Safety practice

The impact of climate events on French industrial facilities between 2010 and 2019

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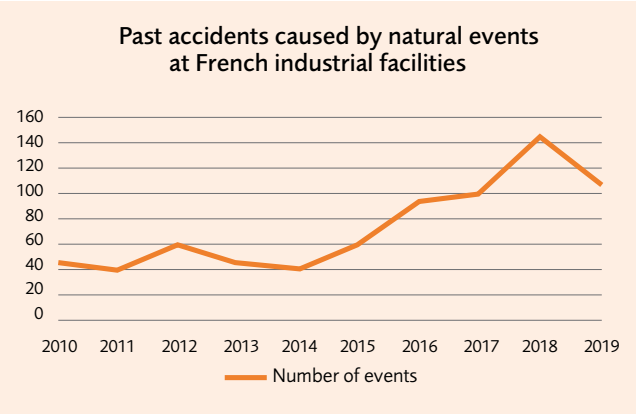
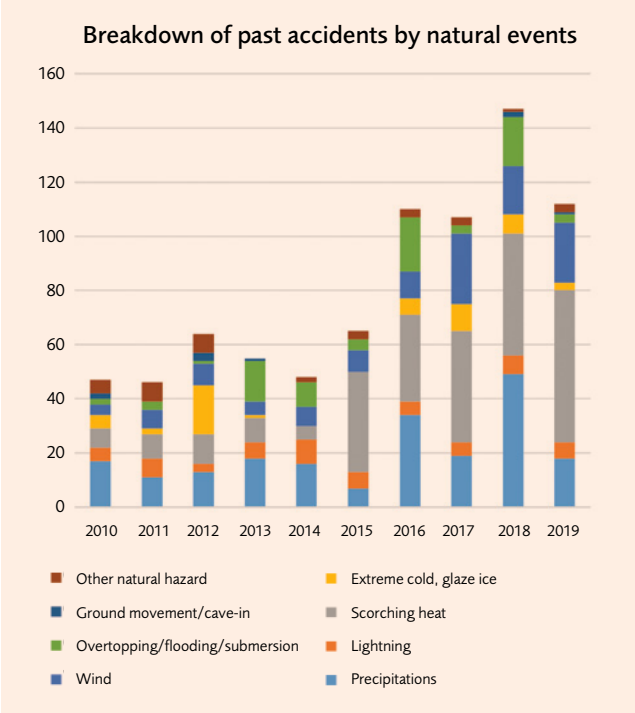
The bureau for analysis of industrial risks and pollution (BARPI) is a branch of the French Environment Ministry. It has been collecting and disseminating data and lessons learned from the analysis of industrial accidents since 1992. It does so by collecting, analysing, formatting and recording data in a database known as ARIA (analysis, research and information on accidents). At the time of writing, the ARIA database is populated with nearly 55,000 events that have occurred in France and abroad. Between 1,500 and 2,000 new events are added each year.

The root causes of these events in the ARIA database range from equipment failures and losses of process control to external hazards. Between 2010 and 2019, there was a clear increase in the number of events that affected French industrial facilities and were caused or exacerbated by intense natural phenomena, such as flooding and rains, scorching temperatures and strong winds. As shown in the chart below, the number of events recorded in the database more than doubled during this decade:



While this trend has been on the rise since 2010, there was a slight decline in 2019 with almost 30% fewer events recorded in the database than in 2018. The main reason was the decrease in the number of rain or flood events, which was divided threefold between 2018 and 2019. However, the number of extreme-heat events increased by more than 20% over the same period.

These data are consistent with those published by Météo France, the country's national meteorological service, which ranked 2019 as one of the hottest years on record in France since the beginning of the 20th century. Although there was a rainfall deficit in France during the first nine months of 2019,



some regions saw an abundance of rain in the final quarter. More than 60% of the year's flooding and rain events were recorded in the ARIA database during that same quarter.

Weather phenomena are responsible for nearly 90% of natural events that affect industrial facilities. The types of weather phenomena that have led to the most industrial events over the last decade are extreme heat, rain and/or flooding.

Extreme heat

The number of events caused or exacerbated by extreme heat increased significantly between 2010 and 2019. For example, the ARIA database lists just seven events affecting industrial facilities in France in 2010, but 56 in 2019.

More than half of the extreme-heat events recorded over the decade impacted the waste and wastewater treatment sector. None were fatal, but injuries were reported in one in every ten.

Economic consequences are recorded in ARIA for a large majority of events. Damage is mainly material and ranges from a few hundred to several million euros. This economic toll can be significant for a given event (e.g., €15 million in internal material damage reported for *ARIA event 54016*).

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Fire in a waste sorting centre

ARIA 54016 – 11/07/2019 – SEINE-ET-MARNE

A fire alarm sounded around 8:40 a.m. on a conveyor in a 6,000 m² selective waste sorting and transit centre. Verification confirmed the presence of smoke coming from a stocking machine. The personnel were evacuated. Overwhelmed by the magnitude of the fire, the personnel did not attempt to fight the fire and waited for a large contingent of firefighters (more than 80) to intervene. Two-thirds of the building had become engulfed in flames and the fire had spread to its roof. A perimeter of 300 m was set up and retention/containment measures on the site were established. A pumping system with an output of 7,000 l/min. was established on the Marne River. The administrative section of the building was ventilated, although the firefighters had difficulty gaining access to the process hall: the operator used two power shovels to knock down one of the facades and dismantled the process elements in an attempt to bring the fire under control. Sensitive equipment was removed from the building. Aerial reconnaissance with a UAV was used to assess the smoke dispersion. A specialised company was called in to pump out the oil separator to prevent the retention basin from overflowing. Public works machinery was assigned to clear out the site and the extinguishing water was conveyed to the local wastewater treatment facility. The fire brigade finished operations at the site five days after the fire had started.

One fireman had to be treated for heat stroke and two employees were treated for smoke inhalation. The 470 m³ of extinguishing water and the 370 t of damp waste were taken to landfill. Property damage totalled 15 M€. Temporary measures were needed to maintain the public waste sorting department in operation, including creating a temporary waste transfer centre and a waste sorting centre.

According to the operator, the presence of a combustion initiator in the stocker material, coupled with the high temperatures on the days preceding the fire, was responsible for the outbreak.

The operator identified the main routes that allowed the fire to spread throughout the structure (ventilation ducts, conveyors, cladding, etc.) and studied the modifications required during the reconstruction of the installations.

Fire was involved in three-quarters of cases over the same period. Unsurprisingly, 85% of these events occurred during the hottest months of the year (June, July and August).

Large amounts of water are sometimes needed to extinguish fires, and this can be hard to come by in extremely hot, dry weather. In addition, there can be a considerable volume of extinguishing water and this must be contained to avoid contaminating watercourses and groundwater, especially during periods of drought.

It should be noted that inert materials are used to extinguish or help control certain fires. This is frequently the case for fires that occur in the cells of non-hazardous waste storage facilities. There, the materials typically used to cover waste each day are used to smother the fire (e.g., *ARIA 51510*).

Fire at a waste sorting centre

ARIA 51510 – 08/05/2018 – SOMME

At around 1:50 p.m. on a bank holiday, a fire broke out in a cell of a waste storage facility. Part of the HDPE geomembrane liner caught fire and sent a large plume of black smoke into the air. The waste was excavated, spread out and sprayed with water. The firefighters set up a 110 m water supply line. Employees used heavy equipment to cover the waste with soil. After the fire was extinguished, the operator had the facility monitored overnight. At around 10:00 p.m., a new fire was reported and quickly brought under control by emergency services.

The fire burnt an area of 1,500 m² (i.e. half the cell where it broke out) and consumed waste material of a height of 10 cm. The extinguishing water which seeped into the bed of waste was treated with leachate. The geotextile and geomembrane on one side of the cell were damaged and required repair. The electrics of the cell's leachate collection system were also damaged (power supply cut off). The prefect issued an order to oversee the work needed to repair the damage and get the facility back up and running.

The facility's employees had left the site two hours before the fire started. As the day had been extremely hot, the operator conjectured that the fire was started by a piece of glass that acted as a magnifying lens.

Fires involving waste occurred in particular at non-hazardous waste storage facilities, on unauthorised waste received at sorting facilities and during waste transport, consolidation and shredding operations.

Self-heating of stored waste (e.g., ARIA 54714), "magnifying glass" effects (concentration of sunlight as it passes through a piece of glass) or runaway reactions during composting are also frequent occurrences.

Outside the waste industry, fires also occur at facilities with materials of other types. Examples include fermenting materials or products (such as sunflower seeds, alfalfa, maize, chlorine tablets for swimming pools, wood chips, coal, dust), overheating electrical and other equipment, rises in temperature or pressure and brush fires.

Self-heating of grease-soaked rags left in a geobox

ARIA 54714 – 25/07/2019 – HAUTE-GARONNE

A fire broke out at 1:22 a.m. inside a geobox parked up against the outside wall of a workshop in an electronics equipment manufacturing company.

It was determined that fire was likely caused by a self-heating phenomenon initiated by exceptionally high summer temperatures and the conditions in which dirty rags were stored. The rags had been placed in a closed, black geobox, in a location exposed to the searing heat of the sun. According to the investigations conducted by the INERIS, it appears that ten or so rags soaked in "MILASOLV BIO"

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cleaning and degreasing fluid and five rags impregnated with "M4 siccative" grease had been placed in the geobox. The grease and the MILASOLV product had saturated the porous material (rags) which fuelled the combustion. The air in the geobox thus served as the oxidiser. An oxidation reaction, initiated and exacerbated by the outdoor conditions (39 °C in the shade), served as the heat source. This oxidation of the grease-impregnated fabric resulted in a self-heating phenomenon that grew into a fire in just a few hours. If the heat released cannot be dissipated as fast as it is produced (as in the case of the closed geobox), the temperature rises in the area around where the heat is produced. This situation is known as thermal runaway. The rags began to smoulder once the solvent's self-ignition temperature (170 °C) had been reached.

Following the event, a new system was planned that would improve the management of geoboxes, soiled rags and chemical waste:

- geoboxes kept outside and away from the buildings;
- use of new geoboxes that are smaller in volume, ventilated and light-coloured;
- review of the service provider's collection frequency of the geoboxes from the workshops.

Pending the implementation of this new management programme, the operator decided to temporarily move the geoboxes away from the buildings in order to avoid the possible spread of fire. The geoboxes were propped open slightly to help balance temperatures during periods of extreme heat.

Although extreme heat as an external factor is the main cause of these events, there are deeper causes such as:

- Checks: accidents are frequently due to no or inadequate checks;
- Inadequate equipment and processes: this can include storage failures (due to conditions, containers or their positioning), insufficient compaction or covering in non-hazardous waste disposal facilities, and inadequately sized fire-fighting systems.
- Failure to identify risks: risk analyses that are either not carried out or do not factor in all relevant aspects — phenomena, risks from extreme heat, mixtures of acids and bases, creation of ATEX zones, or thermal and chemical stability of products — or which underestimate certain risks, or risk analyses that are not updated when on-site changes are made.

Rain and/or flooding

The ARIA database shows that twenty rainfall and/or flood events impacted French industrial facilities between 2010 and 2019. The years 2016 and 2018 were two exceptions. The number of events in those years peaked at 38 and 67, respectively, and corresponded to flooding in the Ile-de-France region and the passage of storms Carmen and Eleanor.

The floods recorded during this period were caused by rivers bursting their banks, rainwater runoff due to poor soil permeability, backflowing sewer or storm water networks, or ruptured pipes.

All sectors of the economy are at risk of flooding. No fatalities have yet been recorded and injuries are reported in only one in every 50 events.

Economic consequences are recorded in the ARIA database for the majority of these events, consisting mainly of internal material damage and internal operating losses. The amounts range from several thousand to millions of euros (e.g., *ARIA 48825*).

Flooding of a logistics warehouse

ARIA 48825 – 30/05/2016 - LOIRET

A logistics warehouse suffered flooding. After four days of heavy rain, the site's retention basin, and another basin belonging to the urban community, eventually overflowed. Due to the lack of drainage channels along the nearby road, runoff water worsened the problem. The unloading docks, which formed a low point around the entire periphery of the site, acted as a retention basin and protected the vicinity from flooding.

Losses of utility networks

The electricity networks did not operate during the flooding period from 10 May at 10:45 p.m. to 31 May at 7 p.m. The site's electrical substation was located on the site's property line, at a low point in relation to the road. The lift pumps went out after the substation flooded. In order to supply the site with electricity, three generators were installed and operated for 25 days to pump stagnant water, and for other purposes. An earlier attempt had been made to pump using agricultural equipment (two 18 m³ tanks) but it proved unsuccessful. The fire brigade was called in to find a better solution.

The site's telephone service was not affected. The lines used for the remote alarms used the public switched telephone network (PSTN).

Consequences

The operator reported 36 hours of operational downtime. Trucks waiting to gain access to the site received municipal authorisation to park in three streets closed to traffic.

Significant property damage occurred including fence damage, structural collapse and ground movement. Operating losses and property damage were estimated at more than 100 million euros.

Lessons learned

The ability of the city's networks to absorb the rainwater proved insufficient during the event. The position of the communal retention basin, located at a high point in relation to the warehouse, as well as the water evacuation capacity in the Lay River were studied. The following work was to be undertaken:

- replacement and elevation of the electricity distribution substation to a point 2m above the natural ground level
- replacement of the guard station's power supply cable
- repair of the fence.

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The operator also expressed concern regarding the designed discharge flow capacity for its retention basin because even with the pumps in operation, the basin would have overflowed given the heavy rainfall.

Over the period of the study, the flooding of buildings and other structures more than often resulted in discharges of hazardous or polluting substances.

Responding to flood events can be difficult. Access routes may be impracticable (submerged roads, water depth, etc.) and high-capacity pump systems may have to be brought in. In addition, emergency services prioritise assisting the general population over businesses, and poor weather conditions at night complicate air-rescue operations.

Again, although external hazards are the primary causes of floods, these events have deeper root causes:

- Checks: no or inadequate checks are the frequent cause of flooding;
- Inadequate equipment and processes: the ARIA database contains instances of inadequately sized storm water networks and ponds, design flaws and unsuitable equipment (such as pumps).
- Failure to identify risks: poor understanding of water networks, underestimation of water-related risks, risk analyses that either ignore or inadequately take into account the risk of flooding or heavy rain, failure to drain retention ponds following an initial rainy period, and site layouts that are susceptible to flooding are all causal factors found in the ARIA database.

Conclusion

Experience feedback from natural and technological events (NaTech) at French industrial facilities between 2010 and 2019 shows a significant increase in the number of recorded events. The root causes identified during the analysis of these events prompt the following recommendations:

Firstly, operators must identify the natural events likely to adversely affect their facilities and select one or more reference events. For example, the water height likely to be reached must be assessed in the case of a flooding scenario.

They must also consider the various scenarios for the selected events and anticipate the difficulties that may arise as they play out. For example, the availability of fire-extinguishing products must be taken into account when considering a fire scenario involving extremely hot weather.

Mitigation measures adopted to reduce the effects of a given natural event must of course be adapted to the vulnerability of facilities and factor in not only the event's duration but also the time required to get back to "normal" operations.

Lastly, the full range of risks identified for each natural hazard must be factored into all operating procedures at a facility and include monitoring of weather alerts. Depending on the situation, alerts issued by Météo France caution operators to exercise the greatest vigilance during a weather event or provide 24-hour advance warning to allow them to take the necessary preventive measures. Experience shows that when designing safeguards, extra vigilance is required to ensure that they can withstand the increasing intensity of weather events witnessed in recent years.

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