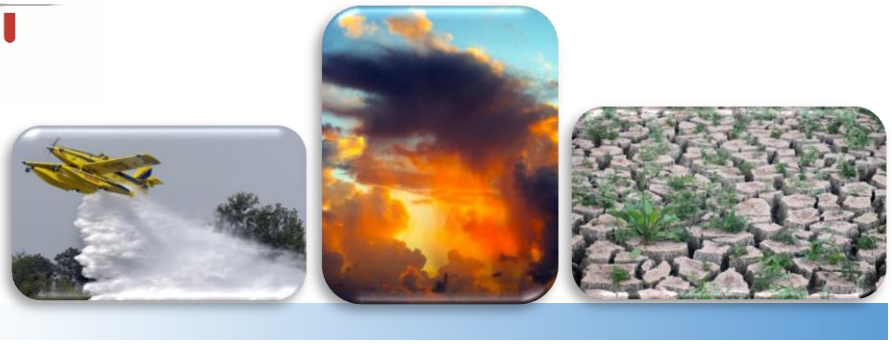
Ministère de la Transition écologique et solidaire

BARP

DGPR SRT



Industrial accidents initiated or exacerbated by high temperatures

May 2020

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Introduction

High temperatures, resulting from either a searing heatwave or unusually high seasonal temperatures, are at the origin of many industrial events.

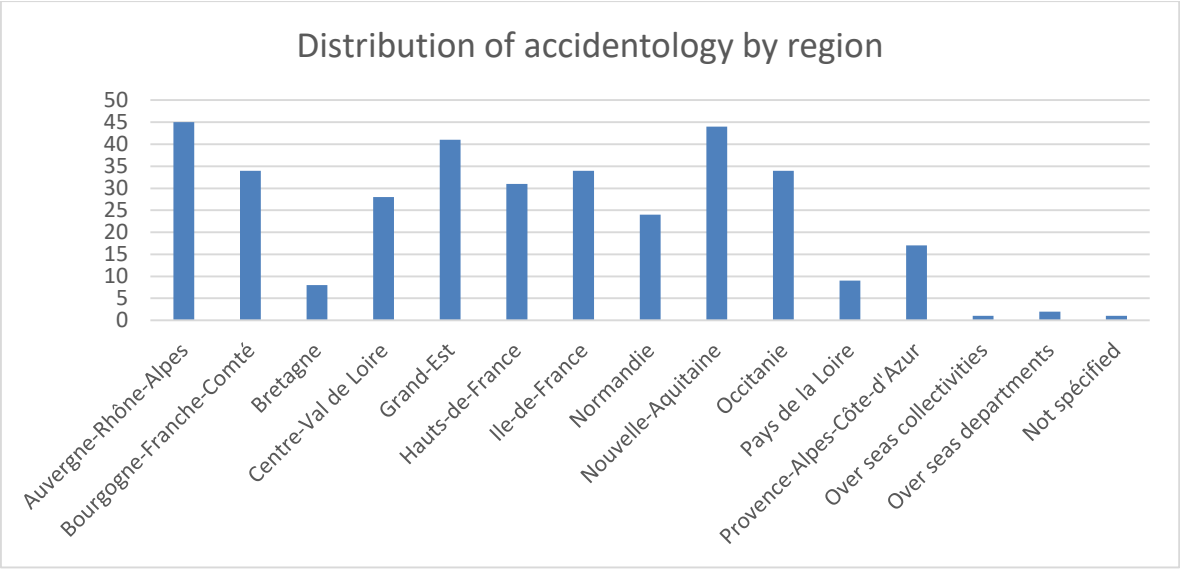
This summary highlights the impacts that high temperatures have on installations. It has been established based on the analysis of events listed in the ARIA database, which is managed by the Directorate General for Risk Prevention (DGPR) of the Ministry for an Ecological and Solidarity Transition.

For this study, 353 events, occurring in France between the summer of 1983 and late 2019, were analysed. All of these events affected installations classified for the protection of the environment (ICPE), and for which high temperatures were either the cause (suspected or proven) or an aggravating factor of the event.
ARIA is not a statistical database. This study is, therefore, an analysis of the trends involving high temperature-related events, from which recommendations can be made to prevent such accidents.

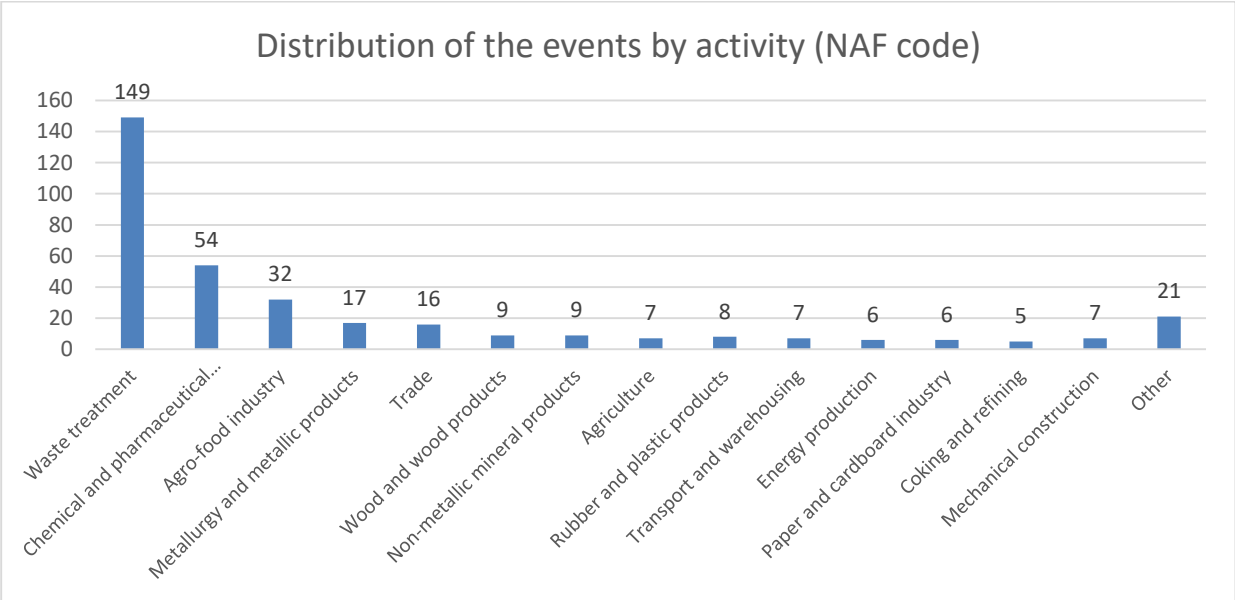
The list of illustrative accidents where high temperatures are involved can be downloaded from the site http://www.aria.developpementdurable.gouv.fr.

1. The typology of this industrial accidentology

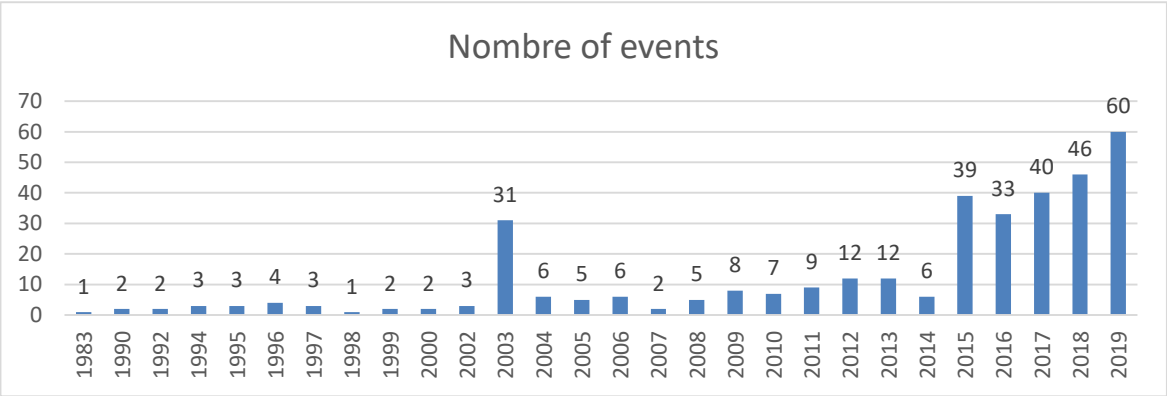
All metropolitan regions in France have experienced accidents involving high temperatures. The ARIA database also includes several events that occurred overseas. There are no peculiarities in terms of geographical location or industrial concentration.



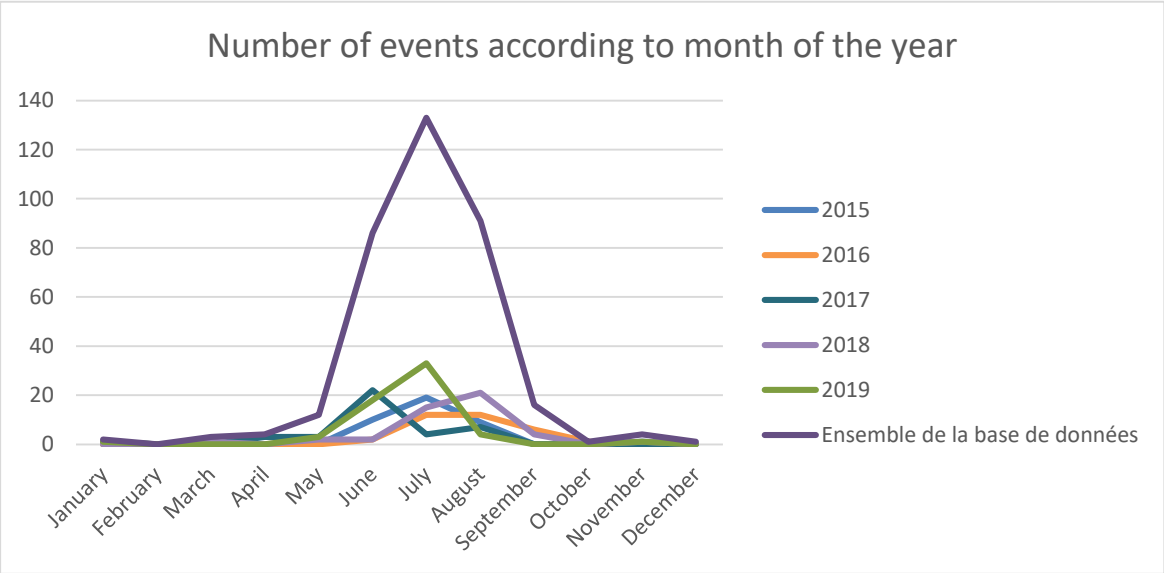
All sectors of activity have their share of high temperature-related accidents. However, some sectors have a significantly higher number of events. This is especially true for activities involving waste collection, treatment and disposal; materials recovery (NAF 38 - trade sector code), which represents 149 events (42% of the sample studied).



Waste materials, particularly those present in manufacturing facilities, are also involved in events caused, or exacerbated, by high temperatures. Twenty-three events are recorded in the database, i.e. 6.5%.
Thus, in total, the events occurring in the waste processing sector, whether associated with the main activity of the site where the event took place or with the nature of the element involved, account for nearly 50% of the events recorded.
The annual breakdown of accidents shows an apparent increase in the number of high temperature-related events, particularly over the last five years. Except for 2003, during which 31 events were recorded, roughly ten events were identified in the ARIA database between 1992 and 2014. A significant increase was noted starting in 2015 when the number of events rose to 39. It reached its peak in 2019 with 60 events in the database at the time this study was written[1].

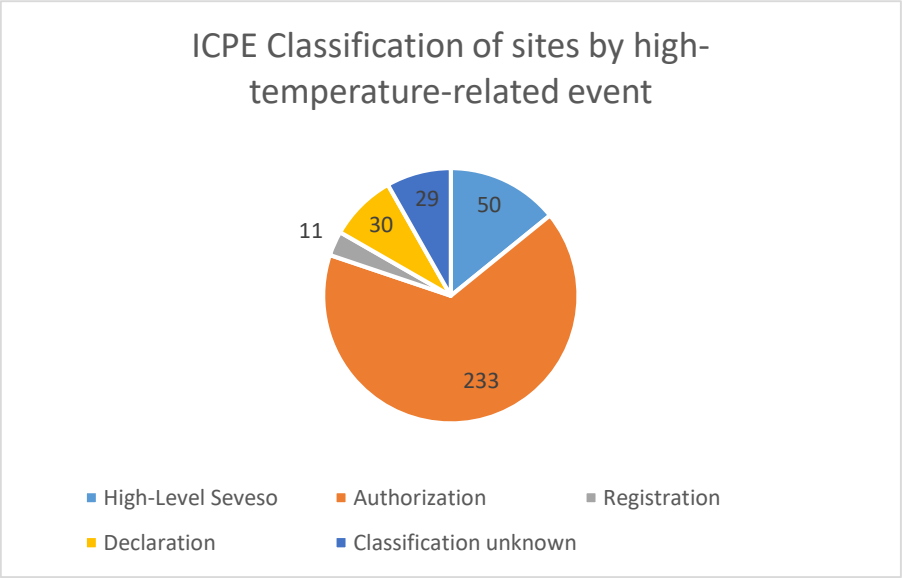


Unsurprisingly, the events mainly occur during the summer months with a peak in July, which includes 38% of the events recorded in the ARIA database. Over the last five years (2015-2019), the monthly distribution of events has remained the same, with a peak in the summer months.

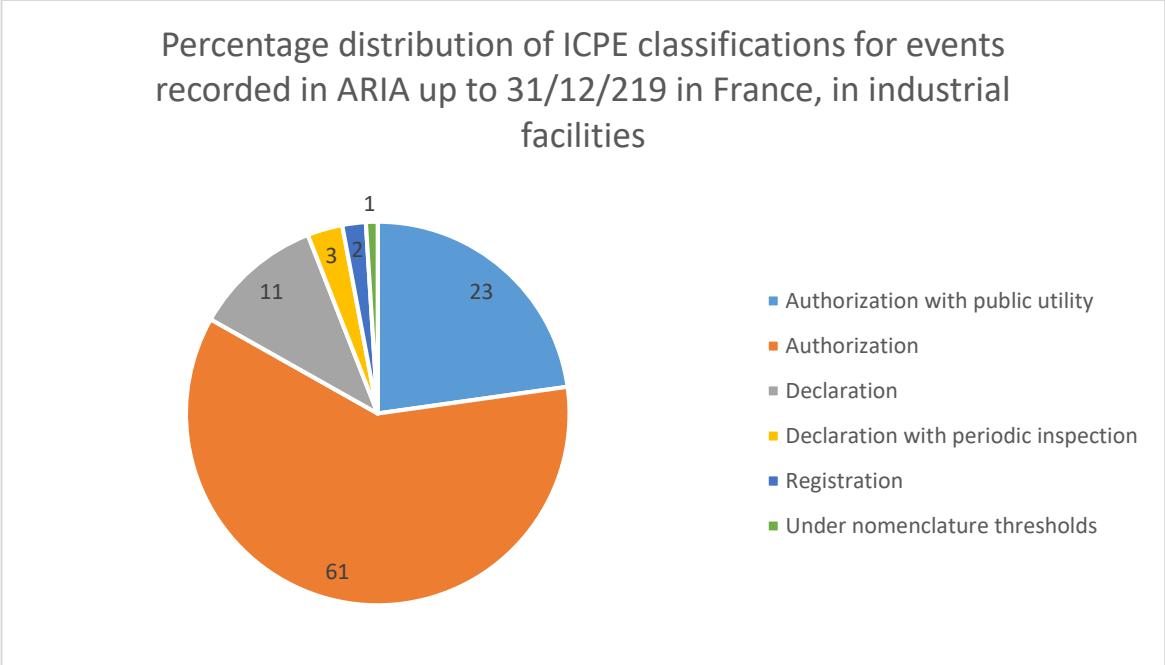


[1] It should be noted that the ARIA database underwent changes in 2014, generating differences in how events are recorded. However, this does not alter the variability of the results between each year (see 2003). In any case, the last four years (2015-2019) show the correlation between the number of events and the temperature differences recorded.

Of the 353 high temperature-related events in the database at the time this study was written, none of them concern a major accident under the Seveso III Directive.
High temperature-related events concern all industrial facilities regardless of their ICPE classification.



The sample includes a high proportion (80%) of sites subject to authorisation or SEVESO high threshold establishments. This corresponds to the classification categories of sites impacted the most in the ARIA database.



[2] 16,901 events were used as the basis for this graph

2. Hazardous phenomena observed

For the 353 events within the scope of this study, 458 phenomena were observed, with one event leading to one or more different phenomena. A maximum of 4 phenomena was observed in the events selected.

The table below shows the distribution of the main phenomena :

	Number of events	Percentage of phenomena encountered	Percentage of events recorded
Fire	259[3]	56.6	73.4
Release of hazardous or polluting materials	144	31.4	40.8
Explosion	22	4.8	6.2
Other phenomena	33	7.2	9.3

Of the 353 events, nearly 75%, or 263 events, had only one phenomenon. Fire was involved in 175 of these events, or two thirds.

A release of hazardous or polluting materials was noted in less than a quarter of the cases, or 63 events.

If we restrict the scope of events to activities related to waste collection, treatment, disposal activities; materials recovery (NAF 38), a total of 149 events were observed, featuring 204 phenomena. A predominance of fire was observed.

The following table shows the distribution of phenomena in events where waste was involved:

	Number of events	Percentage of phenomena encountered	Percentage of events recorded
Fire	150[4]	73.5	98
Release of hazardous or polluting materials	48	23.5	32.2
Explosion	6	2.9	4
Other phenomena	-	-	-

[3] Four events within the scope of the study had 2 fires that were considered as separate. They either occurred several hours or several days apart (ARIA 53956, 54101), or had spread to another, completely different area of the site (ARIA 46797, 49652).

[4] One event within the scope of the study had 2 fires.

Of the 149 events, nearly two-thirds or 98 events, exhibited just one phenomenon. Fire was involved in nearly all of these events (96).

The predominance of fire is also observed in events involving waste outside the NAF 38 activity code: “Collection, treatment and disposal activities; materials recovery”. In the 23 events identified, 28 phenomena were observed according to the following distribution:

	Number of events	**Percentage of phenomena encountered**	**Percentage of events recorded**
Fire	20	71.4	87
Release of hazardous or polluting materials	7	25	30.4
Explosion	-	-	-
Other phenomena	1	3.6	13

2.1. Fire

There were 254 events involving high temperatures in which a fire was observed. In four of these events, two fires were counted either because a second fire started a few hours or days after the first one, but originated from the first, or because two separate areas of the site were affected.

As indicated above, waste was involved in the majority of the fires.

Notably:

- at non-hazardous waste storage facilities (e.g. ARIA 52212, 54101, 54445);
- on unauthorised waste in waste sorting, transit, and grouping centres (e.g. ARIA 53949, 54107);
- during waste shredding operations (e.g. ARIA 54040);
- on end-of-life vehicles caused by the magnifying glass effect (the concentration of sunlight as it passes through a piece of glass) (e.g. ARIA 52042, 53885);
- due to self-heating phenomena of stored waste (e.g. ARIA 52370, 54189, 54714);
- due to runaway reactions during composting (e.g. ARIA 52139, 54026).

ARIA 54714 – 25/07/2019 – HAUTE-GARONNE
26.51: Manufacture of instruments and appliances for measuring, testing and navigation

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

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, and 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" 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, was 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 studied to 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.

Fires were also observed at other types of installations and on materials, with notably:

- fermentation of materials and products: sunflower (e.g. ARIA 52097), alfalfa (e.g. ARIA 54192), corn (e.g. ARIA 43953), meat meal (e.g. ARIA 2227), chlorine tablets for swimming pools (e.g. ARIA 46824), wood chips (e.g. ARIA 49775), coal (e.g. ARIA 54317), dust (e.g. ARIA 54093);

- electrical overheating (e.g. ARIA 52054, 54187);
- equipment overheating (e.g. ARIA 54339, 54363);
- temperature rises (e.g. ARIA 52034, 54066);
- pressure rises (e.g. ARIA 49799, 50058);
- brush fires (e.g. ARIA 30378, 52042).

ARIA 54066 – 09/07/2019 – FINISTÈRE
25.61: Treatment and coating of metals
Zinc powder fire in a metal treatment and coating company
At 2 p.m., a fire broke out in a big-bag containing zinc powder waste behind a furnace in a metal treatment and coating company. […]. A fire extinguisher was used to contain the fire while waiting for the fire brigade to arrive. The emergency services turned the big-bag over and poured sand over the top of it. The fire was brought under control at 4:15 p.m.
The big-bags of zinc powder waste had been stored behind the furnaces, directly below a series of windows. The intense heat caused the temperature of the big-bags to rise, which was accentuated by the heat generated by the sun shining through the window. Big-bags are normally covered with a tarpaulin, although an employee had removed it a few days earlier and then neglected to put it back in place. The moisture content of zinc powder could be high and the big-bags are not watertight. The type of packaging used for this waste had been chosen to comply with the regulations of the European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR).
The operator plans to procure a stockpile of sand. To avoid possible overheating or air- or moisture-tightness problems, the operator also plans to create a sheltered steel storage area with adequate ventilation. The big-bags will be stored under a ton of bagged sand, which, if necessary, can be mechanically opened and poured over a fire.

Significant water resources are often required to combat a fire and are sometimes difficult to procure in periods of extreme heat. The volume of extinguishing water can be considerable (e.g. ARIA 54192) and must be confined to prevent the pollution of rivers and groundwater, particularly during periods of drought.

It should be noted that for certain fires, inert materials are used to extinguish or help extinguish the fire. This is frequently the case with fires in compartments used to store non-hazardous waste where the materials used for daily covering are used to smother the fire (e.g. ARIA 52503). Sand was also used in the final step to extinguish a fire of zinc powder waste (ARIA 54066), and clinkers were also used in a bulk waste fire at a non-hazardous waste incineration facility to cover burnt waste (ARIA 54107).

If high temperatures are not the actual or proven cause of the event, they can be an exacerbating factor (e.g. ARIA 48268, 53848).

ARIA 53848 – 24/06/2019 – SARTHE
22.21 Manufacture of plastic plates, sheets, tubes and profiles

Fire in a printing plant specialising in printing on plastic or aluminium substrates
At around 5:40 p.m., a fire broke out in an ink fountain cleaning tank containing 200 l of ethyl acetate. The cleaning tank was located in a 5,000 m² building of a printing plant specialising in printing techniques on plastic or aluminium substrates. Owing to the flammability of the solvents present in the area, the fire spread to nearby storage drums. The building contained 60 m³ of ink, ethyl acetate and isopropyl alcohol. The 50 employees present at the time were evacuated. As a precaution, the companies located in the surrounding area confined their personnel indoors. […]
The printing facility had to be shut down because the workshop in question was a key element of its operation. Two workshops resumed operations on 08/07/2019. Given the nature of the products used at the facility and the presence of clumps of ink on the ground around the plant, the Classified Facilities Inspection authorities proposed that the Prefect issue an emergency order to analyse the fallout of the fumes in the environment.
According to the operator, a trolley had accidently disconnected the cleaning tank's earth connection. The removal of an ATEX pump may have triggered the fire which, coupled with the high outdoor temperatures, exacerbated the phenomenon.
The operator took the following measures:

- earthing systems were doubled by means of overhead lines;
- insulation of the 1,250 kWh transformer along the property line;
- air conditioning of the premises;
- installation of a 6-hour fire wall rising above roof level;
- purchase of a water-based ink fountain cleaning machine.

Wind can also be associated with high temperatures, complicating an event in progress (e.g. ARIA 50175).

ARIA 50175 – 14/08/2017 – HAUTE-GARONNE
38.32 Recovery of sorted materials

Fire in a waste sorting and transit centre
At around 6:45 p.m., a fire broke out on a stockpile of non-dangerous industrial waste in a 7 ha waste sorting and transit centre. […]. The heat and the wind (70 km/h) fanned the flames causing the fire to spread to 4 neighbouring businesses. The fire created a large plume of black smoke. For safety reasons, the speed limit on the Bordeaux-Toulouse motorway was reduced and an exit was closed. Power supplies were switched off and the fire was eventually brought under control at around 2:30 a.m. […]
The internal economic consequences of the accident (including property damage and operating losses) amounted to 2 million euros. The building was rebuilt, and a new sorting line was commissioned a year later.
The site had been operating normally throughout the day when the fire broke out at the end of the shift. The weather conditions (hot and dry, coupled with strong winds) played an aggravating role in the development of the disaster and its spread to 4 neighbouring companies.

2.2. Discharges of hazardous or polluting materials

Among the events associated with high temperatures, 141 involved the release of polluting or hazardous materials. Such releases can be:

- in the soil or in a retention basin, for 23 of the events within the scope of the study. The significant cases involve container ruptures (e.g. ARIA 35084, 40727) or fire or explosion-related consequences (e.g. ARIA 25320, 54384). One case of land subsidence involving a containment drain (ARIA 1019) and a case of a dyke failure (ARIA 26764) were also identified;

- into the atmosphere: 98 events are concerned. Most of the releases are associated with fires. However, the report includes unscheduled flaring (e.g. ARIA 47542, 53889), malfunctions in wastewater treatment facilities (e.g. ARIA 49833), container decompressions and the evaporation of various products (e.g. ARIA 25587, 48144), leaks on refrigeration components (e.g. ARIA 29925), and discharges from cooling towers (e.g. ARIA 25341);

- into water (26 events). There are consequences of certain fires where the extinguishing water is not contained (e.g. ARIA 46815, 54074), as well as wastewater treatment plant malfunctions (e.g. ARIA 40727, 49926), container or pipe ruptures (e.g. ARIA 35084, 44750) and emptying of cooling systems (ARIA 45361).

ARIA 49833 – 16/06/2017 – YVELINES
37.00. Sewerage

Discharge of biogas in a wastewater treatment plant
In a municipal sewage treatment plant, biogas was being released over a period of 3 days from the sewage sludge digester. The releases coincided with unscheduled plant shutdowns. Each time, the operating technicians put the installations back into operation to stop the releases. A total of 4,000 Nm^3 of biogas was released, i.e. 4.2 t (of which 60% was methane).
The automated trips were caused by 2 methane sensors failing on the gasometer's double-walled casing. These failures, which occurred at midday, were caused by sensors overheating as a result of direct exposure to solar radiation. The shutdown of the systems downstream of the digesters caused the pressure in these vessels to increase, triggering the opening of the safety valves. The biogas was directed to a flare tower. However, the automated control system, which had initiated the emergency stops, also extinguished the flare in an abnormal manner. The biogas was thus released into the atmosphere without prior combustion . Following the accident, the operator modified the PLC so that the flame tower would not be extinguished during emergency stops. It plans to protect the CH4 sensors from solar radiation by means of “caps” or to replace them with sensors that use another, less temperature-sensitive technology.

2.3. Explosion

Among the events related to high temperatures, 22 involve explosions. Fire is an accompanying factor in nearly two-thirds of the cases (14 events). A variety of materials are at cause, although explosive products or munitions are involved in 40% of the cases (ARIA 7181, 24438, 30085, 32144, 36014, 36811, 36880, 48421, 49807).

The ARIA database also records events associated with:

- chemical products or chemical product waste (ARIA 5504, 52026, 54384);
- metal waste (which may be aerosol canisters, batteries, etc.) (ARIA 31960, 32004, 40736);
- canisters of pressurised gas (ARIA 27652, 28238) or coolant (ARIA 54305);
- alcohol (ARIA 25140, 47045) or bitumen storage facilities (ARIA 24855);
- a PCB transformer (ARIA 11549).

ARIA 52026 – 04/08/2018 – YVELINES

20.14 Manufacture of other organic basic chemicals

Fire in a chemical plant

At around 7:15 p.m., an explosion, followed by a fire, occurred in a 50 m² storage building in a production facility manufacturing synthetic products for chemicals and pharmaceuticals. The products stored on pallets included:

- metal drums containing propargyl alcohol (flammable and toxic);
- cardboard drums of non-compliant products containing solvents:
- bags of calcium chloride and sodium chloride.

The site had been shut down for maintenance at the time of the accident. The building in question was typically used for storing toxic products. However, non-compliant finished products were also being stored there temporarily while maintenance work was underway in the usual storage building.

After examining the drums, the operator determined that a drum containing propargyl alcohol (having a flash point below 60 °C) had exploded due to the thermal polymerisation of the product following extended storage at ambient temperatures above 30 °C. The material safety data sheet did not specify this risk; it mentions that the product should be protected from the action of heat and to avoid exposure to temperatures above 80 °C.

2.4. Other phenomena

Only 20 events within the scope of the study, i.e. 5.7%, experienced other phenomena—for example, the release of non-hazardous materials (e.g. ARIA 54328).

3. Consequences

The analysis shows that 309 of the 353 events selected had consequences. They are broken down in the following manner:

	Number of events	Percentage of the 309 events with recorded consequences
Human consequences	**45**	**14.6**
Fatalities	2	0.6
Serious injuries	6	1.9
Minor injuries	31	10
Total injuries	45	14.6
Economic consequences	**241**	**78**
Internal property damage	230	74.4
External property damage	13	4.2
Internal operating losses	59	19.1
External operating losses	2	0.6
Social consequences	**81**	**26.2**
Technical unemployment	17	5.5
Homeless third parties	2	0.6
Deprivation of use (water, gas, etc.)	11	3.6
Noise pollution	7	2.3
Population evacuated	29	9.4
Population confined	8	2.6
Safety perimeter	57	18.4
Traffic disruption	21	6.8
Environmental consequences	**163**	**52.8**
Environmental consequences (air, water, soil)	153	49.5
Harm to wild fauna	6	1.9
Harm to wild flora	11	3.6
Damage to crops	3	1
Damage to livestock	2	0.6
Other consequences	**3**	**1**

It should be noted that an event can generate a variety of consequences and that the results presented in this summary are taken from accidents recorded in the ARIA database. As such, results may be partial in relation to the actual consequences.

Given these results, it can be noted that human consequences are observed in one out of every eight events, most of which involve injuries. A total of 185 injuries were recorded. The event having the greatest impact, involving a case of legionellosis, resulted in 28 injuries (ARIA 25341). The accidents in which people are injured generally involve fire (e.g. ARIA 53876).

ARIA 53876 – 28/06/2019 – VAUCLUSE
17.21 Manufacture of corrugated paper and paperboard and of containers of paper and paperboard

Fire in an corregated cardboard manufacturing facility
A fire broke out at around 6 p.m. on pallets and boxes in a company specialising in the manufacture of corrugated cardboard. The mayor initiated the local emergency response plan and opened a centre to provide emergency accommodation for the residents of 50 homes who had to be evacuated. Traffic on the A7 motorway was shut down and diverted for 2 hours and 35 minutes. Rail traffic was interrupted for 4 hours and 20 minutes.
[…]. Seven firemen were treated for smoke inhalation or heat stroke, 2 of whom had to be taken to the hospital. Four individuals were slightly injured, 3 of whom were also taken to the hospital.
The weather conditions, complicated by high temperatures and wind, helped spread the fire to both sides of the A7 motorway and into the peri-urban area.

Economic consequences are observed in nearly 7 out of 10 events, primarily involving internal property damage. The damage resulting from these events ranged from a few hundred of euros to several millions of euros. Among the 353 events studied, the most significant economic consequences of an event in terms of internal property damage amounted to 15 million euros (ARIA 54016).

ARIA 54016 – 11/07/2019 – SEINE-ET-MARNE
38.11 Collection of non-hazardous waste

Fire in a waste sorting centre
A fire alarm sounded around 8:40 a.m. on a conveyor in a 6,000 m² selective waste sorting and transit centre. A 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 vegetative 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 2 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 evacuated 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 mandated to clear out the site and the extinguishing water was conveyed to the local wastewater treatment facility. The fire brigade finished up operations at the site 5 days after the fire had started.
One fireman had to be treated for heat stroke and 2 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: creation of 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 vectors that allowed the fire to spread throughout the structure (ventilation ducts, conveyors, cladding, etc.) and has studied the modifications required during the reconstruction of the installations.

The ARIA database contains few events involving farm animals, although animal mortality can be quite high (e.g. ARIA 54230). These are mainly economic consequences because farm animals are considered production elements.

ARIA 54230 – 25/07/2019 – SOMME
01.47 Raising of poultry

22,000 hens perish in a heat wave
During a heat wave, 22,000 hens died in a poultry farm consisting of 2 buildings (with a total capacity of 115,000 hens). The indoor temperature has reached 42 °C. The farmer had been able to control the increase in temperature in one of the two buildings. The dead chickens were removed from the buildings and stored on a concrete slab where they were then covered with lime. They were then recovered by a specialised company in the following days.
Operational losses totalled 60,000 €.
Following the accident, the operator planned to reinforce the protection equipment (ventilation and fogging) and revised the company's risk analysis to anticipate periods of high temperatures (> 40 °C).

Social consequences are also observed in more than one event in five. A safety perimeter or the evacuation of the population in the surrounding area are also required depending on the nature of the event. Evacuations range from just a few to several hundreds of people. The most significant occurrence identified in this regard resulted in the evacuation of 600 persons over 4 hours (ARIA 27652).

ARIA 27652 – 25/07/2004 – VAUCLUSE
46.69 Wholesale of other machinery and equipment

A fire spread to several industrial facilities
Fanned by a strong wind and encouraged by an ongoing drought, a massive fire swept through 9 ha industrial park. At 2 p.m., an arson had set fire to a cypress hedge which then spread to an agricultural products company where it destroyed a 1,500 m² building containing 1,000 t of plastics. As a result of the fire, property damage was estimated at 3 M euros and 20 employees were technically unemployed. At around 2:15 p.m., the fire jumped the road and set another cypress hedge on fire. From there, it extended via a domino effect to a 40,000 m² outdoor area used for storing Pregystyrene (polystyrene-backed plasterboard) in a manufacturing facility specialising in plaster-based products (ARIA 28238). The flames spread over the top of the building, igniting another tree hedge and a skip full of boxes, but spared the company's transformer, which had been protected by fire walls. Stock losses were evaluated at 700 K euros and property damage at 150 K euros. The fire moved through the industrial zone where it destroyed 3 m³ of tyres, 10 vehicles parking in a car park, and 2 homes. Several explosions of gas cylinders could be heard for nearly ¾ hour. The water utility boosted the water network to 300 m³/h and the emergency services drew water from the Carpentras Canal. It took two-hundred firefighters, assisted by a helicopter and 2 observation aircraft, roughly 6 hours to completely extinguish the fire. A large amount of black smoke could be seen 60 km away. The situation required the evacuation of 100 employees and 500 local residents. Two emergency responders were injured during the intervention. Floating dams were deployed to channel and isolate the extinguishing water. This fire resulted in extensive property damage. Following the event, the operators of the industrial zone assessed the potential risks of their installations.

Environmental consequences are recorded for nearly half the events with damage mainly to the environment, notably air pollution when fire is involved.

4. Disturbances

Out of the 353 events in the scope of the study, 131 events, i.e. more than one third, had only high temperatures recorded as a disturbance in the ARIA database (e.g. ARIA 53885). Sixty-four of these events (i.e. nearly 49%) were located in facilities associated with NAF code 38: Waste collection, treatment and disposal activities; materials recovery.
Out of the 131 events recorded in the ARIA database, twenty-four occurred during the summer of 2003.

ARIA 53885– 28 /06/2019 – EURE
38.32 Recovery of sorted materials

Fire in an ELV centre
During closing hours, around 8:10 p.m., a fire broke out on depolluted and compacted vehicles in an end-of life vehicle depollution centre. The fire resulted in a large plume of smoke and threatened to spread to an adjacent storage building (engines, pallets of paint, forklift truck), and to lorries pending depollution. The fire brigade set up 4 water hoses and a foam lance, and surveillance operations continued until noon the following day. A few remaining fires continued to burn along the edge of the site, while a handling machine continued to clear brush from the area. The car bodies were separated and the ground was scraped.
Two-hundred tonnes of depolluted vehicles were torched, with damage amounting to €25,000.
According to the fire brigade, the fire was attributed to a magnifying glass effect of the sun and high temperatures.

Among the other types of disturbances, supposed or proved, concomitant with the high heat are listed in particular :

- equipment failures in 89 events (e.g. ARIA 54187);
- loss of process control in 98 events (e.g. ARIA 54026);
- latent hazards for 60 events (e.g. ARIA 54189);
- human interventions in 54 events (e.g. ARIA 53829);
- malicious acts for 11 events (e.g. ARIA 45508).

ARIA 54026 – 13/07/2019 – YVELINES
38.21 Treatment and disposal of non-hazardous waste

Fire at a composting platform
At around 5 p.m., a fire broke out in a pile of raw green waste in a composting centre, releasing a plume of smoke. […]
The fire had been started by a natural self-heating phenomenon among the green waste that was in its fermentation phase. The temperature of the pile reached 150 °C. The runaway of the self-heating phenomenon was compounded by drought and strong winds.
The site was undergoing expansion. The object was to create 10,000 m² of additional storage space to separate the green and wood waste, reduce the height of piles and to increase the spacing between them.

5. Causes

5.1. Organisational causes

The events analysed were caused directly or exacerbated by high temperatures. However, further analysis of the root causes highlights mostly organisational factors.

Out of the 353 events in the scope of the study, 210 events have one or more causes related to organisational factors, which can be broken down as follows:

	Number of events	Percentage of 210 events with causes related to organisational factors
Working conditions of technicians	**67**	**31.9**
Training and qualification of staff	25	11.9
Organisation of the work and supervision	24	11.4
Workplace psychosocial environment	2	1
Procedures and guidelines	33	15.7
Physical working environment	3	1.4
Unsuitable ergonomics	6	2.9
Risk management	**203**	**96.7**
Identification of risks	43	20.5
Selection of equipment and processes	60	28.6
Insufficient safety culture	16	7.6
Insufficient feedback	19	9
Organisation of inspections	91	43.3
Communication	6	2.9

It should be noted that an event may have one or more root causes that are themselves inherent to various disturbances. The modelling tool illustrated below in an event summary helps establish the connections between phenomena, disturbances and root causes.

The root causes related to the technicians' working conditions are mainly associated with:

- Personnel training and qualification. Training defects (e.g. ARIA 48694, 54363), lack of the personnel's awareness of special conditions (e.g. ARIA 51189), lack of knowledge of instructions (e.g. ARIA 52370) or inexperienced personnel (e.g. ARIA 52648) were observed.

ARIA 52648– 09/09/2018 – AISNE

10.81 Manufacture of sugar

Fire in an alfalfa pellet silo

On a Saturday, while conducting rounds in a sugar mill, a security guard smelled a suspicious odour coming from an alfalfa pellet silo. He passed on the information at shift change. Smoke was detected at around 1 a.m. the following day. The silo, containing 5,500 t of pellets, was ventilated by creating openings at the top of the building. The fire brigade began removing pellets at 8:30 a.m. At 11:30 a.m., they momentarily stopped the intervention due to the intensity of the smoke and the wind that was blowing smoke toward the building's access door. During the night, the fire brigade made a hole in the silo's roof by removing 2 m² of tiles so they could spray down a hot spot. By the morning of the following day, a portion of the rescue services was demobilised. By 8 p.m., the carbon monoxide level had returned to normal and the body of the fire had dropped below 40 °C. The majority of the building had been emptied, and the firefighters left the site at 11 p.m.

On the fourth day of the accident, at 8:30 p.m. during the security rounds, incandescent particles were seen falling from the steel structure. The fire brigade returned and protected the pile of remaining pellets with a tarp. On the fifth day, the sensors were replaced on the remaining pile. The outdoor piles remained covered until the 6th day.

Several factors were identified as possible causes for the fire:

- this was the first time that alfalfa pellets had been stored on the site, and the operating personnel had not received training in the specific risks concerning its storage;
- the high ambient temperature during the summer period, coupled with unsuitable temperature sensor warning to differentiate between high temperatures due to weather conditions and high temperatures resulting from self-heating. The values were all displayed in red;
- absence of silo ventilation;
- insufficient training of technicians on the new silothermometry instrumentation installed in 2017, along with the absence of training on how to monitor temperature curves as stipulated in the procedure.

Following the fire, the operator initiated the following corrective actions:

- updating of building and access plans in the emergency procedure;
- updating of the pellet monitoring procedure and initiate measures to raise the awareness of the personnel;
- install silothermometry alarms on the monitoring system;
- train the operating personnel on how to use the temperature monitoring software and repair the sensors;
- review of the sensor lowering procedure with the silo service provider during the silaging procedure;
- study of the installation of an aeration system on the pellet silo.

- The organisation of the work and supervision. Failures in the organisation of storage facilities (e.g. ARIA 52026), activity overloads (ex ARIA 54040), insufficient personnel (e.g. ARIA 49894), and absence of checks on the tasks to be performed (e.g. ARIA 46913), absence of fire permit verification (e.g. ARIA 47045) or unsuitable periods for performing tasks (e.g. ARIA 55084) were encountered.

ARIA 49894 – 01/06/2017 – CÔTE-D'OR

38.22 Treatment and disposal of hazardous waste

Outbreak of fire in a hazardous waste treatment facility

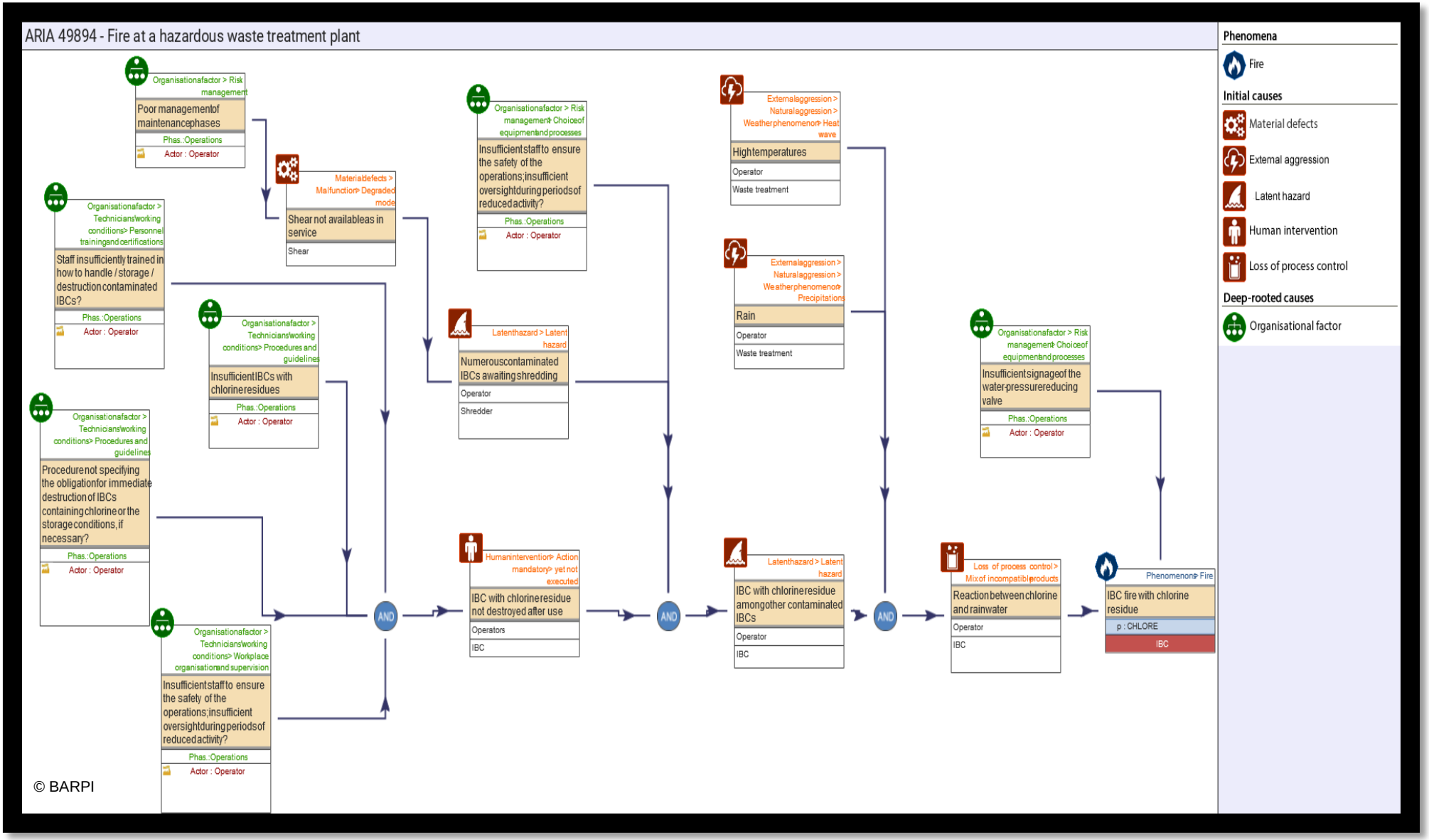
At around 10 p.m., a fire broke out in an intermediate bulk container (IBC) stored outside at a Seveso-rated hazardous waste treatment facility. The IBC had been stored near other similar packaging in the storage area reserved for "contaminated IBCs" intented for destruction. White smoke and flames rising 2 to 3 m high were detected by the site's security company, who then informed the operator. The fire brigade's intervention was slowed down by the search for the operation's pressure reducing valve. They were then able to put out the fire and left the premises at around 11:15 p.m.

The fire had consumed 2 t of waste, and the extinguishing water was processed on site.

The IBC involved in the accident had previously been used to neutralise chlorine tablets. The fire was caused by a reaction inside the IBC between a chlorine residue (oxidiser) and rainwater (from precipitation on the evening of the event). The reaction was promoted by the ambient heat. The "contaminated IBC" storage area had been more congested than usual due to delays in shredding these containers. The backlog was due to a combination of factors: reduced manpower during this period of the year and the transfer of the workload from a shear, undergoing maintenance, to the shredder. Beyond the problem of congestion, the IBC used to neutralise the chlorine tablets should have been destroyed immediately after it had been used, instead of being placed among the other IBCs waiting to be destroyed.

Following the accident, the operator undertook the following actions:

- identification of IBCs that had been used to neutralise chlorine (with an "oxidiser" label) among the IBC waiting to be destroyed. These IBCs are destroyed immediately after use. If immediate destruction is not possible, the IBCs are stored in a workshop and not in the uncovered outdoor storage area;
- improvement of the signage designating the location of the pressure reducing valve;
- increase of its workforce;
- shear returned to service;
- increase employee awareness of the new guidelines.


ARIA 49894 - Fire at a hazardous waste treatment plant
Organisationalfactor > Risk management
Poor managementof maintenancephases
Phas.:Operations
Actor : Operator
Materialdefects > Malfunction> Degraded mode
Shear not availableas in service
Shear
Organisationalfactor > Technicianswork ing conditions> Personnel trainingand certifications
Staff insufficiently trained in how to handle / storage / destruction contaminated IBCs?
Phas.:Operations
Actor : Operator
Organisationalfactor > Technicianswork ing conditions> Procedures and guidelines
Insufficient IBCs with chlorine residues
Phas.:Operations
Actor : Operator
Organisationalfactor > Technicianswork ing conditions> Procedures and guidelines
Procedure not specifying the obligationfor immediate destruction of IBCs containing chlorine or the storage conditions, if necessary?
Phas.:Operations
Actor : Operator
Organisationalfactor > Technicianswork ing conditions> Workplace organisationand supervision
Insufficient staff to ensure the safety of the operations;insufficient oversightduring periodsof reduced activity?
Phas.:Operations
Actor : Operator
Organisationalfactor > Risk management> Choiceof equipmentand processes
Insufficient staff to ensure the safety of the operations;insufficient oversightduring periodsof reduced activity?
Phas.:Operations
Actor : Operator
Latenthazard > Latent hazard
Numerouscontaminated IBCs awaiting shredding
Operator
Shredder
AND
Humaninterventior> Action mandatory> yet not executed
IBC with chlorine residue not destroyed after use
Operators
IBC
AND
Externalaggression > Naturalaggression > Weatherphenomenon> Heat wave
Hightemperatures
Operator
Waste treatment
Externalaggression > Naturalaggression > Weatherphenomenon> Precipitations
Rain
Operator
Waste treatment
Latenthazard > Latent hazard
IBC with chlorine residue amongother contaminated IBCs
Operator
IBC
AND
Loss of process control > Mixof incompatible products
Reaction between chlorine and rainwater
Operator
IBC
Organisationalfactor > Risk management> Choiceof equipmentand processes
Insufficient signageof the water-pressure reducing valve
Phas.:Operations
Actor : Operator
Phenomenon> Fire
IBC fire with chlorine residue
p : CHLORE
IBC
Phenomena
Fire
Initial causes
Material defects
External aggression
Latent hazard
Human intervention
Loss of process control
Deep-rooted causes
Organisational factor
© BARPI

- Procedures and guidelines. Lack of procedures (e.g. ARIA 52981), insufficient procedures (e.g. ARIA 54277) instructions unclear (e.g. ARIA 49846) or not adapted to specific situations (e.g. ARIA 54228) were noted.

ARIA 54277 – 01/07/2019 – CÔTE-D'OR
10.84 Manufacture of condiments and seasonings

Fire in a capacitor bank of a food-processing plant
A fire broke out at around 9:15 a.m. on a capacitor bank in a local low-voltage master distribution panel supplying the process side of a food-processing plant, i.e. 50% of the site's production capacity. The fire spread throughout the premises via the raceway located above the capacitor bank. […]
It was determined that the fire had been caused by the capacitor banks overheating as a result of an exceptional heatwave. In addition, the batteries were 20 years old (showing excessive wear and tear). The regulatory inspections had been performed (thermography, annual inspection), although no current measurements were performed on each bank. The ventilation in the room was not well designed and probably conveyed the smoke to the outside, preventing early detection of the fire.
The operator established a crisis unit for a month and took the following corrective measures:

- installation of a fire detection system on each piece of equipment, in addition to the fire detection in the premises;
- coupling of the fire ventilation with a fire damper and a fire detection system;
- isolation of the capacitor banks in a specific room;
- continuation of the annual inspection of electrical installations and thermography examinations.

The root causes associated with risk management are primarily related to:

- the organisation of inspections. The lack of inspections (e.g. ARIA 54364) or inadequacy of inspections (e.g. ARIA 54159) were encountered.

ARIA 54159 – 28/06/2019 – CHARENTE-MARITIME
11.01 Production of distilled alcoholic beverages

Release of propane in a distillery
At around 4:30 p.m., a leak was detected on a propane tank supplying a distillery. One of the 3 safety valves, calibrated at 16 bar, was actuated. The crew on site activated the sprinkler boom to lower the equipment's temperature and pressure. The company in charge of performing maintenance at the site was contacted at 4:40 p.m. By the time the technician arrived at around 7 p.m., the pressure had already decreased to 10 bar. He replaced the valve and left the premises at around 8 p.m.
The valve was activated due to high temperatures, and the distillery had been shut down at the time of the event. The operator plans to remind operators of the plant's operating rules as soon as activity resumes.

- the choice of equipment and inappropriate processes. Storage areas (due to conditions, container or positioning) (e.g. ARIA 52034), equipment (e.g. ARIA 54093), or processes such as insufficient compaction or covering in non-hazardous waste storage facilities (e.g. ARIA 54228) and also poorly dimensioned firefighting resources (e.g. ARIA 53949) have been identified.

ARIA 52034– 05/08/2018 – RHÔNE
20.41 Manufacture of soap and detergents, cleaning and polishing preparations

Fire in a detergent factory
The event took place on a Sunday at around 3 p.m. in a company specialising in the manufacture and packaging of detergent products. A big-bag containing 200 kg of 30 % sodium percarbonate (oxidiser) began to self-heat. A security guard from a security services company, present at the site during off-business hours, noticed abnormal temperature on a big-bag while using a infrared thermometer to measure the temperature of a group of big-bags containing oxidising products. The smoke set off the fire alarm by the time the security guard could raise the alarm. […]
The self-combustion was caused by high temperatures. According to the operator, the temperature in the big-bag had risen exponentially. The semi-finished products containing 30% sodium percarbonate had been placed in a storeroom without any means to maintain the temperature below 40 °C, as recommended by the product's MSDS. The security guard followed the alert procedure, but did not have instructions on how to handle abnormal temperature. The organisation of the operator's crisis management programme did not provide information on the products concerned. Furthermore, the big-bags were not labelled, as the characterisation of the products' risks had not been completed. […]

- identification of risks. Risk analyses not conducted (e.g. ARIA 54305), not taking all the phenomena into account (e.g. ARIA 55271), risks associated with high temperatures (e.g. ARIA 50057), acid/base mixtures (e.g. ARIA 53918) formation of an ATEX zone (e.g. ARIA 47045), the thermal stability of products (e.g. ARIA 52026), underestimation of specific risks (e.g. ARIA 49853) or not updated when a change occurs on-site (e.g. ARIA 52981) are identified.

ARIA 50057 – 07/07/2017 – SEINE-ET-MARNE
77.32 Renting and leasing of construction and civil engineering machinery and equipment
Fire of contaminated paint booth filters
A fire broke out in 2 bins of waste containing glass fibre-based filters contaminated by paint. The filters were from a paint booth in a company specialising in the rental of construction machinery and equipment. The operator had the building evacuated while the fire was releasing black smoke. Property damage was estimated at 300,000 €, and operating losses at 50,000 €.
The drying process of alkyd resin-based paint is exothermic (evaporation of water then oxidation of the paint). The filters below the paint booth's grating gradually become saturated with paint. After 150 h hours of use, the saturated filters are replaced and stored in specific closed waste bins, where the oxidation reaction continued for several days. On the day of the event, the outside temperature was very high. This situation was compounded by a mass effect due to the filters being wound. The temperature in the bins had reached the self-combustion temperature of the paint residues that had impregnated the filters, causing them to burst into flame. This phenomenon had not been included in the risk analysis; the supplier had not provided any information about this risk.
The operator took the following measures:
- collaboration with the paint and filter suppliers on the causes of the fire and the measures to be taken;
- contaminated filters will be stored in sealed metal drums to limit the supply of oxygen;
- drums will be stored in the shade, outside the workshop;
- drums will be systematically removed by the waste contractor on the same day or, at the latest, the day after the filters are disposed of;
- raise staff awareness about the risk.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During events for which only high temperatures are recorded as disturbances, 63 of them have assumed or proven causes recorded in the ARIA database. All the events are related to organisational factors and the root cause in all 63 events is risk management (e.g. ARIA 34994).

ARIA 34994 – 22/06/2008 – MARNE
16.23 Manufacture of other builders' carpentry and joinery
Fire in a hydrophobization workshop of a joinery shop
A fire in a joinery shop spread to the wooden structure of fire protection (flocking) element below the roof of a hydrophobization workshop. Burnt pieces of wood fell onto oily, plastic tarps, resulting in a significant release of smoke. […]
The most likely hypothesis to explain the cause of the accident would be the ignition of a acetic acid vapours. These vapours were the by-product of the decomposition of the hydrophobization product due to the high temperatures from the day before.

5.2. Human causes and imponderable factors

Out of the 353 events in the scope of the study, only 4 cite the human factor as the root cause for failure. Forgetfulness was one of the causes of the accident in 2 of these cases (e.g. ARIA 47004).

ARIA 47004– 05/08/2015 – HAUT-RHIN
38.32 Recovery of sorted materials

Fire in a shredded plastic silage facility
At around 4:45 a.m., when starting his shift at a plastic waste processing facility, a foreman smelled something burning and saw smoke coming out of a building. Upon entering the building, he noticed 1 to 2-m high flames at the base of a shredded plastic collection hopper. […]
The fire had started in a 500-litre recovery bag (sock) filled with shredding fines. The sock was attached to a cyclone filter, at the top of the hopper, which separates the shredding fines from the plastic shreddings. The fire then spread from the second sock attached to the same cyclone. Before falling to the ground, these 2 flaming socks spread the fire to the socks of the neighbouring hopper via a hose connecting the 2 cyclones of each hopper.
The cause of the fire was not determined. Work had ended the previous day at 9 p.m. and was to resume in the morning at 5 a.m. At the time of the event, the socks had not been emptied for 3 to 5 days. However, this operation is normally performed at the end of each shift, i.e. twice a day. It should also be noted that the fines and the shredded material are normally humid. This had not been the case at the time due to the hot weather over the last few days. The operator suggested that the fire may have been started by static electricity, which may have led to slow combustion throughout the night.[…]

On the other hand, only 2 events are recorded having an imponderable factor as the cause.

6. Main lessons learnt

Several lessons can be drawn from the analysis of these 353 events recorded in the ARIA database, which occurred between the summer of 1983 and late 2019.

High temperatures cause or are an aggravating factor in many fires in waste treatment facilities or waste storage areas at other facilities, such as manufacturing installations. Production facilities, waste dumps or storage areas are only very rarely the prime concern of operators due to the lack of added value produced by these activities.

Risk analysis is a core component of accidentology associated with high temperatures. Of course, it must be kept up to date and consistent with the parameters and operating conditions, particularly if modifications have been made. Concerning high temperatures, the risk analysis must specifically take into account the following points irrespective of the type of industrial installation concerned:

- identification of raw materials, finished products or waste susceptible to react with heat (through decomposition, polymerisation, overpressure, etc.). The goal is to be able to store such elements optimally while limiting their exposure to the sun's radiation;
- identification of all equipment stored outdoors and exposed to direct sunlight. The aim is to organise the examination of this equipment and particularly evaluate any potential damage due to the high temperatures;
- compartmentalisation or the creation of limited storage areas to restrict the propagation of fire, but also to keep incompatible products away from each other;
- implementation of special measures to reinforce surveillance of the outdoor storage of materials susceptible to fermentation when exposed to heat;
- brush clearing and maintenance of the site's surroundings or outdoor storage areas to prevent the spread of a brush fire;
- consideration of potential electrical overheating or short-circuits on motors and transformer capacitor banks, as well as the dimensioning and maintenance of cooling units;
- establishment of a special procedure for issuing welding and cutting permits during periods of high temperature, which includes a list of specific precautions to be taken;
- consideration of how high temperature affects the site's various operating procedures, with the various parameters to be monitored for each piece of equipment or installation (including temperature and pressure). The procedures governing occasional work and on-site intervention by subcontractors must also take this into account;
- consideration of the magnifying effect. The concentration of the sun's rays through glass (glass waste, windscreen, windows without shades or blinds, etc.) must be avoided;
- adaptation of the fill levels of equipment containing products likely to expand due to heat and inspection of safety accessories (valve type), which can be reinforced during periods of high temperatures;
- special surveillance measures concerning cooling towers and the increase of inspections during periods of high temperature to detect the presence of legionella.

Weather alerts should be closely monitored, and a specific procedure must be defined before high temperatures occur so as to anticipate the problem. Also, in the event of an accident, particularly a fire, one must ensure that the site has sufficient and usable water reserves that can be quickly replenished. Attention should also be focused on extinguishing water management and the possible use of inert materials.

Generally speaking, shortcomings in risk management are the leading root cause of events related to high temperatures. Risk assessment must be a core component of prevention and mitigation measures. The operating procedures must take into account high-temperature situations, and the specific actions to be taken in the event of a weather alert must be defined. These procedures and the actions to be taken must be reviewed before the summer season.

ACCIDENTS
ONLINE TECHNOLOGIES

Our society is fully justified in demanding safety and transparency.
Since June 2001, professionals and the general public have been able to access the results of analysis of technological accidents on the website www.aria.developpement-durable.gouv.fr of the Ministry for an Ecological and Solidary Transition.
The main sections of the website are presented in English and French.
The Internet user can, for example, use the general headings to learn about governmental action, read large extracts from the ARIA database, discover the presentation of the European scale of accidents, and learn about the index relating to hazardous materials released to complete “real-time communication” in the event of an accident or incident.
A considerable portion of the website is devoted to accident reports, which are essential for all measures based on experience feedback. The proven or presumed causes, circumstances, sequence of events, consequences, action taken and lessons drawn are all provided.
A hundred or so detailed and illustrated data sheets present accidents that have been selected as particularly informative.
Numerous analyses are also available by theme and industrial sector. The section providing technical recommendations offers various themes including warehouses, surface treatment fine chemistry, storage and incineration of waste…
A multisearch engine offers information on accidents in France and abroad.
The website (www.aria.developpement-durable.gouv.fr) is constantly being updated.
Details of nearly 50,000 accidents are now available online and new analyses will be added regularly dealing with specific themes.

Summaries of the events presented are available on the website:
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To submit a comment or suggestion, to notify of an accident or to obtain permission to use this data for publication purposes:
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