; • Verification by a specialised company of the soil subsidence issues after the waters had receded (inspection of the pipe runs at the manholes); • Traffic circulation (lorries) over the oxygen piping was prohibited; • Special attention was given to the risk of carbon monoxide emission, particularly when a motor-driven pump during clean-up operations. Pumping equipment engines tend to overheat as they are under greater demand than usual; • Improve the reliability of the electrical power supply of certain equipment (well pumps for cooling water).

LESSONS LEARNT

The provided feedback immediately after the flood, including the following points:

- The need for detailed studies to manage crisis situations in the long term, notably with regard to the industrial process (studies of scenarios in which utilities are lost: oxygen, natural gas, electricity, cooling water; supply of fuel oil to the generator sets);
- Protection of certain equipment from water (pumps, cable sheaths, kiln pollution control equipment, safety equipment);
- Ensure the reliability of telecommunication networks (replacement of the telephone exchange);
- The identification of the vital equipment and the review of their location (electrical enclosures and terminals including the special intervention plan siren, critical spare parts) or increase in height (generator set);
- Logistics management (flood kit: boots, waders, boats, headlamps, engine-driven pumps, etc., logistics and equipment available in the crisis room);
- The crisis was handled calmly by the entire staff, even though the situation was critical at times;
- A more systematic dissemination of weather warnings. This early warning allowed the operator to get in contact with its suppliers quicker, so as to be the “first one served”;
- Preparation of a business continuity plan to formalise the various actions to be undertaken in case of a similar event.

Beyond the lessons learnt specifically during the Bagneaux-sur-Loing event, several elements of operational feedback overlap with the flooding that occurred at a Seveso fine chemicals site in 2008 in Haute-Loire (ARIA 35426), including:

- Early warning is essential in order to compile an event management team and to organise the necessary actions (meteorological monitoring system, SMS alerts, etc.);
- Several specialist trades are used to manage the situation efficiently;
- A list of the resources and tools necessary for the initial actions (elevation devices, sealing and absorbent products) simplifies the management of the event. A list of companies specialised in clean-up, drying and disinfection is also useful. These companies may be contacted at the start of the event in order to be able to organise the return to “normal” operation as quickly as possible;
- The need to place these installations in a “safe” demobilisation phase, so as to limit risks to both the environment and the production facilities;
- Monitoring rounds are needed owing to the unavailability of the detectors;
- The production facilities, cooling towers, electrical equipment and rotating machinery, must be returned to service with caution;
- Handling means able to operate in water are often appreciated for lifting goods;

- The differential settlement analysis by a specialist company to identify the equipment that should be subject to special monitoring;
- Placement of the inverters at a higher elevation to prevent battery failure. Although these elements may be shut off from the power supply, it is impossible to "empty" the charge accumulated in the batteries;
- **Weather events in the years to come are likely to be more intense. Appropriate measures must, therefore, be adopted to increase the resilience of an industrial site and the facilities associated with it (utility delivery stations, optical connection nodes or subscriber hubs for the telecommunication networks) in order to deal with them**.