



Floods

20 Flooding of an industrial site

ARIA 35426 - 01/11/2008 - 43 - SAINT-GERMAIN-LAPRADE

21.20 – Manufacture of pharmaceutical preparations

	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

A pharmaceutical plant on a 55 hectare platform out of which 15 hectares were used was flooded (ARIA 35427) with 20 cm to 1 m of water due to torrential rains (300 mm in a few days including over 100 mm in less than 24 hours – The French metrological department put the region on “red alert” (highest level of alert) due to the rains.)

The site was on internal alert before the rise in the water level. The internal emergency plan was triggered. Thirty employees of the company evacuated or place the equipment and products at heights at around 4.00 pm. Safety alert was sounded in the company (safety fold back phase: production stopped, planning of power cut sequence).

Leak detectors, especially gas indicators were not functional after the power supply was stopped. The company staff and voluntary fire-fighters patrolled the site. No pollution was observed except for 2 to 5 litres of hydrocarbon (Isopar G) and 200 g of powder in the laboratory that had spilled. On the other hand, significant damage on account of water was reported (building partitions, documentation, electronic equipment that was not placed at heights)

Additional resources were called in: trucks and power lift truck operating at great heights were used to move the products. Two high-speed pumps (850 m³/h) provided national civil safety department of the French Home ministry were used to rapidly evacuate the residual water.

The production facilities, cooling towers as well as electric equipment and rotating machines were re-commissioned with care and monitored.

A hydraulic study was commissioned by the metropolitan authorities of the industrial zone. The operator updated the internal emergency plan by including the flood situation and fine tuned his crisis management action plan (human and material resources).

The torrential downpour on the industrial area spread out over two towns was recognised as an act of God on 29 December 2008 (Official Gazette dated 31/12/2008).

Floods

The flooding of a facility resulting in its total or partial submersion in variable lengths of time is due to various reasons: torrential rains for extended periods of time (ARIA 35426), flooding of a water body (ARIA 26459), obstruction of the sewage network (ARIA 29645), rupture of a dam (ARIA 15513, 26457), rising of the water table, etc.

The two main accident typologies observed include release of dangerous materials or pollutants (ARIA 160, 1699, 4570, 4909, 4910, 6413, 9260, 21611, 21631, 23053, 25231, 27920, etc.), as well as fires (ARIA 4743, 5677, 17023, etc.). The most famous fire accident is undoubtedly that of the Mohammedia refinery in Morocco in 2002 (ARIA 23637) where the floating hydrocarbons ignited upon contact with the walls of high-temperature installations.

Are these accidents just destined to happen? Not always. The analysis of accidents recorded in the ARIA database regularly highlights implantation errors, flaws in design or operation of sites that contributed to the rise in water levels or worsened their consequences: storm drain networks of inappropriate size or that are poorly maintained (ARIA 29645), unsafe storage (ARIA 27920).

Rise in water levels, "waves" or mudflows either result in equipment damage, rendering motors, pumps, compressor, electric and IT equipment required for the site's safety (ARIA 26459, 26460, 29645, 29646, etc.) non-functional or destroy labelling of dangerous substances (ARIA 21600).

In addition to equipment damage, the problem is further compounded by production losses arising from stoppage of work along with technical unemployment that may last several weeks or even months (ARIA 16975, 16976, 32258, etc.). It is sometimes hard to express damage as a figure such as financial assessment of losses pertaining to IT information, prototypes or intervention plans.

After periods of floods, there is a risk of collateral accidents that needs to be closely studied. Checks must be carried out primarily focusing electrical components (mechanical relays, sensors, earthing, etc.) crucial to the safety of the site (ARIA 4743) while separating intense and weak current circuits.

The 2001 report of the Intergovernmental Panel on Climate Change (IPCC) has forecast an increase in torrential rains in middle and high latitudes of the northern hemisphere. It would be advisable to anticipate even more serious events than ones already observed and implement appropriate preventive measures: upgrading equipment vital to the safety or smooth functioning of the site (ARIA 15513), securing and positioning of water-sensitive material at heights and material likely to be swept away by floods (ARIA 26004), device to measure the rise in water level with stoppage of operations and folding back of facilities when the level crosses a predefined water mark (ARIA 26459), flood storage area (ARIA 26460) or flood risk-free zones facilitate rescue operations.

Generally speaking, the danger studies must highlight actions that can be carried out in the time between the sounding of the alarm and the predictable occurrence of the flood. These actions must be implemented on a permanent basis. The aim is to keep the list of actions to a strict minimum in the time period following the alert and have simple measures that can be rapidly implemented.

Pre-defined mitigations measures adapted to the risks help complement the risk prevention plan and limit the consequences of an accidental increase in the water level: drain or pumping systems to reduce submersion times, rescue devices in the event of increase in water levels (rescue boats, power lift trucks operating at increased heights, etc.), rescue services deployed on a priority basis to help the distressed population. Compiling a file of sub-contracting companies along with the training of all involved players ensures smooth rescue operations that are often needed after floods.

Nevertheless, these measures must be proportionate to the risks and vulnerability of the stakes involved. In flood-risk zones, reference floods and the predictable kinetics of the rise in water level must constitute the basis of such measures. A detailed risk analysis must be carried out that must examine scenarios involving dangerous reactions likely to be triggered, loss of utilities and fall of equipment. Buoyancy studies can prove useful.

Technical measures must be backed by organisational ones such as forecast of heavy rains or floods.

The frequency and gravity of floods in the recent past confirm the need to take site submersion scenarios into account for danger studies involving classified facilities.

Moreover, it must be noted that building private or public facilities (roads, fills, traffic lanes, sewage networks) and more broadly any structure modifying water flows (ARIA 29646) near classified facilities may increase the risk of flooding: inaccurate proportioning of drain pipes, various players involved in the maintenance of storm drains, etc.

For further information, a study on atmospheric precipitation and floods can be downloaded from the website: www.aria.developpement-durable.gouv.fr .

The accidents whose references are not underlined may be consulted at:

www.aria.developpement-durable.gouv.fr

-  □ □ □ □ □ □ **ARIA 4743 - 13/10/1993 - 57 - SAINT-AVOLD**
 22.29 – *Manufacture of other plastic items*
 □ □ □ □ □ □ A fire broke out in a building adjoining a company specialised in manufacturing plastic containers and dust bins. Significant resources were deployed to quickly bring the blaze under control. Part of the stock along with the roof of the building was destroyed. The accident resulted from the malfunctioning of electric circuits subsequent to floods. Material damage was estimated at 1.4 MF.

ARIA 17318 - 27/12/1999 - 33 - BLAYE

35.13 – *Electricity supply*

During a violent wind storm accompanied by heavy rains, the production site of a power plant was hit by an 80 cm water wave. Administrative buildings, workshops, company canteens and the cooling water pumping system were all flooded. A part of the pit housing the pipes was submerged and the drip collection tank overflowed due to excess water. According to the operator, 90,000 m³ of water was pumped out and emptied into the Gironde river. The water that seeped into the underground tunnels led to the failure of equipment and circuits vital for safety (total failure of the emergency injection pump and enclosure sprinkler pump and partial failure of the emergency raw water pump).

-  □ □ □ □ □ □ **ARIA 21600 - 25/10/2001 - 26 - LIVRON-SUR-DROME**
 46.75 – *Wholesale of chemicals*
 □ □ □ □ □ □ In a warehouse of a company specialised in agricultural treatment products, an operational error led to a violent reaction resulting from the mixing of potassium permanganate with sulphur. Two 1 tonne containers caught fire and emitted toxic fumes. Some containers had lost their identification labels following incidents of flooding with 50 cm of water in and around the site a few days before the accident.

-  □ □ □ □ □ □ **ARIA 23637 - 25/11/2002 - MOROCCO - MOHAMMEDIA**
 19.20 – *Crude oil refining*
 □ □ □ □ □ □ The OUED MALEH dam overflowed following continuous torrential showers that lasted several days and flooded the facilities of a refinery located in the heart of the port of Mohammedia. The site's production was stopped around 4.00 pm due to the water level that rose to as high as 1m at a site in the facility. A violent fire ensued, as well as several explosions of tanks, electrical equipment (transformers) and pipes.

At around 8.00 pm, two fire areas still persisted in the gas and crude oil sectors of the refinery. The fire was extinguished after 20 hours of struggle under difficult conditions and required considerable human and material resources: 3.5 million m³ of water, 30 tonnes of chemicals (foam compounds, etc.). Two persons died and four were injured despite the contradictory information published on human casualties. Significant material damage resulting from the accident led to the closing of the refinery and suspension of all activities. A crisis unit chaired by the Moroccan Home Secretary was set up. France dispatched a technical operations team in the days following the accident. 17 other industrial units were damaged by the floods. Based on the initial findings of the conducted surveys, the roof of one of the storage tanks had given in and another had cracked during the rainstorms. Petroleum products possibly flowed into the tanks and were mixed with the flood water. The hydrocarbons floating on the water surface caught fire upon contact with the high-temperature installations. This explains how fires were triggered in the various fire areas and that were fuelled by short circuits due to flooding of the facilities.

ARIA 26004 - 01/12/2003 - 69 - CHATILLON

23.51 – *Cement production*

A cement production plant was flooded following torrential rains that poured down the region. The 35 employees of the plant were on technical unemployment for an undetermined period of time. None of the storage tanks (liquid waste tank, fuel tank) were submerged by the flooding river. All retention proved to be waterproof and the water level did not cross their upper mark. The transfer area and its recovery pit were protected at the start of the flood by a circle of cement bags stacked to four levels that proved to be efficient. The rest of the facility especially the electrical equipment suffered considerable damage.

-  □ □ □ □ □ □ **ARIA 26459 - 02/12/2003 - 13 - TARASCON**
 17.11 – *Production of paper pulp*
 □ □ □ □ □ □ The RHONE river overflowed due to heavy rains and flooded a paper mill located in an industrial area.
 □ □ □ □ □ □ This upper tier seveso site produced kraft paper pulp from softwood bleached with oxygen, hydrogen peroxide and chlorine dioxide also stores black liquor, fuel oil, methanol, chlorate and several tonnes of wood. Further to three flooding incidents that occurred in 2002 and 2003, when the RHONE river rose to

10.27 m (French surveying and levelling), various measures were taken in the site: risk of flooding included in the danger studies, drafting of guidelines to secure the site, production workshops, black liquor boilers and turbines recorded at 10.56 m, 15 m and 21 m (French surveying and levelling), storage with 0.7 m retention tanks, anchored tanks, boxing up electrical equipment, piping mounted on racks (only water pipes were underground). On 1 December, the site was alerted to floods by fire department and consequently operated with reduced staff right from the next day. Given the unrelenting rise in the water level, an emergency procedure was implemented according to the water level: at 6.4 m NGF, implementation of a 600 mm diameter bladder on the pipes to prevent rain water from spilling on to the acidic effluents; at 9 m NGF, evacuation of staff and securing of the site by 25 employees (total stoppage of facilities, boxing up exposed equipment). The RHONE reached 10.50 m NGF on 2 December at 3.00 pm and 11.3 m NGF on 3 December at 3.30 pm. Since the site was completely flooded, the inspection of safety devices on facilities was carried out on boats. Despite IT, electricity and telephone communication failure, the operator could be reached on his mobile throughout the course of events. The water currents swept away 4,500 tonnes of wood ((ripping off the enclosure) and empty or sparsely filled containers (less than 3 m³ of products); on the other hand the anchoring of storage tanks proved to be efficient. Environmental impact was limited as there was no leakage of chemicals. Material damage, production losses and cost of site refurbishment were estimated at 11 M euros: 6 000 tonnes of wood and 2,000 tonnes of paper pulp were soiled or carried away by the current, 400 submerged motor units were taken down and cleaned, electric devices were damaged and the archives were dried using cryogenic processes.

ARIA 26460 - 04/12/2003 - 13 - SAINT-MARTIN-DE-CRAU

20.51 – Production of explosives

An upper tier SEVESO site manufacturing explosives was flooded following heavy rains. The products involved are not sensitive to water. A 15 hectare marshland located upstream to the site serves as an outfall for water overflowing from neighbouring lands. A 150 m³/h lift pump pumped out the excess water from the marshland via a pipeline to the CHAPELETTE marshland situated northeast. A non-stop and heavy downpour caused the water level to rise in the LANGLADE canal running southwards and adjacent to the plant. The gate valves that were shut for unknown reasons were unable to evacuate the excess water from the overflowing canal. Water swept into the site from the south west direction in form of a wave and drained into the 15 hectare marshland. The lift pump, completely submerged due to the rapidly rising water level could not prevent the flooding of the site where the water level reached 1.2 m. The operator installed four mobile pumps available on the site and requisitioned emergency pumps from neighbouring industries. A 2,000 m³/h capacity helped curb the rise in water level. After a week of pumping, the water level in the CHAPELETTE canal returned to normal. Despite the risk of exposure to water, a transformer suffered no damage. Even though the storage and production sites were not impacted, the two-week long production stoppage resulted in losses estimated at 105 K euros. The operator updated the internal contingency plan by adding the particulars of the companies capable of providing emergency pumps.

□ □ □ □ □ □ **ARIA 27920 - 13/01/2004 - 37 - AUZOUER-EN-TOURAIN**

□ □ □ □ □ □ 20.14 – Manufacture of basic organic chemicals

A chemical plant manufacturing basic organic chemicals was partly flooded when the reactors were being washed. The washing water (acrylic emulsions) got mixed with the flood water due to the backflow of the water in the pipeline and in the mouth of the drain located in the traffic lane. The abrupt rise in the level of the La BRENNE river submerged the efflumeter containing effluents from the sewage treatment plant.

Red coloured water flowed out of this efflumeter and spread onto the ground near the plant. Each time the La BRENNE river flooded, a “low” point at the main fire door caused the site to regularly flood. The inspection authorities for classified facilities observed the facts and ordered a hydraulic study taking into account data on the river and a study on the measures to be implemented to prevent the flooding of the site (removal of the “low” point, protective dam, transfer of sensitive stock to flood risk-free zones, etc.) and carry out identified operations. The prefectoral decree dated 16/02/04 has ordered the protection of the site against floods.

ARIA 29645 - 04/09/2002 - 13 - PEYPIN

20.14 - Manufacture of basic organic chemicals

Following violent rainstorms, the runoff water in an industrial zone could no longer flow into a mud-clogged pipeline serving a pharmaceutical plant. The arrival of water caused the retention tank of the site to overflow, thereby flooding the fire premises located in an underground pit. As a safety precaution, the water triggered the start of the motor pump (whose motor was damaged by the entry of air), that activated the water and foam networks of the storage buildings. To reduce the chances of recurrence of such an accident the operator has elevated the entry point of the fire premises, ensured surveillance of the storm drains and carried out maintenance of existing structures.

□ □ □ □ □ □ **ARIA 29646 - 01/09/1993 - 13 - ROGNAC**

□ □ □ □ □ □ 52.10 – Warehousing and storage

An 11,000 m² warehouse storing crop protection products, stuffed toys and life jackets was flooded following a heavy downpour. The operator prepared, repackaged and palletised the stored products. The site is located on the foot of a hill and is encircled by a railway track whose raised portion upstream to the site forms a dam. After three days of intense downpour, the rain water from the hill that involuntarily flowed into the dam could not be contained. The overflowing of the dam led to the offices, storage cells and the packaging workshops being flooded by 50 cm of water for four hours. The IT network was down. Material damaged was assessed at 7 MF (the precise day of the accident was not known). After a year (October-November 1994) and under similar conditions, a second wave flooded a warehouse with 80 cm of water for ten hours. Further to these new flooding incidents, the town built an underground pipeline connecting the BERRE canal as well as a retention basin upstream to the industrial site whose excess water flowed into the canal. The operator, on his side, built 20 cm high sleeper walls between the entry points of the storage cells and ensured constant monitoring of the site.