MINISTRY OF ECOLOGY, SUSTAINABLE DEVELOPMENT AND ENERGY


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Results of an accident study covering the 2015 summer heat wave in France

- December 2015 -

Source: DREAL Environmental Agency, Lorraine

ARIA
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Introduction

While its impact was not quite that of the deadly heat wave in 2003, the hot weather experienced during summer 2015 was still highly exceptional for France. At the global scale, the month of July 2015 went down in history as the hottest on record.

According to an assessment by the French Institute for Public Health Surveillance, the three individual heat wave episodes recorded in France during summer 2015 caused a total of 3,300 additional deaths, equivalent to an excess mortality rate of 12%. In 2003, the rate had reached 55% (resulting in 15,000 additional deaths).

Beyond the impacts of the 2015 heat wave on day-to-day life, BARPI has undertaken an analysis of the effects of these recent extreme hot spells on accident trends occurring in industrial activities.

This topic has already been studied by BARPI, giving rise to an executive summary published in 2014 and a 2012 news flash. The lessons learned from these publications remain applicable to today's context. The present document is intended to provide a close-up on the summer 2015 heat wave as well as on the experience feedback to draw upon.

Scope of this study

The analysis was conducted on the various accidents that took place in France between 1st April and 30th September 2015 in which extreme heat appeared as a cause or factor serving to magnify the perceived hazardous phenomenon.

The final list contains 43 accidents.

The summaries of all accidents analysed are available on the ARIA website http://www.aria.developpement-durable.gouv.fr/

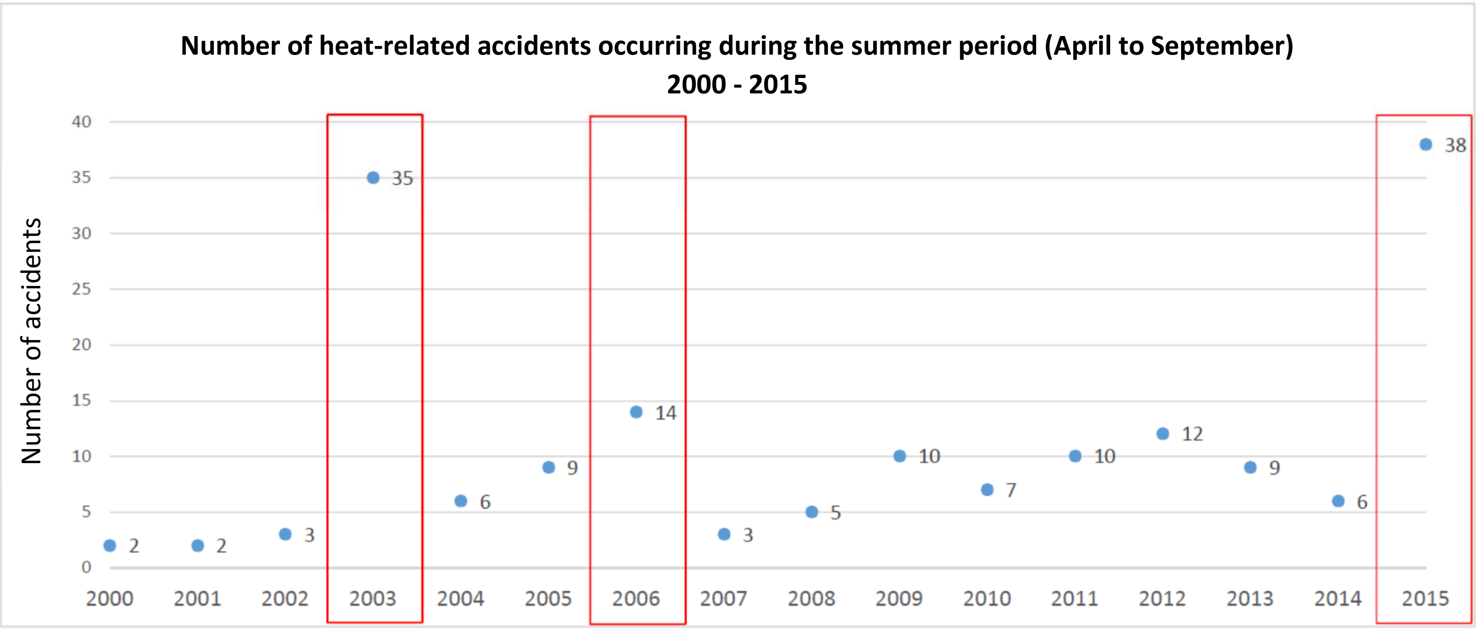
The summer 2015 accident study report: a magnitude comparable to that of the 2003 heat wave

In order to objectively situate the size of our sample containing accidents correlated with the extreme heat recorded in 2015, a comparison was drawn with previous years.

The following graph shows the evolution in number of accidents for which extreme heat was identified as a disturbance (i.e. with the corresponding box checked in ARIA3) between the beginning of April and the end of September in each year since 2000.

While the variations in number of accidents between "normal" years are all not necessarily easily explained, **the impacts of the three hottest summers since the beginning of the 21st century can be distinguished quite clearly**, i.e.:

- **summer 2003 heat wave**
- **July 2006 heat wave**
- **summer 2015 heat wave**



The number of accidents recorded in 2015 is of the same order of magnitude, even slightly higher, than the number attained during the 2003 heat wave. The smaller number of accidents registered in 2006 is related to the shorter duration of the heat wave (only during the month of July).

Attention must be paid however to the possibility of bias entering into the analysis of causes. More specifically, in the midst of a heat wave, industrial site operators and the press tend to quickly tie the occurrence of an accidental event to the intense heat experienced. Additional analyses may be needed therefore to substantiate these claims.

Details of the 2015 heat wave

➢ Dates of accidental events: The visible impact of the first heat wave

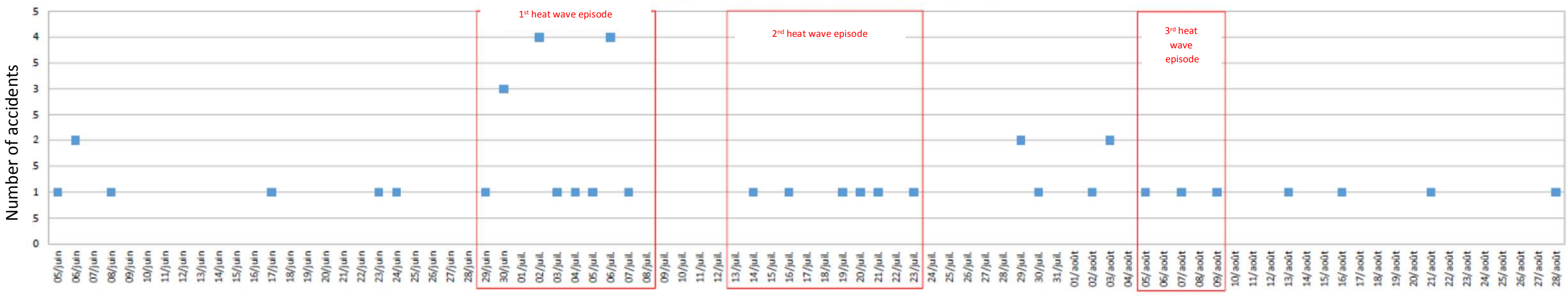
In compiling an overview of summer 2015, the “Météo France” weather agency singled out three consecutive heat wave episodes:

- initial 10-day episode, from Monday 29th June through Wednesday 8th July: considered the main episode in terms of intensity

- second episode lasting 11 days, from Monday 13th through Thursday 23rd July: lower heat intensity measurements

- third episode lasting 5 days, from Wednesday 5th through Sunday 9th August: duration, intensity and geographic coverage all less than the first two episodes

Date of accident occurrence: The visible impact of heat wave episodes



An analysis of the dates of occurrence for accidents recorded in the ARIA database clearly exposes the effect of the first heat wave, extending from end of June to beginning of July. The effects of the second and the third waves are less perceptible from the accident statistics.

➢ Regional breakdown of the accidents recorded

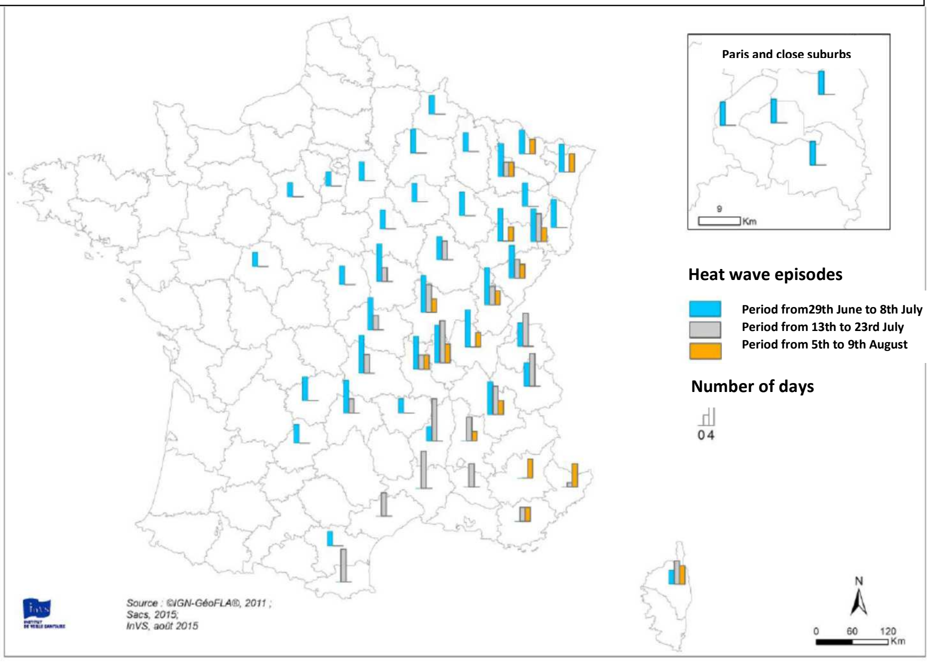
<u>Data provided by Météo France Agency on the regional distribution of heat wave conditions</u>:

- The first episode primarily affected a large swath of France's north-eastern quadrant: Alsace, Auvergne, Burgundy, Franche-Comté, Paris Region, Lorraine, Rhone-Alpes, and more sporadically the country's central and southern geographic departments.

- The second episode primarily affected France's south-eastern quadrant: Burgundy, Franche-Comté, Languedoc-Roussillon, Provence-Alpes-Côte d'Azur, and Rhone-Alpes.

- The third episode primarily affected some departments in Alsace, Lorraine, Franche-Comté, Burgundy, Corsica, Provence-Alps-Côte d'Azur and Rhone-Alpes.

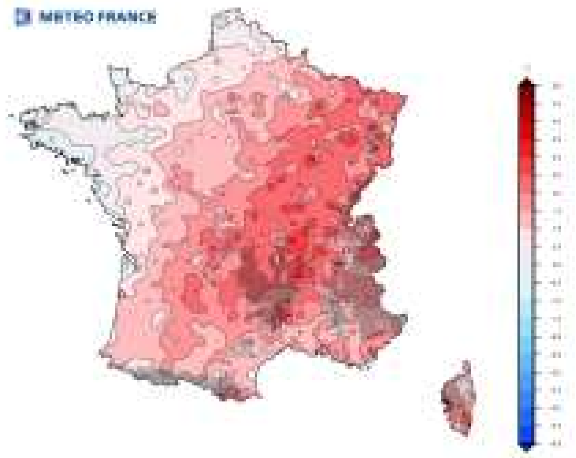
Number of heat wave days by department and by episode, June - August 2015



Deviation in the reference seasonal average, 1981-2000, from the average temperature

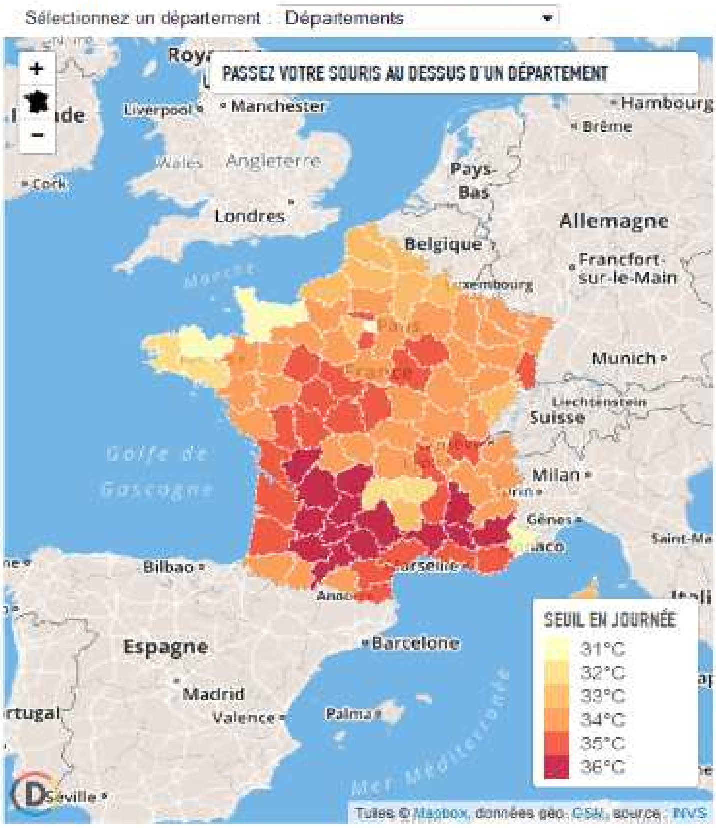
France

Summer 2015



Beyond the information presented above regarding the geographic distribution of noteworthy episodes from summer 2015, let's point out that since France's various regions are not all as accustomed to such outbreaks and thus not similarly adapted to hot conditions, "heat wave" alert thresholds are not standardised across all regions. For example, Météo France has determined that a heat wave can be declared for Brittany's Côtes d'Armor department when temperatures exceed 31°C during the day and 18°C at night. In Paris, these thresholds stand at 31°C daytime / 21°C night-time, while in Marseille the corresponding temperatures are 35°C and 24°C.

When can a heat wave be officially declared?



<u>Impacts on accident statistics:</u>

The rate of accident occurrence is obviously correlated, first and foremost, with the density and type of local industrial activity. Nonetheless, **the geographic distribution of accidents due to extreme heat tends to be aligned with information relative to the nation's territories most heavily affected by the heat wave**, as indicated by Météo France

Region	No. of accidents recorded in the base	Share of total	Comments
AQUITAINE	7	16.3%	Region that always experiences hot summers. Aquitaine is not listed as being adversely affected by these heat wave episodes because its alert threshold is one of the highest in France (temperature required to declare a heat wave: 36°C during the day and 21°C at night).
BURGUNDY	6	13.4%	Region affected by all 3 heat wave episodes
RHONE-ALPES	6	13.4%	Region affected by all 3 heat wave episodes
ALSACE	3	6.7%	Region affected by just the first episode
CENTRE	3	6.7%	Region affected by just the first episode
PARIS REGION	3	6.7%	Region affected by just the first episode
Other regions	15	34.9%	

➢ Breakdown of accidents by activity: a distinct trend pointing to the waste sector

Accidents due to the 2015 heat wave arose both in classified facilities and during the transport of hazardous substances whether by road or rail. The following table shows the breakdown of our accident sample by the main category associated with each accident.

--> => Classified facilities	37	86.0%
--> => Road transport of hazardous substances	4	9.3%
--> => Rail transport of hazardous substances	2	4.6%

The accident breakdown vs. industrial activity (sorted by NAF code) of the leading actor is as follows:

Activity (NAF code)	Examples	No. of accidents	Share of total
38: Waste collection, treatment and disposal; waste recovery	**Storage installations (landfills), sorting centres, transit platforms, etc.**	**21**	**48.9%**
49: Land transport and pipeline transport	Road or rail freight transport	6	14.0%
20: Chemical industry	Manufacturing of fertilisers, explosives, perfumes, etc.	5	11.6%
47: Retail trade, with the exception of automobiles and motorcycles	Filling stations	3	7.0%
Other activities	Food processing industries, manufacturing of rubber and plastic products; Wastewater collection and treatment	8	18.5 %

➢ Accident consequences: primarily economic and environmental

The human consequences of these accidents remained quite small with just four cases involving slight injuries sustained by first responders (9%). None of the accidents reported proved to be fatal.

The economic consequences however were often more extensive with internal property damage being reported in 51% of cases and external property damage in another 4.5%.

The social consequences were more focused on disturbances experienced by neighbouring populations during response efforts: orders to evacuate from their homes or remain confined indoors were issued in respectively 12% and 7% of cases, a safety perimeter had to be set up in 26% of cases, and traffic had to be suspended in 16% of the accidents declared.

Environmental consequences were reported in 39% of cases, with a high occurrence of air pollution incidents (25.5% of accident records).

➢ The hazardous phenomena responsible for these accidents: fires and/or discharges of hazardous or polluting substances systematically involved

Fires and discharges of hazardous or polluting substances are the most commonly cited phenomena during heat wave periods. These two types of phenomena are often coupled, in the case of fire outbreaks, with sizeable releases of foul smoke.

An explosion phenomenon was only identified in a single case.

Hazardous phenomenon	No.	Share of total
--> => Fire	30	69.8%
--> => Discharge of hazardous / polluting substances	18	41.9%
--> => Explosion	1	2.3%
--> => Other phenomenon	2	4.6%

The heading "other phenomenon" corresponds to "near accidents" in which experience feedback is still useful (ARIA 46756: Deformation of metal barrels containing silicon due to metal dilation caused by extreme heat; ARIA 46796: Various disturbances occurring in a refinery subsequent to heat-related electrical problems: overheating of a transformer, electrical power supply cut-off at a pumping station, untimely tripping of an alarm).

➢ Analysis by hazardous phenomenon

o <u>Discharges of hazardous/polluting substances</u>

Heat can initiate leaks on certain storage or transport equipment, especially when subject to the effect of a **pressure surge tied to thermal expansion of a gas** (ARIA 46777, 46944, 46529, 46683) or other **modifications to the physicochemical properties of the specific products** (ARIA 47035).

Examples of accidents involving lorries or tanker railcars:

- propylene leak as the result of seepage from a railcar tanker parked in a marshalling yard (ARIA 46529);
- nitric acid release via a series of inadequately sealed degassing valves on a tanker lorry parked in a marshalling yard. A pressure rise occurred due to the effect of extended exposure to the sun (ARIA 46777);
- an oxygen leak subsequent to a pressure surge in a liquefied oxygen tank exposed to the effects of heat (ARIA 46944);
- leak of pasty wastes during their transport by lorry: the separation of solid and liquid phases subject to the effect of heat, combined with transport-related handling operations, led to a loss of confinement (ARIA 47035);

Examples of accidents involving LPG tanks at a filling station:

- leak on the bottom flange of an LPG tank at a filling station (ARIA 46635);
- leak on an LPG tank manhole at a filling station (ARIA 46842);
- leak on an LPG tank undergoing filling at the station. Appearance of a pressure surge in the

expansion space due to the effect of temperature, coupled with insufficient clamping of the joint (ARIA 46683).

Substances may also be emitted subsequent to **heat-induced interruptions in the industrial process**. Such disturbances may, for example, be related to:

- an **electrical defect** triggered by heat: leak of ammonia inside a chemical plant following an extended shutdown of the NH_3 compressors due to malfunction of the electrical distribution equipment, caused initially by the extreme heat (ARIA 46789);
- an **unexpected reaction** of the substances or organisms involved as the result of heat exposure:
    - NH_3 release into the CO_2 liquefaction circuit of a chemical plant. The origin could be traced back to a heat exchanger containing NH_3 in a liquid/gaseous equilibrium: due to the effect of extreme heat that had struck during a one-month maintenance phase, the liquid phase temperature increased dramatically. Evaporation then initiated a pressure surge and opened a relief valve (ARIA 46915);
    - pollution of a watercourse subsequent to a problem pertaining to the biological treatment step taking place at a wastewater treatment plant as the result of intense heat (insufficient oxygenation of bacteria) (ARIA 46845).

o **Fires**

- **75% of the cases of fire catalogued in the sample involve wastes**. The most common ones encountered are of the following category:
    - fires igniting in waste storage areas found in installations such as transfer centres, sorting centres and automobile scrapyards, and applicable to headings 271X (ARIA 46715, 46720, 46809, 47009, 46797, 46799, 46808, 46819, 46873, 46918, 46997, 47004, 47049, 47128).

      Nearly three-fourths of these accidents pertain to outdoor storage facilities (ARIA 46720, 46797, 46799, 46808, 46873, 47049, 46819, 46918, 46997) with direct exposure to the sun's rays.

      The wastes categorised here are quite varied in type yet in most instances consist of municipal waste generated by economic activities (paper, cardboard, wood, plastics, glass, refuse from sorting: ARIA 46716, 46720, 47009, 46873, 47013, 46715, 46997.

      Two accidents occurred at automobile scrapyards while working with lightweight wrecking residue (foams, fabric and plastics: ARIA 46809) or heavier residue (plastics and non-ferrous metals: ARIA 46808).

      Depending on the targeted installations, the wastes generated may also be: compost (placed in the compost pit at a waste dumpsite: ARIA 46799), scrap iron, mixed metals, milling of metals or cast iron turnings imbibed with cutting oil (on the premises of metal recovery firm: ARIA 46918, 47128, 46819 and 47128), plastic shavings (at a plastic waste treatment facility: ARIA 47004).

    - fires igniting at municipal waste storage installations applicable under the heading 2760 (ARIA 47023, 47026, 46973, 47020, 46900, 47119)

It can be noted that all accidents occurred during the waste storage phases, with the lone exception involving a waste handling machine accounting for accident ARIA 47013: inside a pharmaceutical plant, fire broke out within an ordinary industrial waste compactor that inadvertently contained fouled waste.

The mechanisms (whether known or presumed) causing the outbreak of fire in waste management installations are most often:

- **"magnifying glass" effects** tied to the action of sun rays on glass or plastic fragments: ARIA 46716, 47026, 47009, 47049;
- **runaway fermentation reactions** with fermentable waste (ARIA 46720, 46873) **or heating reactions** of auto wrecking residue wastes, plastics (ARIA 46973, 46809);
- **ignition of flammable liquids or solids** present inside any number of stored products:
    - overheating of scrap iron, leading to ignition of the flammable elements included in the mix: ARIA 46918;
    - ignition of cast iron shavings imbibed with lubricants: ARIA 46819;
    - ignition of fouled packaging (jugs that had contained hydrogen peroxide) overheated upon starting up a waste compactor: ARIA 47013;
- a fire outbreak subsequent to an explosion caused by the effect of heating an aerosol type waste unexpectedly present within the pile of wastes: ARIA 47009.

Drought conditions make wastes more sensitive to combustion sources. The ignition of plastic shavings, stored in a filter recovery bag, by means of static electricity discharge (ARIA 47004) serves as an illustration. Under basic conditions, these same shavings are wet, which offers a protection against such phenomena. This was not the case at the time of the accident due to the heat wave.

- Excluding waste, the products leading to fires associated with this heat wave included:

    - **products with a sensitivity highly dependent on temperature and relative humidity conditions:**
        - ignition of nitrocellulose "cakes" imbibed with nitro-glycerine. Exposed to the effect of scorching temperatures, the minimum rate of humidity needed to guarantee stability was no longer being met (ARIA 46815);
        - combustion of wastes containing chlorinated cakes inside a cleaning products factory subsequent to their self-ignition (ARIA 46824);
    - **products in powdery form**, highly sensitive to heating:
        - fire outbreak in a flour bin at a flour mill (ARIA 46904);
        - fire in a silo containing polyurethane dusts in a plant producing insulation panels (ARIA 46919).

Other isolated examples include:

- Ignition of farmland in a state of drought following the spraying of inflamed projectiles from a zone designated for burning pyrotechnic waste (ARIA 46913);
- Vehicle fires in an automobile garage (ARIA 46994);
- Fire outbreak inside a pump and compressor plant subsequent to an electrical short-circuit on a lighting system, caused by excessive condensation, as the result of simultaneous effects from high relative humidity, extreme heat and running of the workshop air conditioning unit (ARIA 47047);
- Ignition of the axle on a trailer transporting hazardous substances (in this case, tire rubber and rubber in solution) upon the bursting of a tire caused by the extreme heat (ARIA 46826).

o Explosions

Just one experience with an explosion phenomenon was recorded in the 2015 accident sample. This explosion occurred following an unplanned polymerisation reaction in the pasty waste barrels stored in a lorry that was parked for the night (ARIA 46755).

Analysis of causes

It is important to point out that in many cases, extreme temperatures were not the lone cause of the accident. In general, **a combination of weather conditions and unrelated operating deficiency led to the accident**. Such deficiencies give rise to "**latent hazards**" capable of initiating an accidental drift under conditions of extreme heat. Among the deficiencies identified, quite often found to lie on the organisational side, let's cite the following:

- Operating procedures that fail to account for the vulnerability of products being stored or handled to hot weather (lack of familiarity with risks related to state changes / possible reactions of stored products or wastes when exposed to heat):
    - ARIA 46755: lack of control device to ensure temperature-controlled transport of highly reactive wastes;
    - ARIA 46915: failure to drain an exchanger containing NH_3 in a state of liquid/gaseous equilibrium for a long down-period in the middle of summer.

  Operating procedures, despite their application, may also be violated and thereby raise the level of accident risk. Take the example of ARIA 46815: non-compliance with the control frequency mandated for explosive products (in this case, nitrocellulose cakes imbibed with nitro-glycerine) whose stability is actually known to be directly correlated with the rate of humidity.

- Negligent actions and insufficient personnel training, bringing about the unexpected presence of elements with the potential to cause harm at the facility site:
    - ARIA 47009: Incomplete sorting of waste, leading to the presence, among the flammable waste, of hazardous physical items in the event of exposure to the sun (e.g. broken glass debris sensitive to the magnifying glass effect, aerosols);
    - ARIA 47013: untimely storage of packaging fouled by organic peroxide in a compactor intended for ordinary industrial waste.

- Maintenance or repair practices incapable of avoiding accidental drift under heat wave conditions:
    - ARIA 46529, 46635, 46777, 46842: insufficient clamping of valves, flanges, etc. on tanks or cisterns;
    - ARIA 46799, 46913: inadequate attention given to the vegetation surrounding an industrial site, thus inducing combinatorial effects in the event of fire.

When not cited as the direct cause of an accident, **extreme heat can still play an exacerbating role**, capable of triggering much more serious consequences than if the event had occurred under more typical weather conditions.

As an example, let's take ARIA 46913: Ignition of pyrotechnic waste due to the presence of an abnormal quantity of aluminium in the mix. Local drought conditions had facilitated combustion of the adjacent fields when exposed to the spewing of flammable debris, thus preventing early extinction of the ensuing blaze. Note that the risk mitigation measure calling for regular sprinkling of the surrounding farmland had not been correctly implemented.

In many cases, the effect of heat coupled with wind gusts had produced highly devastating consequences as well (ARIA 47026, 46797, 46799, 46873, 46973).

Deficiencies and vulnerabilities revealed by the accident analysis / Proposed corrective measures

Without claiming to be exhaustive, this section is intended to summarise the main deficiencies identified within the scope of this accident sample, in addition to determining a series of appropriate recommendations associated with each type of deficiency (→).

➢ **Checklist relative to operating and control procedures**

- **Added focus during reduced activity phases**, with even more vigilance exercised during periods of extreme heat than the rest of the year (30% of accidents recorded in 2015 occurred during such phases):

  → Set up a reinforced site monitoring program, extending in particular to the most sensitive storage areas during down periods (ARIA 46809, 46973), by use of either security staff or video surveillance. It is advised to place the security control room (equipped with a video surveillance system, as needed) on a higher ground to be able to look out over the entire site (ARIA 47128).

- **Be careful to avoid the extended storage/parking in direct sunlight of tanks/vats or tanker lorries containing heat-sensitive substances** (ARIA 46529, 46777):

  → Limit storage time and reconfigure the site to avoid direct exposure to the sun's rays and offer heat insulation capabilities:

  → Whenever possible, install a system to ensure the temperature-controlled transport of products or wastes (ARIA 46755).

- **Beware of applying standard operating procedures without allocating for necessary adjustments should temperatures become extremely hot.**

  Quite often, no specific procedure is adopted to cope with periods of extreme temperatures. Standard operating procedures do not account for risks related to state changes / possible product or waste reactions when exposed to heat.

  → Adapt operating procedures to meet the challenges of heat wave conditions:

  → Increased frequency of existing controls (e.g. perform additional monitoring rounds during extreme hot spells within waste storage facilities: ARIA 47119);

  → Conduct additional controls with respect to critical equipment and zones in terms of heat sensitivity (ARIA 46904). Thermal cameras may be used to detect any suspected heat release (ARIA 47128). When transporting substances, regular temperature controls may be carried out with a heat probe (ARIA 46755).

  → Modification of some settings or setting values (ARIA 46683: in filling stations, adjust to lower tank filling levels, undertake pressure monitoring at a lower value than normal; ARIA 47119: in waste storage installations, reduce operating floor areas and extend daily coverage space during bouts of extreme heat).

→ Introduce additional technical devices (ARIA 46845: in a wastewater treatment plant, temporarily install an extra oxygenation system on the basins in order to satisfy the greater need for bacteria in the biological treatment process as temperature rises).

- **Be mindful of non-secure operating protocols that, even more so than during normal weather, may exacerbate the consequences of an accident.** For example:
    - storage of abnormally large quantities of waste (ARIA 46720, 46819, 46873, 46755, 47004), perhaps using an organisation that fails to comply with safety prescriptions (lack of storage zone policing: ARIA 46720, 46918, 47004). Site clutter can restrict access by first responders and worsen the risk of fire spreading (ARIA 46716);
    - the presence of unauthorised wastes (ARIA 46819).

    → Provide for a separation between storage zones so as to prevent fire from spreading, especially when the wind is blowing hard (which often accompanies a heat wave): ARIA 46797, 46918;

    → Limit the quantities of stored products or wastes potentially exposed to an ignition risk or another type of heat sensitivity (ARIA 46918).

➢ **Checklist relative to personnel training**

- Beware of **ignorance towards risks related to extreme heat; should the level of vigilance decline when performing certain strategic tasks, hazardous situations may arise** (ARIA 47009: inadequate attention paid to types of incoming waste, thus enhancing the presence of highly heat-sensitive waste; ARIA 47013: presence of packaging fouled by organic peroxide in a compactor dedicated to ordinary industrial waste).

    → Train technicians to adopt the right level of vigilance to exercise during critical operations (ARIA 47013);

    → Train technicians regarding fire risks when performing tasks under heat wave conditions (ARIA 46904, 47119) and regarding a heightened vigilance to practices executed;

    → Train technicians in the use of specific procedures and an array of technical/organisational prevention measures to be adopted during the heat wave in order to limit risks (ARIA 47128: training of watchmen in the use of preventive waste sprinkling systems prior to the crushing step).

➢ **Checklist relative to maintenance and repair procedures**

- Take note of the level of wear and clamping of valves, flanges, nuts and joints on both storage and transport containers (ARIA 46529, 46777, 46635, 46842, 46683).

    → Enhance the level of maintenance on these components to forestall any leaks.

- Focus on maintaining the vegetation bordering industrial sites in order to prevent a fire burning outside the site from spreading into the facility (ARIA 46799) or, in the opposite direction, to avoid sparking an external blaze by a fire ignited on the premises (ARIA 46913).

    → Adopt strict maintenance procedures (ARIA 46900: regular mowing; ARIA 46913:

speedy removal of stubble after the harvest, sprinkling of neighbouring farmland)

→ Monitor the state of fences or isolation systems very closely (ARIA 46913 : installation of a firewall around the pyrotechnic waste burning zone to protect the surrounding environment).

- Heed maintenance conditions on electrical systems since electrical problems directly tied to excessive heat could trigger chain reactions (ARIA 46789, 46796, 47047):

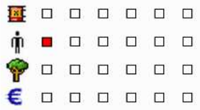
  → Perform preventive maintenance on all such devices on a regular basis. Ensure constant availability of backup systems capable of coming online (electric generating sets) in the event of an electrical supply outage caused by hot weather (ARIA 46789).

A few illustrative accidents

A number of illustrative accidents will be presented below; they pertain to the primary sectors of activity adversely affected by events due to extreme heat experienced during summer 2015.

Case in the waste management sector

Fire inside a metal recovery firm



ARIA 46918 - IC - 21st July 2015 - 57 – MAIZIERES-LES-METZ
NAF code 38.32: Recovery of sorted waste materials

Events and response

Around 2:45 pm, inside a firm specialised in metal recovery, **fire broke out at a zone for storing scrap iron originating from dumpsites** (metal bin contents) and from individual refuse (water heaters, gas cookers, etc.).
In observing the smoke release, site personnel attempted to respond with extinguishers and a hydraulic shovel to access the source located at the bottom of the scrap heap. Incapable of bringing the blaze under control, the team notified emergency services. Fire-fighters sprayed some 6,000 litres of water per minute. They removed the intact waste using a crane. Due to the fire's extreme heat emissions, metal began to melt (iron melting point: 1,500°C).
A thick plume of black toxic smoke spread throughout the expansion space and was visible as far as 30 km away. A safety perimeter was set up around the site. The local town hall organised an evacuation of residents under this plume (in all, 400 individuals involved). A municipal room was made available for the evacuation effort. The next morning, new sampling indicated that the smoke was no longer toxic. Local residents returned home. The fire was contained by the beginning of the afternoon.

Consequences and actions taken

One fire-fighter was injured during the response.
A total floor area of 1,300 m^2 and a total volume 8,000 m^3 were affected by this incident. The burnt scrap iron was sorted and routed through its normal disposal channels.
The fire had broken out on a ground that was not impermeable. Of the 7,000 m^3 of water used by fire-fighters, just 80 m^3 could be recovered in the rainwater settling tank. The remainder was absorbed by the soil and sprayed into the air. An analysis of the site's 4 piezometers was conducted to evaluate the impact on groundwater. Other analyses focused on the zone's soils and plants to determine the impact of falling smoke particles.

Analysis of the causes

Among the metals processed at this site, a portion is routed for crushing at specialised facilities (given that they contain sterile and flammable components), while the other portion is routed for on-site shearing (considered clean substances devoid of sterile components). **The fire broke out in the part containing substances tagged for crushing** (200 m^2, i.e. 150 tonnes) and then spread to the adjoining heaps, which contained a smaller proportion of flammable substances (1,100 m^2).
Temperatures had been soaring to heat wave levels for several consecutive days. The overheated metal compounds most likely ignited in contact with flammable elements (grease, paper, etc.) contained in the mix of materials.

Measures adopted

The facility operator implemented the following measures:

- 25-tonne limitation in the waste storage zone dedicated to crushing
- Storage of wastes on a concrete floor in the vicinity of fire-fighting resources

- Reduction of heap dimensions (in both length and height)
- 2-m spacing of the various heaps in order to avoid spreading.

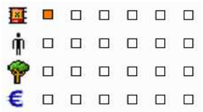
Moreover, it was anticipated to install a first responder fire protection network.

Case in the sector of hazardous materials transport

Loss of pasty waste on city streets

ARIA 47035 - ROAD TRANSPORT - 13th August 2015 - 94 – NOGENT-SUR-MARNE
NAF code 38.12: Hazardous waste collection
Around 11:30 am, a **lorry hauling hazardous waste in pasty form lost 229 kg of its load** in an urban setting. Traffic was suspended for over 3 hours. The **separation of its solid and liquid phases due to the intense heat** and transport-related movements had resulted in this product loss.

Gaseous leak on tanker railcars containing nitric acid



ARIA 46777 - RAIL TRANSPORT - 30th June 2015 - 64 - BAYONNE
NAF code 20.15: Manufacturing of nitrogenous products and fertilisers

Gas releases were detected at 6:30 am on 2 tanker railcars transporting concentrated nitric acid that were idle at a marshalling yard. The Internal Emergency Plan for hazardous substances was activated. A 50-m safety perimeter was set up and all rail traffic suspended. Toxicity measurements recorded adjacent to the railcars turned out to be negative.
A technical expert with the shipping company visited the site where the cars had been filled a few days prior. He observed that the leaks were located around degassing valves on the upper part of the cars. Their structural integrity was not in jeopardy. Given the lack of immediate danger, both rail and road traffic resumed at 10:30 am. The railcars were returned to their filling site around midday.
According to the operator, **a breached seal on both cars' valves, exacerbated by the extreme heat and extended exposure to the sun, had raised pressure in the cistern expansion space to a high enough level to cause leaking.**

Case in the chemical industry

Brief release of ammonia (NH3) subsequent to opening of a relief valve

ARIA 46915 - IC - 29th July 2015 - 68 - OTTMARSHEIM
NAF code 20.15: Manufacturing of nitrogenous products and fertilisers

The facility involved: A CO_2 liquefaction plant. Gaseous CO_2, a by-product during the fabrication of NH_3, which is a key input in nitrogenous fertilisers, was separated from the other input gases (N_2 and H_2) for subsequent reuse. It was being piped to the plant's compression / liquefaction installation, which features an ammonia cooling circuit intended to liquefy the CO_2, consisting of: compressor, condenser, and exchanger/evaporator

Around 5:20 pm, a **short-lived atmospheric release of ammonia (NH_3, a toxic gas) occurred on the CO_2 liquefaction circuit of a chemical plant** specialised in producing nitrogenous fertilisers.

Circumstances surrounding the leak

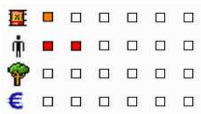
Upon restarting the liquefaction installation, the compressor's feed valve opened as programmed, but pressure in the compressor exceeded the set pressure of its relief valve (i.e. 4.8 bar): the relief valve then opened to the atmosphere at an elevation of 6 m above the premises. This opening created a pressure drop in the installation circuit, followed by sudden evaporation of a portion of the liquefied NH_3 in the downstream exchanger (flash point). A high-level safety device detected the rapid pressure rise in the circuit and automatically closed the compressor's inlet valve. Its relief valve closed after a few seconds. A detector, positioned in the downwind direction adjacent to a neighbouring building 100 m away, recorded a very brief NH_3 spike (like a puff). The operator estimated that the quantity of NH_3 released into the atmosphere was less than 50 kg. When a local resident called after noticing an ammonia smell, fire-fighters visited the site around 6 pm to verify the absence of ammonia in the vicinity of the site and discussed the circumstances surrounding this incident with the operator. The ammonia contents measured at and around the site read zero.

Hypothesis regarding the causes of this leak

The exchanger containing NH_3 in a liquid/gaseous equilibrium state was not drained during the (1-month) maintenance period. These works had been scheduled for the summer; when the heat wave struck, the liquid phase temperature inside the exchanger (despite its heat insulation) slowly rose from -30° to +15°C. The ensuing evaporation caused the pressure to reach 8 bar. This pressure did not pose a problem for the exchanger, which was capable of withstanding considerably higher pressures (the relief valve had been calibrated at 15 bar). Upon opening the compressor valve, the exchanger pressure filled the compressor via the circuit. This pressure level, exceeding that of compressor operations, triggered opening of the compressor relief valve, which had been calibrated at 4.8 bar.

Case in a filling station

Leak on an LPG tank at a filling station



ARIA 46683 - IC (ASP) - 16th July 2015 - 47 – BOE
NAF code 47.11: Non-specialised retail outlet selling mainly food

Around 5:15 pm, **a gas leak was noticed on an 11,750-litre capacity LPG tank being filled at a filling station.** The delivery driver, assigned this operation, sounded the alarm. Fire-fighters sprinkled the tank to lower its interior pressure, installed a safety perimeter and evacuated the adjoining pharmacy, strip mall bar and nearby stores. Traffic was suspended in front of the station. An attempt to tighten the joint by a technician working for the tank owner failed. The decision was then made to transfer the LPG back to the tanker lorry that had performed the initial filling. Once this step had been completed, the cistern was flared.

This leak happened at the joint located between the LPG tank's buffer and manhole flange. **A pressure surge occurred within the cistern's expansion space at the end of the filling step due to the scorching temperatures**. The pressure, while less than that required to activate the relief valve, could not be withstood by the joint, which was a "new generation" part and made of fibreglass as a replacement of the previous asbestos models. **The poor quality of clamping for this type of joint might have created conditions conducive for a leak.**

In light of the extremely hot atmospheric conditions, gas delivery drivers were in fact advised to only fill cisterns to 80% of their capacity instead of 85%, with a pressure control setting of 14 bar instead of 16.

The Environmental Inspectorate requested the tank owner to explain why the joint had leaked before the relief valve, which was normally designed to eliminate the pressure surge (according to ESP regulations for pressurised equipment).

Once the joint had been changed the following week, new leaks were observed: on the relief valves undergoing permeability testing (6 bar) and on the manhole buffer/flange junction during filling (8.5 bar). The gas supply company decided to exchange the cistern on 21st July.

Additional investigations are underway on the small bulk cisterns of this same batch; these efforts involve periodic re-certification by means of sampling. The same model of relief valves, also inspected by sampling, is undergoing a thorough examination.

Conclusion

Lessons drawn from the analysis of accidents arising during the 2015 heat wave are very similar to those developed in the summary report entitled "Analysis of industrial accidents occurring during periods of intense heat", published in 2014. The present document however serves to highlight a number of configurations or lessons specific to this year's events.

References

- **Summary (In French): "Analysis of industrial accidents occurring during periods of intense heat" (2014):** http://www.aria.developpement-durable.gouv.fr/syntheses/par-theme/accidentologie-industrielle-sur-les-periodes-de-fortes-chaleurs/
- **ARIA news flash: "Heat wave, extreme heat: Heightened risks of fire as well as other hazards" (2012):** http://www.aria.developpement-durable.gouv.fr/aria-news-flash/na-tech-risks/heat-waves/?lang=en

- **Weather data (Météo France and INVS):**
  - http://www.meteofrance.fr/actualites/28268797-bilan-l-ete-2015-au-second-rang-des-etes-les-plus-chauds
  - http://www.lemonde.fr/les-decodeurs/article/2015/07/01/a-quelles-temperatures-peut-on-parler-de-canicule_4665560_4355770.html
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