LESSONS LEARNT from INDUSTRIAL ACCIDENTS

14th SEMINAR

European Union Network for the Implementation and Enforcement of Environmental Law

MINISTÈRE DE LA TRANSITION ÉCOLOGIQUE

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Enrich the debate

The European Union Network for the **IMP**lementation and Enforcement of **E**nvironmental **L**aw (commonly known as the IMPEL network) was created in 1992 to promote the exchange of information and experience between the environmental authorities. Its purpose is to help building a more consistent approach regarding the implementation and enforcement of environmental legislation.

Since 1999, this network has been supporting the French project on lessons learnt from industrial accidents. In order to promote the exchanges, which are crucial for the improvement of the prevention of industrial accidents and the control of risks management, France regularly organizes a seminar for European inspectors. The analysis of disruption factors and root causes, known or supposed, is rigorous and distinguishes technical, human and organizational levels.

The active participation of inspectors from numerous European states enables to cross views and to enliven the debate, which explains the success of these seminars.

Reports of all the events presented since 1999 are available on the Barpi website :

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LESSONS LEARNT

from industrial accidents

Sommaire

Anticipating the risk of fire

More than 60% of the events recorded in the ARIA database regarding accidents at industrial facilities in France involve fires. Fires are relatively common, but the risk is not always well prepared for and even less well managed. Emergency rescue services are often called upon to extinguish fires, but the measures taken by the site operator, before or immediately following the accident, are essential in controlling the spread. The consequences of fire are often catastrophic and can lead to other phenomena, such as explosions, the release of dangerous or polluting materials into the atmosphere, such as smoke and gas, or into the water in cases where the extinguishing water is poorly managed.

1. Hazard identification

A fire needs three elements to ignite:

- an oxidising agent: very often, the oxygen in the air;
- fuel: objects, products or waste present at the site;
- the activation energy may be a thermal, electric, mechanical or chemical source.

Fire triangle

The conditions that could lead to the “fire triangle” must, therefore, be identified:

- conduct an inventory of the combustible, flammable or explosive products (and their packaging, ARIA 55792). This inventory must not be limited to a list of any fuels present at the facility but must also specify their physical condition, physico-chemical characteristics and the conditions in which they are used and stored (quantities, temperature, retention, etc.);
- identify sources of ignition. Sources can be thermal (hot spots, heating equipment, etc.), electrical (obsolescence or overloading of certain installations may be the reason), electrostatic, mechanical (sparks and heat resulting from impact, friction or abrasion), chemical (with exothermic reactions, self-heating, runaway reactions, etc.), bacteriological (bacterial fermentation can release heat and initiate self-heating). An explosion can also be the source needed to ignite a fire and vice versa;
- determine the at-risk operations. Among these, an inventory of potential malfunctions must be drawn up (e.g., shutdown of the cooling system, product leakage, etc.);
- identify sources of external danger such as extreme heat (ARIA 55774), malicious intent (ARIA 54292) or the spread of a fire outside the site (ARIA 55714);
- Certain factors can aggravate the accident, such as unfavourable weather conditions (wind, ARIA 55556), difficult access to the site by the emergency rescue services (ARIA 54724), water procurement difficulties (ARIA 54276) or a lack of information provided to rescue services regarding the products involved in the accident (ARIA 52012).

2. Evaluation of fire prevention and protection means

The risk may be reduced at the source by evaluating the prevention and protection means that may be used in the event of an accident. These means are chosen based on the very nature of the activities carried out at the facility and on the objects, products and waste present on site.

Firstly, the potential causes of a fire must be reduced. These are preventive measures, which aim to implement actions to remain outside the fire triangle, e.g.:

- in terms of fuels, by reducing the quantities of combustible materials, products or waste present at the site that are stored or used (ARIA 54879), replacing them with less combustible equivalents, capturing fuel emissions, ventilating rooms and storage locations, and by frequent vacuuming or tidying of the premises;
- regarding oxidizers, by reducing the oxygen content, for example, by injecting an inert gas (although the risk of hypoxia for an operator must be appropriately assessed), or by isolating the oxidising products (oxygen, peroxides, etc.) from combustible products;
- in terms of ignition sources, by actions on processes and materials (cooling, appropriate equipment in areas at risk of explosion, etc.), regular inspection and maintenance operations (electrical installations, fire detection and protection equipment, etc.), with the implementation of appropriate procedures (hot-spot work: ARIA 55023, no smoking areas: ARIA 52853).

All of these actions must be reviewed regularly, and in particular when changes and developments in the process occur.

Next, reducing the scale of a possible accident (intensity and consequences) must be examined. These are the limitation measures. Limitation measures concern both detection systems and firefighting equipment.

So-called passive measures can be used and primarily concern the design phase of an installation: partition walls and fire doors, fire resistance and reaction to fire of the materials used, distances between the various storage areas or buildings, separation of combustible elements, etc.

Active measures can also be implemented:

- fire detection devices (thermal, flame and smoke detection, explosimeters, alarm processing, etc.). These devices are not to be neglected. In nearly one out of seven fires, the alert is raised by someone from outside the establishment (ARIA 54848). Experience feedback, however, shows that early detection and initiation of firefighting measures are essential conditions to bring a fire under control quickly;
- manual extinguishing equipment such as extinguishers, pressurised hose reels or the presence of inert materials and dedicated resources (e.g., public works machinery in non-hazardous waste storage facilities) or automated extinguishing devices, whether water-, foam-, powder- or gas-based. Such extinguishing devices must be adapted to the types of fire likely to occur and, above all, must be present in sufficient quantity and arranged optimally;
- smoke control devices. This equipment is used to discharge smoke and hot gases and to facilitate the evacuation of personnel and the intervention by the emergency services.

Organisational measures must also be considered, such as procedures and instructions (for everyday operations, during special operations and in the event of a fire) as well as staff training and qualification operations (whether in-house or for subcontractors, concerning the process or firefighting efforts, ARIA 55860).

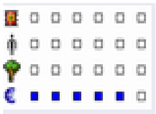
And finally, the measures to be implemented as soon as an accident occurs, such as the containment of firefighting water or the blocking off of networks, as well as moving any substances likely to aggravate the accident, must be anticipated and organised beforehand (ARIA 53689).

3. Assessing the consequences of a fire

The scale of fatal accidents involving fire is less than for those involving hazardous or polluting substances or explosions. In terms of events where people are injured, they are of the same order of magnitude as those related to other phenomena. Burns due to heat radiation and intoxication attributed mainly to the inhalation of fumes and gases should also be noted (ARIA 50082).

Beyond the economic consequences of a fire (whether in terms of material damage, operating losses or the restoration of the facilities), the environmental impact is often extensive:

- significant releases of smoke with consequences on the site itself and beyond, which may require the implementation of environmental monitoring measures for the more or less long term, as well as clean-up measures or restrictions on use (ARIA 52838);
- soil and water pollution due to inadequate management of fire extinguishing water that may be contaminated with products having harmful effects (ARIA 47755).



ARIA 44544 – 02/11/2013 – Fos-sur-Mer (Bouches-du-Rhône) – France
Fire in a household waste sorting and incineration centre
At around 2:30 a.m., a fire broke out in a 2,000 m² sorting building of a waste processing centre. A massive firefighting effort was deployed under challenging conditions: significant assets to be protected (biogas digesters, incinerator), debris from partially collapsed structures, weather conditions, thick and persistent smoke. More than 60 h were required to extinguish the fire.

The analysis of the fire's rapid spread revealed several shortcomings in the design of the facilities:

- Firewalls not extending past the roof and conveyor penetrations only partly equipped with water curtains;
- Numerous combustible elements (facade elements, wooden framework, PVC, etc.);
- Insufficient smoke-extraction and compartmentalisation;
- No detector in the area where the fire started. The alarm was raised by a detector in an electrical room on the 1st floor of the building when the fire was already well underway;
- Water supply ponds of sufficient quantity but poorly designed during the reconstruction.

The damage caused by the fire was evaluated at more than €60 million.

Short-form accident feedback

Short-form accident summaries on the topic of "Anticiping the risk of fire"

Mischmetal fire in a steelmaking company

ARIA 53991 – 11/07/2019 – La Léchère (Savoie) – France

Mischmetal is an alloy of rare-earth elements. Its composition includes:
- 47-75% cerium: H228
- 20-54% lanthane: H228
- 0-20% neodymium: H228
- 0-10% praseodymium: H250

It is used in metallurgy to improve the properties of metals and in the manufacture of stone used for lighters.

At around 3:30 p.m., a fire broke out in steel plant, in a hopper containing 13 t of mischmetal. The flaming metal flowed under the hopper and onto rubber conveyor belts. Two raw material pits located nearby were also affected. At around 4 p.m., the 3 ovens were shut down and 100 employees were evacuated. The firefighters then analysed the toxicity of the fumes released from the fire: explosive characteristics, CO, SO_2, NH_3, NO_2, PID (all VOCs regardless of product type). The Ministry's Emergency Support Unit (CASU) was activated to define areas potentially affected by the fire. The public road located next to the site was closed to traffic, and the oxygen lines routed nearby were shut off and injected with an inert gas. As a precaution, the emergency rescue services confined 20 households and 7 companies. The initial analysis results were subjected to further analysis of a gas sample taken near the source and at chest height. The sample was analysed by the detection, identification and sampling vehicle (VDIP) of the departmental fire and emergency rescue department (SDIS 69), transported via helicopter in response to the accident. The products measured included alcohols and ketones in low concentrations, sulphur dioxide (3 ppm), metal dust and nanoparticles that could not be quantified and discriminated.

The initial attempts by the fire brigade to extinguish the fire proved unsuccessful because the burning metal flowing from the hopper continued to reignite the fire each time. The site had silica fume (powder) but no means to project it (overhead hopper). At around 7 p.m., a system consisting of 80-mm dia., semi-rigid pipes at 3 bar was used to spray 12 t of cement (supplied by a private firm) onto the flames to create a crust and smother the fire: 9 t of cement powder was sprayed onto the main body of the fire and 3 t was used to cover the hopper.


© DREAL Auvergne-Rhône-Alpes

The fire was attributed to a self-combustion phenomenon caused by friction in a big bag of mischmetal while it was being unloaded into a hopper. Unlike the incident that occurred in April 2017 (ARIA 49518), the ingots of earth elements were oiled, but just enough sparking was created by the product to set off a fire.

Following the event, the operator limited the hopper capacity to 3 t. An agreement is currently being worked out with the local cement works to incorporate it into their emergency plan where certain metal fires are concerned: supply of cement and spraying means.

Fire in a foundry's casting shop

ARIA 53642 – 15/05/2019 – Caudan (Morbihan) – France

Slightly before 5 a.m., a pressurised oil leak burst into flames on a casting machine in a foundry's casting workshop. A ball of fire, followed by a blast, spread to the "8 m" level via the conveyors. The fire damaged the casting machine, shaking machine, and the shotblasting and sandblasting equipment. The night crew evacuated the building before the emergency services arrived on site. The 2 operators who had witnessed the fire experienced psychological trauma and were granted 2 weeks sick leave. The fire brigade set up 7 fire hoses equipped with a fire-suppressant additive in an attempt to put out the fire. All the machine tools in the shop were cleared out in order to finalise the extinguishing operations. The upper levels and other workshops were spared damage. The fire was finally put out at 9:50 a.m. Damage to the assembly line was extensive and partial layoff measurers were considered.


© SDIS 56

The oil leak had been caused by the rupture of a flow regulator designed to control the casting machine's oil pressure. The equipment cracked a short time before it failed. The crack initially lead to oil being sprayed at 200 bar, creating an oil cloud that rose up to the "5 m" level. The crack continued to grow and eventually ruptured, causing an even greater oil leak at the base of the casting machine. The leak lasted 30 min. During this time, 93 chassis moving along a conveyor and past the jet were covered in oil. The mould assembly technician present at the 8 m level raised the alarm, warning the operators in the supervision booth that the chassis arriving on the conveyor were covered in oil. Upon inspecting the workshop, 2 operators noted the oil mist. Just after their inspection, the oil burst into flame upon contact with the hot parts in the shaker located behind the conveyor, opposite the flow regulator. The temperature of the parts in the shaker reaches 400 to 600 °C, whereas the flashpoint of oil is 230 °C. A fireball, followed by an explosion, spread to the casing door located on level 8 m. The fire continued to spread though the casting machine and the conveyors. Three assumptions have been submitted regarding the flow regulator:

- manufacturing defect;
- abnormal loading of the regulator induced by the hydraulic unit;
- impact on the regulator's mechanical control elements.

Following this accident, the operator conducted an operation to evaluate the risks on similar hydraulic systems in operation at the group's other sites.

Fire in a warehouse of an online sales company

ARIA 52103 – 24/08/2018 – Valence (Drôme) – France

At around 9:15 a.m., a fire broke out in a 6,000 m² cell of a warehouse subject to operating authorisation (section 1510). The sprinkler system was triggered (the 1st substation at 9:19 a.m. and the 2nd at 9:31 a.m.), as was the fire alarm. The cell contained more than 108,000 tyres that had been stored on racks or in piles (stacked on pallets). In particular, the area was dedicated to order preparation for a company selling tyres online. The site's personnel were evacuated. Reconnaissance was conducted in the burnt cell, but given the large amount of smoke, the emergency response equipment could not be deployed before the fire brigade had arrived. An hour after the fire broke out, the engines controlling the sprinklers were stopped owing to the risk of damage due to a lack of water (the site had been equipped with two 780 m³ water tanks).

Upon their arrival to the site, the firemen set up a water curtain on the roof, near the 2-hour firewall separating the cell from another one located to the north. A pumping system was set up to draw water from the RHÔNE. Holes were made in the wall of the adjacent warehouse space on the west side, protected by a 4-h fire wall, to allow the fire brigade to fight the fire from that side. The firefighting water was recycled in a retention basin. Starting at 8 p.m., firefighting foam was sprayed for 2 hours. The fire continued for several hours on 24 and 25/08. Water was sprayed continuously on 26 and 27/08 to cool down the storage cell. Throughout the operation, firefighters managed to contain the fire within the burnt cell (fire protection REI 120 and 240 + double-skin, metal cladding wall on the quay side).

Analyses of the extinguishing water were conducted on a continuous basis. The public infiltration basin located downstream from the site on the rainwater drainage network was closed by the network's manager (a plug was installed). Water and sediment analyses were performed on the basin as the fire had generated a large amount of smoke. Air quality measurements, conducted starting 24/08, indicated a significant increase of PM10 and sulphur dioxide particles in the air. The peak effect was low, however, and the levels returned to normal during the night of 24 to 25/08. The air quality monitoring programme was lifted at noon on 28/08. The shutdown of the site following the accident resulted in significant operating losses for the operator.


© SDIS 26

The operator conducted a study to assess the environmental and health impacts of the accident. A report must be submitted detailing the effects of the fallout of pollution on the soil and plant life. The waste resulting from the accident was then processed by specialized treatment companies. The operator has compiled a file describing the measures taken to secure the cells that were not damaged by the fire.

Fire in a plastic packaging recyclions plant

ARIA 53367 – 27/03/2019 – Billy-Berclau (Pas-de-Calais) – France


© Séverine Courbe - VDNPQR

At around 11:45 a.m., a fire broke out in a company specialised in the recycling of used metal drums and the washing of plastic packaging designed to contain liquids. The fire started on an 1500 m² outdoor storage platform consisting of empty metal cages, clean and palletised drums and IBCs (1,000 l) containing non-washable chemical products. A large column of black smoke was visible from several kilometres away. The plant's internal contingency plan was activated. The first responders attended to the fire using a hose reel and a fire hose. The 30 employees present at the site were evacuated to safety. Upon their arrival, the fire brigade was able to put the fire out using 9 fire hoses, 4 of which were used to prevent the fire from spreading to the building (1,300 m²). Traffic was halted on the surrounding roads, but was reopened just after 1 p.m.

Four firemen were slightly injured during the operation, although no one was taken to the hospital. 6,420 metal cages, 1,820 drums and 2,000 IBCs were destroyed or impacted by the fire. The operator estimated material damages and operating losses at €800,000. The firefighting water was pumped and processed by a specialised company.

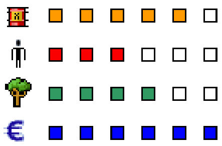
The operator suspects that the fire was the result of malicious mischief. As such, 24/7 surveillance by a security company was established at the site. There are also plans to equip the site with a surveillance camera and a thermal imaging system. Plans have also been made to improve the site's firefighting means with the addition of a foam tank linked to the hose reels and fire hydrants. The operator has also increased the frequency of fire drills and emergency situational awareness training.

A similar fire had already occurred at this site in 2018 (ARIA 53368).

Fire at two neighbouring industrial sites
26/09/2019
Rouen (Seine-Maritime)
France

Widespread fire
Slick fire
Combustible liquids
Warehouses
External storage facilities

THE ACCIDENT AND ITS CONSEQUENCES



On 26 September 2019, at around 2:35 a.m., a fire broke out on two neighbouring classified facilities for environmental protection. One of the sites was specialised in the manufacture of lubricants and additive products classified as an upper-tier SEVESO establishment, and the other one being a logistics warehouse subject to registration but known under the simple declaration scheme. The fire spread to the various outdoor storage areas and buildings on both industrial sites, creating a flaming slick extending over more than 3 hectares.
The special intervention plan was initiated, traffic was halted on the roadways adjacent to the sites. The fire was extinguished at 3 p.m. thanks to the efforts of 280 firefighters.

Human consequences: the fire resulted in no deaths or serious injuries directly. However, the extensive area engulfed in flames and the large amount of combustible liquid products created an immense smoke cloud (firefighters estimated that the smoke plume spread over an area of 22 km by 6 km). Numerous reports of unpleasant odours were received, most often associated with health problems (headaches, nose, throat and eye irritations, nausea, vomiting, and respiratory discomfort). Over a period of 20 days following the fire, 254 people shown up to the hospital for symptoms related to the fire and smoke plume. Nine people were hospitalised for short stays of less than 5 days. The French National Agency for Public Healthcare (Santé Publique France) conducted a health survey among 4,777 people, including 1,306 children. The results of this survey are currently being processed.

Environmental consequences: the plume of smoke resulted in soot fallout extending several kilometres. A docking area in the port of Rouen, not far from the site, was affected by liquid hydrocarbons. The decision was made to confine the pollution in the area, preventing it from entering the Seine and making its way to the sea. Several thousand analyses (water, soil, plants, animal products, etc.) were conducted in 215 municipalities, including those located in the Hauts-de-France region affected by the pollution. However, there was no evidence suggesting that the health risk thresholds were exceeded or greater than the background noise associated with the fire.


© DREAL Normandie

Economic consequences: the impact of the smoke plume and the associated fallout had significant economic repercussions. The damage causes and the resulting remediation costs for operators amounted to several tens of millions of euros: dismantling of the damaged installations, buildings, and the cleanup of soil and networks. As a precautionary measure, production operations on numerous farms was suspended for several weeks. The farmers then received compensation through a fund established by the operators.

THE ORIGIN AND THE CAUSES

The origin of the accident (exact location, nature) and the underlying causes remain unknown to this day. The expert assessment of the incident is ongoing, and the case has been referred to the courts.


© SDIS 76

It should be noted that more than 9,500 metric tonnes of combustible products (liquids for the vast majority), packaged in drums and intermediate bulk containers (IBC), were consumed by the blaze. Several aggravating factors were identified. Firstly, non-fire resistant containers contributed to the formation of burning slicks of flammable products which could not be contained due to insufficiently sized retention structures. Secondly, the proximity of the two sites resulted in a domino effect, increasing the amount of material burnt and surface area of the fire. Difficulties with the supply of water also complicated the firefighting operations. The problem was solved using fireboats and the provision of extinguishing means (emulsifiers) by other manufacturers located in the department.

ACTION TAKEN

Legal investigation: the matter was submitted to the public healthcare division of the Paris Court. The following charges were retained to open a preliminary legal investigation; “reckless endangerment”, “unintentional destruction by fire due to the manifestly deliberate violation of an obligation of safety” and “operation of a classified facility with failure to comply with general rules”. This investigation is still ongoing.

Transparency: The data relating to the incident was gradually published on the prefecture's web site, including the material safety data sheets of the products burnt and the results of the environmental analyses. Regular presentations were held before bodies such as the Site Monitoring Commission (CSS) and the Departmental Committee for the Environment and Health and Technological Risks (CoDERST). In addition to this, a Committee for Transparency and Dialogue (CTD) was created in October 2019 to bring together everyone concerned by the fire's consequences to monitor all the issues related to the consequences of the accident and shall all the information available.

Administrative and parliamentary enquiries: in support of the administrative enquiry conducted by the Inspection for Classified Facilities, the Ministry mandated the General Council for the Environment and Sustainable Development (CGEDD) and the General Council for the Economy (CGE), to analyse the event from a technical point of view and make recommendations in light of the findings.
Parliament also looked into the case. Thus, a fact-finding mission by the National Assembly and the Senate Committee of Enquiry looked into the experience feedback from the accident and submitted recommendations in Spring 2020. These reports were compiled into the government's action plan presented by the Ministry on 11 February 2020 and then completed on 24 September 2020.

Monitoring of safety measures and the remediation site: the Inspection for Classified Facilities was heavily mobilised, with presence at the site on a daily basis over a period of several weeks to monitor the operations to secure the site, These operations notably required the installation of a containment system under a controlled atmosphere in order to handle the drums still containing product. Several prefectural orders provided a framework for these operations. In addition to safety, one of the critical issues involved the remaining odour nuisance, which required the installation of monitoring and misting systems. The disposal of surface waste was completed in September 2020. A diagnosis of soil conditions is currently underway and will undoubtedly lead to soil decontamination work in the future.

Environmental and health monitoring: two prefectural orders, published on 14 October 2019, prescribed a broad environmental monitoring programme to be implemented by operators, covering 215 municipalities over 5 departments and various sectors (air, water, soot, plants, soil, agricultural products, etc.). An interpretive report on the condition of the environment was submitted in the summer of 2020. It highlighted incompatibilities of soil use in more than 40 municipalities, although not related to the fire: historical pollution was at issue. All the countryside areas complied with the health risk thresholds, or, where these did not exist, to the local background noise. A quantitative health risk assessment will be submitted to third party expertise to complete this environmental risk assessment approach.

LESSONS LEARNT

At the national level, on 11 February 2020, the Ministry for the Ecological Transition presented the governmental action plan aimed at drawing experience feedback from this fire. Two decrees and 5 ministerial orders were published on 24 September 2020. These texts significantly enhance the obligations of Seveso sites and the requirements relating to the prevention of fire risks and the limitation of their consequences in storage facilities for flammable and combustible liquids and in warehouses. This includes the gradual banning of certain types of mobile non-fire resistant containers. The requirements apply to new installations starting 1 January 2021, and existing facilities with deadlines for compliance extending to 2026.

The texts also provide for the increased legibility of inventories and substances disclosed to the general public and the availability of means for taking the first environmental samples in case of an accident.

In addition to these texts, and to prevent the risk of a domino effect between Seveso facilities and their neighbours, the Inspection for Classified Facilities was assigned the mission of inspecting, between 2020 and 2022, all classified facilities for environmental protection (ICPE) located within a 100-metre perimeter of Seveso sites.

At the local level, the Inspection for Classified Facilities took the experience feedback from this fire into account, particularly when examining the request for partial resumption of activities submitted by the lubricant and additive product manufacturing site. The decrees concerning the partial resumption of activities required that the operator undertake the following actions:

- the installation of fire detection measures in all zones where combustible liquids are stored or used, in packages or bulk containers;
- strict measures regarding retention facilities in these storage and use areas;
- automatic or pre-positioned fire extinguishing devices or systems in each storage area (with a specific fire defence plan drawn up for each area).

Several of these measures go beyond the requirements established by national regulations since 100% of the storage areas, including unclassified combustible products, are equipped with retention vessels, fire-detection and extinguishing systems.

Criteria for the Assessment of the Environmental Damage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© Operator

In 2019 the IMPEL Network set up a project named "CAED - Criteria for the Assessment of the Environmental Damage" in order to help Member States and specifically their competent autorities in improving their determination of the environmental damage and its imminent threat.

1. The CAED project within the european policy landscape for environmental damage

The CAED project takes guidance on key terms and definitions of Environmental Damage under the Environmental Liability Directive (2004/35/CE) as a springboard. It focusses on the technical-administrative procedures and methods necessary to determine the environmental damage caused by environmental incidents, non-compliances, offences and criminal actions.

The CAED project concerns the environmental damage to the natural resources protected by the ELD, namely:

- protected species and natural habitats (included in Habitat and Birds Directives);
- waters (under Water Framework and Marine Strategy Directives);
- and land.

In addition, the project includes areas protected by national legislation (such as protected areas, national and regional parks, wetlands) and international conventions (RAMSAR).

Moreover, the CAED project concerns environmental damage under ELD, which is assessed as "significant" according to the criteria defined in the Directive and clarified in March 2021 in the ELD Guidelines on the definition of environmental damage.

For further details on the criteria, follow the link:

https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021XC0407(01)&qid=1617956961808

Finally, the CAED project has been included in the ELD Multi-Annual Rolling Work Programme (MARWP) 2021-2024 of the EU Commission as one of the actions for training and capacity building.

2. What can the environmental inspectors expect when the CAED project will be completed?

The ultimate goal of the project is to produce a practical guide including criteria for the determination of the environmental damage and imminent threat of damage, based on reference parameters relating to 'evidence' and to 'clue' of environmental damage or imminent threat of damage.

The phases of the environmental damage assessment that involve the quantification of the damage for the equivalency analysis, as well as the choice and design of preventive and remedial measures, are not included in the scope of the project.

3. So far, what are the main findings?

The CAED report is the first of the IMPEL Network products concerning the ELD implementation and the environmental damage assessment in general, moreover, it is the first European report entirely devoted to the ascertainment/investigation phase of the whole process of the environmental damage assessment.

3.1. Analysis of the various contributions from Member States

The report compiles a collection of 32 case studies of 'ELD cases' and 'non-ELD cases' across Member States to identify common and different approaches from a regulatory, practical and technological point of view. It shows how the "clues" and the "evidence" of environmental damage and threats of damage are detected, identified and evaluated.

This analysis highlighted that there are significant differences between Member States regarding the way they assess environmental damages that mainly depend either in the implementation (especially in the parts of monitoring and evaluations) of the Habitat Directive, Birds Directive, Water Framework Directive, and in the existence, or not, of a national law for the protection of land.

In order to accompany their national transposition of ELD legislation, nine Member States have adopted technical and/or legal guidance documents (among which France).

The analysis of the 32 case-studies and the existing legal guidance documents allowed identifying:

- best practices;
- shortcomings;
- lessons learned;
- rooms for improvment;
- training needs.

to make environmental damage prevention and remediation more effective.

Currently, the main difficulties in implementing the ELD result in the definition and measurement of "significant adverse effects" that determine environmental damage. There is a lack of corresponding criteria or thresholds and it makes difficult to reach an accurate assessment and an effective remediation.

3.2. A new methodology

The report of the first year offers a new practical methodology composed of three steps:

- screening process;
- determination of clues;
- determination of evidence.

For further details on the methodology above, follow the link:

https://www.impel.eu/projects/criteria-for-the-assessment-of-the-environmental-damage-caed/

3.3. Training of inspectors is crucial

Another conclusion of this interim report is that **all inspectors involved in site visits for the competent authorities should be trained on screening for potential or suspected environmental damages under ELD** to ensure that any such cases are identified quickly and investigated adequately upon discovery.

The study highlighted **the crucial role of inspectors** (of IPPC-IED, EIA, SEVESO Directives) in the success of the whole process of assessment of the environmental damage. Indeed, inspectors are at the frontline in the collection of clues and evidence and in the evaluation of potential environmental damages and imminent threats of damage both during routine inspections and when activated for accidental events that may have consequences on the environment.

The best education of the environmental inspectors on ELD requirements and on the criteria for the assessment of environmental damage and imminent threat of damage is fundamental to optimize the cooperation with the responsible operators and competent authorities in charge of environmental damage assessment. It would allow inspectors to be more relevant and more reactive in the immediate ascertainment actions which would consequently stregthen successfully the preventive and remedial measures under ELD.

3.4. Many practical tools to come

The CAED project is working on practical tools such as;

- check-lists for inspectors and other public officials useful for the identification of potential cases of environmental damage and imminent threat of damage;
- supportive flowcharts giving guidance for the determination of the clues of the environmental damage;
- and some planning tools regarding the determination of the environmental damage and the imminent threat of the damage, based on selected case studies (integration envisaged in the next years).

Those practical tools from the guide to come aim to enhance competent authorities and practitioner's capability.

For example, when assessing the environmental damage following an industrial accident, this guide will be an essential tool for the environmental inspectors; it will greatly contribute to monitor the relevance of the proposed preventive and remedial measures.

Rupture of a dike on a setting pond in a sugar factory

09/04/2020

Escaudœuvres (Nord)

France

Classified installations

Dike breach

Organic pollution

THE ACCIDENT AND ITS CONSEQUENCES

The beet wash water from the Escaudoeuvres sugar factory is decanted then stored in one of ten ponds pending biological processing in the site's treatment facility. The water stored in the lagoon is collected during the sugar production season (between September and February) and then treated beginning in May-June when the temperatures are optimal.

On 9 April 2020, at around 1 p.m., a leak was detected in the dike of a settling pond following a tip from a resident. Water was leaking from a hole in the dike measuring 30 to 50 cm in diameter. The resulting flow continued into the Râperie stream after passing along the base of the dike and into the adjacent ditch.

© Operator

By around 10:30 p.m., the hole had expanded due to erosion, causing the dike to collapse locally. The resulting breach drained the pond completely, i.e. releasing approximately 108,000 m³ of water.

Approximately 25.6 ha were flooded, including 2.6 ha of roadway and 3.6 ha of inhabited areas (homes and gardens). The water also made its way into streams and rivers, passing down the RÂPERIE and then into the ESCAUT River. An estimated 88,000 m³ entered the ESCAUT.

The water contained in the lagoon is generally dark in appearance, gives off a strong smell and contains a high level of organic material (in this case, more than 6,000 mg/l of COD – Chemical Oxygen Demand).

Samples taken in the mixing zone between the ERCLIN and the ESCAUT showed that the dissolved oxygen was back to a good level as of 11 April. The COD had returned to the comparatively normal level as of 13 April.

The surrounding grasslands contained to drain into the RÂPERIE stream for a few days. About ten days were needed for its COD level to return to normal, but the dissolved oxygen level returned to normal more quickly.

In the first few days following the accident, no fish mortality was noticed in the ESCAUT; however, cases began to be reported shortly afterwards. It should be noted that this accident occurred while France was in a lockdown period during the Covid-19 epidemic. Therefore, watercourse observers were rare during that time, limiting and delaying the number of reports coming in.

Fish collection operations conducted by the operator in France recovered approximately 8.4 tonnes of dead fish. On 20 April, the Belgian authorities (Wallonia, particularly) contacted the French authorities after noting nearly total mortality of fish populations. The press reported more than 100 tonnes of dead fish.

An electric fishing operation conducted on 14 May in Fresnes-sur-Escaut, roughly 30 km downstream from the pond, indicated the presence of fish. However, the population had dropped 90% and with 40% fewer species in relation to previous years. Another fishing operation in October 2020 reported drops in 70% and 40%, respectively.

Legal proceedings are still ongoing at this time. The operator does not dispute that the environmental impacts in the region are associated with its accident. However, it questions its liability for all the impacts cited and particularly those in Belgium. It states that there is "no scientific evidence to date on fish mortality associated with the spill".

THE ORIGIN AND THE CAUSES

The accident resulted from a breach in a linear portion of a settling pond dike. On the other hand, the various causes and their significance in this accident have not yet been determined, although a few elements have been suggested.

Firstly, regarding the failure, the operator's expert geotechnical assessment indicated that only two dike rupture modes appeared plausible. The first could be rotational slippage (along a circular arc). As the dike became saturated with water, the inertial pressures decreased the frictional resistance of the dike's construction material to the point where it ruptured. Internal erosion is another possibility. A flow line through the dike developed, carrying material with it. The erosion could have led to a breach over time. The expert assessment indicated that the evidence of the causes of the collapse was carried off with the collapse itself. Nevertheless, internal erosion is the most likely hypothesis.

The report established that "the presence of burrows, roots and a high water level are factors that promote and aggravate internal erosion".

Various factors can promote this phenomenon, including inadequacies in the structure's design. In this case, the design and construction processes were not documented (dimensions, characteristics of the materials, construction, etc.). These pools do not have a sealing membrane or drainage system used to control the flow into the structure.

There may also have been deficiencies in terms of routine maintenance and monitoring. It was determined that the measures implemented were less than the current practice for dams. These included poor treatment of shrubby and woody vegetation, which can attract burrowing animals and hamper proper monitoring of the structures' behaviour over time. Moreover, the linear section in question had not undergone an in-depth inspection in many years. The operator's regular monitoring efforts had focused primarily on managing water volumes and not so much on identifying structural damage.

The structure's poor operating conditions may have also encouraged the internal erosion phenomenon. At this stage, the question of a possible overfilling of the pond is still pending. It should also be noted that significant modifications (merging of several ponds or raising of dike walls in other cases) were conducted without preliminary geotechnical studies.

ACTIONS TAKEN

The operator was immediately asked to conduct analyses (COD and dissolved O2) in the watercourses and monitor the consequences of the spill. The operator also fulfilled its role concerning the victims of the accident.

The prefectural emergency measures order issued on 29 April required the operator to conduct a geotechnical study on all the other ponds on the site before the end of June and to complete any stabilisation work that might be required before 15 September, as well as immediate implementation of reinforced monitoring measures for these structures. Urgent action was required to avoid another accident on a similar settling pond.

Subsequently, the operator was issued a formal notice via a prefectoral decree (17 June) in connection with the operating conditions and the grouping together of several ponds. A second emergency measures order was issued to stop the filling of certain ponds and reinforce the monitoring measures. An additional decree required the operator to draft an accident report and an environmental impact study, including a soil and water sampling plan, fish monitoring and hydrobiological monitoring (diatoms, micro-invertebrates). The objective was to evaluate the impact of this event on the environment, habitats, species, ecosystems and the environment's ability to recover from the accident.

Finally, a review of the geotechnical studies led to extensive work on the existing ponds. This work was conducted in conjunction with DREAL engineers specialising in hydraulic structures. An environmental remediation procedure was initiated, supervised by a steering committee convened by the Prefect and made up of: governmental departments, elected officials, associations, Belgian authorities, etc. This committee met on 4 December 2020.

The Cambrai public prosecutor's office is currently conducting legal proceedings.

LESSONS LEARNT

At this stage, lessons have been learnt in several areas.

Firstly, the question was raised regarding the need for a more specific regulatory framework for operating this type of structure, potentially inflicting significant damage on third parties and the environment. Evaluations are currently underway with the Ministry for the Environment.

This case reminds us that the release of organic substances, which are not dangerous à priori, can have significant environmental consequences.

For the operator, this means significantly improving the understanding and management of risks inherent in such structures related to its activity. This notably concerns; careful and rigorous monitoring of the structures and possible disorders, routine maintenance, particularly regarding vegetation growth, rigorous follow-up of the recommendations derived from internal monitoring programmes as well as expert opinions, the consideration of experience feedback or even complete control of the risks inherent in the modifications performed.

This event also highlighted opportunities for improvement in coordination between the various governmental departments in charge of water, biodiversity, hydraulic works and classified facilities, and cross-border environmental cooperation.

Fire in a clariflocculation facility of a wastewater treatment plant

03/07/2019

Achères (Yvelines)

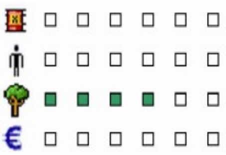
France

Fire

Pollution of watercourses

Damage to wildlife

THE ACCIDENT AND ITS CONSEQUENCES



The Seine-Aval wastewater treatment plant, operated by the Interdepartmental Syndicate for the Sanitation of the Paris Urban Agglomeration (SIAAP), processes approximately 1.7 million m³ of wastewater per day. It is the fourth largest wastewater treatment plant in the world.

Among the various processes employed at the site, clariflocculation is a critical stage in the wastewater treatment process, and mainly consists in removing suspended solids (SS) and phosphorus.

In anticipation of regulatory changes, concerning water quality in particular, the SIAAP began to overhaul the site starting in 2012, with operations scheduled to continue until 2025.

On 3 July 2019 at 4:50 p.m., a fire broke out at the site while maintenance operations were underway in the 2nd basement of the clariflocculation facility (containing 10 tanks of ferric chloride, i.e. a total of 180 m³). The fire produced a thick cloud of black smoke, and the operator initiated its internal emergency plan. The fire brigade encountered problems procuring water to fight the fire, but the fire was contained in the early evening, A few residual fires were extinguished after 5 days. In all, 20,000 m³ of water had been used in the firefighting operations. During the fire, the ferric chloride storage tanks, made of glass resin laminate, were destroyed allowing the product to drain into the retention structures on the building's 3rd basement level. The building's roof collapsed, and the clariflocculation unit was destroyed. Reconstruction will take 3 to 4 years.

© Operator

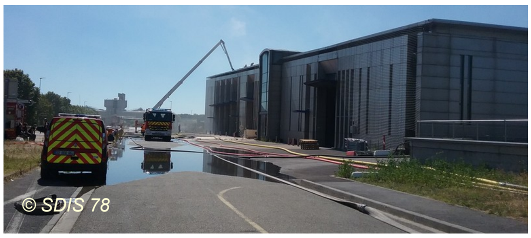
In addition to the clariflocculation unit, the fire also damaged the electrical system, causing the biological treatment line to go offline for several hours. Consequently, effluents that had only undergone pre-treatment were released directly into the Seine over the first few days following the accident until alternative solutions were put in place. The aquatic environment and river banks were severely impacted, particularly regarding fish mortality caused by the degraded discharges from the wastewater treatment plant. This mortality was concentrated at a point 3 km downstream from the discharge. A specialised company collected 10 t of asphyxiated fish. The pollution plume was characterised by a drop in the level of dissolved oxygen in the river water, a peak in ammonia nitrogen, ortho-phosphates and bacterial content (E. Coli and Enterococcus). However, the quality of the Seine returned to a normal level a few days after the event, and an inventory of the fish population conducted in July and November 2019 showed that the fire had not had a lasting ecological impact.

Stormy weather resulted in another discharge of partially treated water just 24 days after the fire, while the plant was still at reduced operating capacity. Fish mortality was again reported in the river.

The accident was widely reported in the media due to its visual impact and consequences for the natural environment.

THE ORIGIN AND THE CAUSES

At the time of the accident, the operator was in a period of significant investment involving the construction of new facilities, modernising existing installations and ensuring the compliance of facilities, generating a lot of parallel activities. Labour relations and working conditions also appear to have been deteriorating at the time of the fire (strikes, reports of serious and imminent danger from the labour inspectorate).



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These elements may have led to a shift in human and organisational factors within the establishment conducive to accidents. The Seine-Aval SIAAP had already noticed an increase in the number of incidents in recent years, reflecting shortcomings in risk management.

As far as the technical causes of the event are concerned, the report indicated that maintenance work (cleaning of fire dampers, dismantling of scaffolding, electrical work on the duct between 2 tanks) had been performed near the location where the fire had started on 3 July. That day, workers from an external service provider noticed a burning smell in their work area, although they could not identify its origin. The report specified that the fire had started in the ferric chloride storage room. The most likely cause of the fire was identified as an insulation fault on electrical cables.

ACTIONS TAKEN

A reactive inspection under the ICPE (classified installations for environmental protection) and a control under the French Water Act were conducted at the site on 4/07/2019. These inspections led to the issuance of a joint prefectoral order on 5/07/2019, instituting emergency measures regarding the environment and water. The order prescribed the following:

- submission of a status report on the control of the accident until the fire was completely extinguished and the building secured, a statement of the stocks impacted, and the creation of a communication system via the operator's website to inform the public;
- transmission of an accident report;
- an assessment of potential environmental damage based on air samples in the environment, the transmission of the protocol for conducting soil samples or other means of measuring atmospheric fallout with the assessment of the type and quantities of hazardous materials likely to be released into the environment, implementation of a reinforced self-monitoring system of the Seine upstream and downstream of the plant's discharge;
- a study on the possibility of installing an oxygenation system at specific points to reduce fish mortality;
- monitoring of the operation of treatment lines and conducting impact studies on the environment generated by the various wastewater management alternatives in the absence of clariflocculation.

The Inspectorate relied on the following elements for its analysis of the damage caused to the environment:

- the prefectoral order under the French Water Act (notably based on the Water Framework Directive and the sensitivity of the environment) concerning the site to characterise the impact of the effluent discharges into the water;
- testimonies of witnesses outside the influence of the site and, as required, technical guides (Ineris) to characterise pollutant emissions in the air and soil following the fallout of smoke generated by the fire, to take samples and to conduct post-fire analyses.

The results show that there was no lasting ecological impact following the fire. An inventory of the fish population was performed, and spawning grounds were subsequently built by the SIAAP. As far as the fish populations are concerned, a repopulation was noted, assisted by flooding of the Seine after the fire. Concerning the spawning grounds, the SIAAP has planned to conduct de-silting operations in the coves and enhance rocky breakwaters. Additional efforts will be taken to continue and improve the maintenance of the vegetation in the area.

The SIAAP also offered the regional fisheries association the customary compensation.

Following the accident, in addition to the creation of a wetland zone (a 6-hectare ecological corridor) provided for in the initial project to redesign the site, the SIAAP proposed to develop a fish refuge zone downstream from the Seine Aval discharge point.

A new complementary prefectoral order was signed on 3 July 2020 to reinforce fire protection at the site. The operator is required to submit the conclusions of the fire vulnerability study and the resulting corrective actions taken in the 1st quarter of 2021. The operator must also be able to ensure the containment of firefighting water before 31 July 2021.

The site is subject to reinforced monitoring by the DREIAT Île-de-France.

LESSONS LEARNT

As part of the site's global overhaul, the SIAAP Seine-Aval was faced with significant organisational and human challenges. There has been an increase in the number of incidents at the site in recent years. The safety audit conducted by the SIAAP confirmed that the site's safety culture was insufficient for an upper-tier Seveso site.

The inspections and various audits conducted following the fire highlighted numerous areas for improvement:

- implementation of an organisation to ensure that discrepancies identified at the site are duly reported and properly taken into consideration;
- more in-depth analysis of accidents, including the organisational causes;
- enhanced monitoring of combustible loads on the site, and reducing them to a strict minimum;
- an exhaustive inventory of the fire prevention requirements for all buildings to correct any discrepancies and improved identification and monitoring of firefighting resources.

Unexpected situations: illustration by the Covid-19 period

The Covid-19 pandemic has created unexpected situations that have led to significant incidents or accidents. Health regulations/guidelines may have compromised certain maintenance operations or works at certain facilities. The lockdown measures reduced the number of personnel present on site and changed the management of stocks or waste. The consequences, and in particular the economic and environmental consequences, have been significant. Changes in production intended to meet certain medical needs, such as sanitiser gel, may lead to risky situations that have not been sufficiently taken into account and need to be assessed.

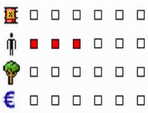
1. Situations encountered during the Covid-19 epidemic (ARIA database, 23/12/2020)

1.1. Maintenance or work postponed

The lockdown measures put in place throughout 2020 have led to the closure of several companies, including maintenance providers. Certain equipment repair operations, notably following incidents, have been postponed (ARIA 55332 et 56356). sans que des mesures compensatoires ne soient systématiquement mises en place. For certain operations that had usually been subcontracted, operators sometimes performed them themselves and underestimated risks.

ARIA 56340 – 17/07/2020 – Saint-Clément-de-la-Place (Maine-et-Loire) – France
Fire in a chicken house
At around 6:30 p.m., a fire broke out in an empty building (1,200 m²) intended for fattening up chickens on a poultry farm. On the day before the fire, the operator was in the process of preparing the chicken house for the arrival of chicks, covering the ground with crushed straw. Before the Covid-19 lockdown period, the farmer had had a contract with an external company to disinfect the chicken house. Faced with the partial stoppage of the company, the operator decided to conduct the operation himself. He ignited 3 disinfection smoke bombs which had been placed on the ground on a piece of slate. The straw around each smoke bomb was removed over a distance of approximately 1 meter. Upon igniting the smoke bombs, he then left the chicken house. The fire started 15 minutes later. The operator stated that he had not observed the recommended minimum safe distances regarding combustible materials (in this case, straw) specified in the smoke bomb's safety data sheet (1 m instead of the recommended 3 m).

Other examples: Fires have resulted from the postponement of maintenance or servicing operations. Two vegetation fires were caused by a lack of green space maintenance following the stoppage of business activities by subcontractors in charge of this (ARIA 55698, 56016). Two fires in non-hazardous waste storage centres were linked to work being postponed, due to the lockdown, planned for the operation or improved site safety (ARIA 55666, 56159).



ARIA 55700 – 02/07/2020 – South Africa
Two deaths in a refinery explosion
At around 4 a.m., an explosion occurred in a refinery and was then followed by a fire. The fire was brought under control in just a few minutes. The site's activity was shut down. Two persons were killed in the accident, and 7 other employees were hospitalised. A survey gave that maintenance work was supposed to have been conducted several weeks prior but was delayed due to Covid-19-related restrictions.

According to the information recorded in the ARIA database for this period, the economic consequences of deferred work, in terms of property damage (ARIA 55709, 20 k€) or operating losses (ARIA 55584, 90 k€), were significant. This underscores the importance of preventive and corrective maintenance in industrial facilities.

1.2. Reduction in the workforce

The health measures taken in response to the Covid-19 pandemic have led to a reduction in the workforce present on sites in an effort to limit potential contamination. At times, there was no staff on the site. In the event of an accident, more time was needed to detect it and respond (ARIA 55709). Furthermore, facilities that had been left unattended were the cause of a major disaster in India (ARIA 55467).

1.3. Difficulties managing stock and waste

The Covid-19 pandemic reduced demand for certain products, driven by the decline in consumption of non-essential goods during lockdown periods. The anticipation of medical needs, meanwhile, led to an increase in stocks of pharmaceutical products. As high levels of inventory were reached in warehouses, there were situations that were not under the operators' control. The consequences were, for example, products leaking from the valves (ARIA 56181).

Some sites stored waste temporarily, such as polluted fire-fighting water stored in IBCs, pending subsequent disposal through specialised channels (ARIA 55496).

The closure of waste disposal sites resulted in hazardous waste making its way into residual household waste. Local authorities were informed of the situation to boost communication with their citizens (ARIA 55344). Certain sorting centres remained partially open but with different organisations and users were no longer accompanied when disposing of their waste. This unusual situation led to hazardous waste being found in sorting centres not intended to handle it (ARIA 56173).

2. New risks

The implementation of protective measures and health protocols led to new risks. This can lead to any new unforeseen situation, which can then be assessed as a whole in order to maintain the "benefit/risk" balance.

Protective measures Health instructions	Risks	Consequences
Ventilation and airing of premises	Loss of containment	Dispersion of products in administrative premises or outdoors
Use and storage of sanitiser gel	Product ignition or leakage	Fire, pollution
Wearing a surgical mask	Respiratory discomfort, loss of vision, difficulty communicating	Slowing down of the rescue services in case of accident intervention, Difficulties encountered during the evacuation of personnel
	Unusual level of stress due to fear of contamination	Human error, incorrect interpretation of certain situations
Wearing of surgical gloves	Static electricity, difficulties in handling sensitive products (pyro)	Fire, explosion
Disinfection of intervention equipment	Disinfected equipment unavailable	Slowing down of the rescue services in case of accident intervention
Disinfection of hands using hydroalcoholic gel	Gel unavailable	Slowing down of the rescue services in case of accident intervention, notably when communicating via walkie-talkie
	Contact of sanitiser gel with a source of ignition	Burns to hands Fire

ARIA 55615 – 27/05/2020 – Cholet (Maine-et-Loire) – France
Chromium contamination of premises in a metal processing plant
A maintenance technician noticed chromium deposits in the sanitary facilities of a metal processing plant. The installations were shut down as chromium contamination was identified in all the buildings on the site. It was determined that a degassing reaction in the chromium bath had generated chromium VI aerosols which were deposited in the workshop. The changing rooms, sanitary facilities and offices were also affected as the inside and outside doors had been left open to aerate the workshop in compliance with the Covid-19 health protocols.

ARIA 55755 – 09/07/2020 – Prigonrieux (Dordogne) – France
Fire in a sanitiser gel packaging unit
A fire broke out in the sanitiser gel packaging unit in a 3,000 m² facility specialised in the development of active ingredients for cosmetics. Fifteen or so employees were evacuated from the workshops. The emergency services established a safety perimeter.
A plume of smoke was visible from well beyond the perimeter. The fire brigade was able to put out the fire around noon. Having fallen ill, an executive employee was attended to by the emergency rescue services. The site was completely destroyed, and 45 people found themselves without a job (technical unemployment).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3. Conclusion : recommandations

Unexpected situations were identified during the Covid-19 pandemic. When a particular context is identified, organisations must be adapted to the new situation. To achieve this, a few recommendations can be made:

- Evaluate the risks induced by these new situations;
- Train oneself and train one's staff to deal with these new risks;
- Implement compensatory measures;
- Adapt the organisation of work:shutdown of certain high-risk activities;
  - certain delicate operations are prohibited;
  - reinforcement of inspections;
  - review of the equipment monitoring process;
  - ...
- Reinforce communication.

Shutdown or startup/restart: heightened vigilance

The first lockdown period led the BARPI to issue a specific Flash ARIA on this subject.
These transitional phases could potentially be more frequent due to the lockdown and then the resumption of activities. Such phases are particularly critical in an economic context which can be quite difficult.
Operators must ensure that installations are shut down safely despite time constraints. A high level of safety must also be maintained throughout the shutdown period.
During restart operations, special attention must be given to raw materials, which may have been degraded during the shutdown period. There must be no production constraints in order to safely restart an installation. Reinforcing tests, safety barriers and the presence of personnel during these phases is a way of preventing incidents and accidents.

The European Commission's Joint Research Centre's Major Accident Hazards Bureau also issued recommendations in a bulletin dedicated to health crisis management and the safety of chemical installations, which can be consulted here.

Release of Styrene Vapours from a Polymer Plant

07/05/2020

Visakhapatnam, Andhra Pradesh
India

Polymerization
Exothermic reaction
Hazardous release
Covid-19 pandemic
Risk assessment

THE ACCIDENT AND ITS CONSEQUENCES

During the night, a release of styrene vapours occurred in a polymer plant.

It is estimated that 800 tonnes of styrene were released into the atmosphere.

The Report of the Joint Monitoring Committee records that 12 people died and 3 000 were affected. Other media reports record higher numbers (13 dead, 5 000+ injured).

In addition, late on 7 May the police ordered the precautionary evacuation of all people within a 2 km radius around the plant. Birds and animals near to the plant died.

Styrene properties

N° CAS : 100-42-5
Hazards identification :
H226 (Flam. Liq. 3), H315 (Skin. Irrit. 2), H319 (Eye Irrit. 2), H332 (Acute Tox. 4), H372 (STOT RE 1), H316d (Repr. 2), Seveso Substance.
Acute Exposure Guideline Levels :
AEGL-1 1 h : 20 ppm (notable disconfort or irritation)
AEGL-2 1 h : 130 ppm (irreversible health effects)
AEGL-3 1 h : 1100 ppm (life threatening health effects or death).
Safety parameters :
Flash point : 31 °C
Boiling point : 145,2 °C
Auto-ignition temperature : 490 °C

ACCIDENT CHRONOLOGY

At about 02:42 hrs on 7 May 2020 CCTV records show that vapours were released from a pressure safety valve on the roof of the tank M6 that contained 1 830 t of styrene. No alarm was triggered and the styrene detector failed to detect the vapour emission. At 02:54 hrs, the control room operator received a vapour release alert and 8 minutes later a temperature alert was received.

At 03:03 hrs, it was no longer possible for the night duty officer to reach the fire hydrant sprinkler valve due to the high concentration of the vapour cloud.

At 03:07 hrs, the security-in-charge was instructed to request help from outside agencies. At this point, it had been recognised that the styrene in the tank was undergoing self-polymerisation as an exothermic run-away reaction.

At 4:30 hrs two members of staff wearing self-contained breathing apparatus were sent to open fire-hydrant sprinklers for the Storage tanks M5 and M6 as well as the Pentane tank.

At 04:32 arrangements were made to add emergency “inhibitor” chemicals (n-Dodecylmercaptan; tertiary Dodecylmercaptan; Eunox-76) and addition was started at 05:15 hrs with around 2 200 l of chemicals being pumped into the tank.

At 06:30 hrs, 10 t of styrene were pumped to feed preparation tanks and 15 t to feed solution tanks. An hour later 70 t of styrene were pumped to a spare storage tank. Water was poured through foam pourers and water sprinklers on to the affected tank in an attempt to cool the contents.

At this point, it is necessary to make the following observation that Mercaptans do not act as reaction rate inhibitors - they are chain transfer agents that shorten the polymer chains and reduce the viscosity of the polymerising mass. The fact that they were added to the tank may have been seen as the “only possible option” if no TBC reaction rate inhibitor was available on site.

By 09:30 hrs that is more than six and half hours after the initial release the neighbouring urban areas with significant residential population are significantly affected. It was at this time that the Andhra Pradesh Pollution Control Board (APPCB) initiated air quality measurements for styrene with handheld devices. The highest levels measured were 461 ppm measured on 7th May at Venkatapuram, a location around 600 m north of the site. The maximum measurement on the following day was at the same location and reached 374 ppm.

At 22:45 hrs on 7th May the temperature of the affected tank had reached 154 °C (above the boiling point of styrene monomer).

At 03:30 hrs on 8th May the temperature had started to fall and reached 120 °C by evening.

At 09:00 hrs on the 9th May following continuous cooling of the tank the temperature had reached 100 °C. From this time onwards no significant emissions of styrene vapour are documented.

THE ORIGIN AND THE CAUSES

The industrial unit was closed on 24th March 2020 due to the COVID-19 lockdown. On this date the styrene was being stored in four storage tanks with inventories of 1 830 t, 2 725.9 t, 242.6 t and 242.5 t. Maintenance activities were carried out by a staff of 15 persons per shift with a three-shift operation. Thus for a period from 24 March to 7 May there was no consumption of styrene by the production processes.

Storage Tank M6 is of an old design and only had temperature sensors at the base of the tank. There were no sensors at the middle or the top of the tank. This means that it was not possible to determine whether a temperature gradient or a homogenous tank temperature existed in the tank. In addition, the pressure safety valve emitted directly to the atmosphere and not to a flare system or other emission control unit.

The styrene monomer should under no circumstances exceed 25 °C otherwise self-polymerisation will slowly start. Storage of Styrene is stabilised by adding an inhibitor, such as tertiary butyl catechol (TBC). Depending on the storage conditions, it is necessary to replenish the inhibitor level. The affected tank M6 had not been topped up with TBC since 1st April and no TBC was on site. The inhibitor concentration is not the only parameter that is relevant with regard to the potential for self-polymerisation. The polymer content should also be measured. For bulk tank storage at 25 °C or more a daily analysis of TBC content and polymer content is recommended.

The refrigeration system for chilling the tank contents was switched off at 17:00 hrs on the previous evening (6 May) as per usual practice, as ambient night time temperatures allegedly required little or no cooling. However, this meant that there was no possibility of mitigating the event by reducing the internal temperature of the tank via the refrigeration system. Given that, the mean low temperature range is ca. 18.5–28 °C, with April and May having low temperatures at the upper end of the range, there appears to be little justification for switching off the cooling system.

The emergency systems were not designed so that they could be readily operated in an emergency situation. Neither the fire sprinkler system nor the public alarm system could be activated immediately due to the vapour cloud. Access to personal protective equipment was also not immediate and hindered the initial response.

The lock-down as a result of the Covid-19 pandemic contributed to the impact of the incident in two ways. Firstly the fact that the turnover of the styrene in the tank through the production process together with the lack of monitoring of the state of the tank contents meant that the probability of a self-polymerisation was heightened. Once the release of hazardous styrene vapours had reached the local community the local inhabitants suffered from respiratory problems with damage to the lungs and airways. This meant that a large number of patients presented at the same clinic dealing with Covid-19 infected patients. The number of patients and lack of social distancing between those attending the clinic gave cause for concern regarding the transmission of infection. It should be noted that Styrene itself is not classified as highly toxic. The fatal effects of Styrene inhalation are due to the aggressive effects on the tissue of the respiratory system.

LESSONS LEARNT

1. The design of a storage tank or any other process plant must include the necessary monitoring equipment and safety devices to allow a controlled and safe operation of the plant at all times.

2. Should the operation of the plant be shut down (for example during a pandemic), then the plant must be kept in a safe mode. This includes aspects such as nitrogen blanketing, concentration of inhibitor, continuation of stirring, cooling or electrical power supply. This may mean that arrangements need to be made to continually monitor the plant and to order and receive supplies even though the production facilities are not operational.

3. Facilities that are part of a larger, international corporation must be overseen by the corporate management, and resources provided so that safe operation is always possible. The corporate governance should ensure that risks are identified and managed appropriately and that a high standard of safety is achieved, even under unusual circumstances such as a pandemic.

Short-form accident feedback

Accident summaries presented in short format on the following topic: Managing unexpected situations, illustrated by the Covid-19 period.

Overheating of a fire-fighting pump unit and drainage of the fire-fighting water reserves

ARIA 55709 – 30/03/2020 – Cramans (Jura) – France

The fire-fighting pump in a gas company started up unintentionally, causing the site's fire-fighting water reserves to be emptied in just a few hours. At 7:40 p.m., the remote monitoring system received an alarm that smoke was detected in the fire-fighting pump room. The time required to confirm the alarm was longer than expected (more than one hour instead of thirty minutes), owing to a lack of personnel during the Covid-19 lockdown period. The responder noted smoke exiting the plant room where the overheating pump unit was located. At around 9:40 p.m., the fire brigade disconnected the pump unit's electrical power supply, thereby securing the site. The fire-fighting pump unit was damaged, and a window in the pump room was broken. Material damages were estimated at €20k.

Following the incident, the operator decided to halt all gas transfer operations until the end of the Covid-19 lockdown period. The operator also plans to undertake the following measures:

- review of whether to add or modify remotely-monitored detection systems located in the fire-fighting pump's plant room;
- a study to render the site's alert system more reactive in the event of an alarm;
- limitation of the capacity of the liquefied flammable gas tank to below the 35 t threshold by installing devices to prevent the threshold from being exceeded.

Release of hexane into an effluent pit in a plastics manufacturing plant

ARIA 55514 – 05/04/2020 – Sarralbe (Moselle) – France

Hexane is a flammable, environmentally hazardous, harmful and reprotoxic liquid. At around 8 a.m. on a Sunday, hexane was released into an effluent pit not intended for this purpose. The accident occurred during a tank rinsing operation in a plastics manufacturing plant. A first tank (A) was undergoing a preparatory operation, consisting of successive rinsing operations using just water, while a second tank (B) was being used to collect the subsequent wastewater. As the level in B was rising higher than usual, the operator decided to purge the tank. He opened the purge valve and went away to monitor the levels. Upon returning, he noticed that hexane, not water, was flowing from the tank and immediately closed the purge system. A volume of hexane had been drawn in and trapped in the wastewater collection pit. To prevent flammable gas from migrating from the pit to the workshops via the effluent pipes, nitrogen was injected into these pipes to act as a barrier. By doing this, the gas cloud was confined in the pit. The operator considered using foam or water to limit the evaporation of the hexane. However, the increase in the liquid level could have drawn the hexane toward the internal treatment station. No water resources were thus deployed. The operator then contacted a specialised service provider equipped with an ATEX hydro-jet vacuum lorry, but it was unavailable (the incident happened on a Sunday and during the Covid-19 lockdown period). No gas could be seen floating in the pit 30 minutes after the incident, and there were no more hydrocarbons in the pit at 6 p.m. The spill was estimated at 400 kg.

At the start of operations, the operator purged a tank bottom that was supposed to contain water:

- the composition in tank B had been modified by a purge operation involving water and solvent (mainly hexane) during a previous shift. The operator had not been informed of the presence of these elements in the tank;
- the interphase levels are not reliable and do not allow for precise detection of the various levels for three-phase discharge tanks (water, polymer, hydrocarbons);
- the gas detector closest to the purge valve was faulty and pending repair. The repair operation had been postponed due to the lockdown period associated with the Covid-19 pandemic. No compensatory measure had been implemented;
- the procedure for making the tank available was not sufficiently explicit in how to return to the standard level. It also did not stipulate that the purge operation must be continuously monitored.

Following the incident, the operator implemented the following actions:

- review of the procedure for making tank A available;
- technical measures were put in place to prevent the discharge tanks from being purged if they are likely to contain hydrocarbons (padlocking of purge valves before inerting operations);
- stipulate, in a general safety procedure, that it is forbidden to leave a purge unattended;
- improve the transmission of information between shifts;
- study another technology for measuring tank levels;
- review the monitoring process of gas detectors to limit downtime and ensure that compensatory measures are implemented.

Release of liquid oxygen in an industrial and medical gas plant

ARIA 56181 – 07/04/2020 – Portet-sur-Garonne (Haute-Garonne) – France

At around 3 a.m., in a company specialising in industrial and medical gas, 12 tonnes of liquid oxygen were released via an overflow valve on a 1,000 m³ tank and spread to the retaining basin. The discharge was discovered by a roundsman when he arrived on the site the next day. He shut the supply line to the tank and directed the tank's surplus liquid oxygen to the ejector. The layer of gas vaporised.

At the start of the Covid-19 pandemic lockdown period, stocks were being maintained at abnormally high levels, due to a decrease in demand for industrial oxygen and in anticipation of a possible increase in the need for medical oxygen. The overfill valve is a hazard control measure designed to prevent overfilling and opening of the tank dome. The physical overfill was reached without the tank's very high-level alarm being tripped. The very high-level threshold was not adapted to the position of the overflow valve. The oxygen spread into the retention basin without activating the low-temperature sensor installed there.

Following the event, the operator undertook the following measures:

- the low-temperature sensor was moved closer to the overflow valve's release point;
- verification and redefinition of the tank's high and very high fill levels;
- review of the parameter settings for the tank's very high fill level alarm and activation of the tank's high fill level alarm (previously deactivated);
- drafting of the ejector procedure;
- redefinition of the parameters for monitoring production and tank filling levels for the supervisory staff.

Fire in a biomass boiler system in a sawmill

ARIA 55592 – 11/05/2020 – Saint-Symphorien (Gironde) – France

At around 7:20 a.m., during operations to restart the boiler at a sawmill following the Covid-19 pandemic lockdown period, the operator noticed smoke inside and outside the boiler building and the smell of oil. This boiler was fed with wood residues and used for drying the wood via a system through which heat transfer fluid circulates. The company's personnel were evacuated. The heat transfer fluid (oil) used in the heating process had reached 428 °C, whereas the normal operating temperature was 220 °C. The audible and telephone alarms had not been triggered on time.

The fire brigade chose not to spray the system down, fearing that the water would cause a thermal shock upon contact with the oil tank. The operator opened 2 of the 4 dryers to increase oil circulation, causing its temperature to decrease by 30 °C. The boiler burst into flames at around 8:15 a.m. Following this, the electrical power supply and the dryer's supply valves were shut down, and traffic on the nearby road was shut down. The firefighters used the site's fire-fighting means. The extinguishing water drained into the stormwater system, then into unsealed ditches, which emptied into a 2,000 m³ lagoon. The network's shutoff valve to the ditch was actuated. A hydraulic excavator was used to fill in the ditches to limit discharges into the lagoon. The fire was brought under control at around 2:30 p.m. The temperature of the aboveground oil tank dropped to 42 °C, and then the fire brigade left the site at around 6 p.m.

The site's main installations (sawmill, cutting and end-to-end joining) were not affected, although the destroyed boiler was dismantled. No injuries were reported. The oil contained in the installation was pumped out and processed by an authorised company. Water samples were taken in the lagoon and from underground sources. The ditches were cleaned, and the excavated soil was processed in an approved treatment facility.

The cause of the fire was linked to the rupture of a pipe conveying heat transfer fluid in the boiler room and its discharge onto a hot spot. Two days earlier, heavy rains had dampened the boiler's fuel (sawdust, chips and bark), making it difficult to stabilise the oil temperature. To correct this, on the day before the accident, the site's caretaker had increased the inflow of fuel to raise the temperature of the heat transfer fluid. The boiler was being fed with too much fuel.

The operator is currently studying the following elements as part of its reconstruction project:

- roofing over the boiler's fuel supply;
- measurement of oxidizer humidity (boiler air), coupled to an alarm if the humidity is too high;
- alarm for the oxidizer inlet;
- sprinkler device above the fuel supply in the case of fire;
- remote monitoring of the boiler via external control rooms;
- heating with water instead of heat transfer fluid.

Integrity concept for hight-risk installations: methodology developped in the Netherlands

FACT SHEET

1. What do we mean by the « Integrity of installations »?

The following definition is formulated to describe the "integrity of installations":

The whole of systems, methodologies and processes that demonstrate that the use of the installation is suitable for its objectives, within the process conditions determined. The basic principles are known and secured in the operation windows and alarm management systems. An appropriate inspection and maintenance system have been set up to guarantee continuity. All this with the aim of operating the installation safely and with low disruption.

In other words, integrity of installations is determined by the connection between the design, operation windows and the alarm management of the installations. The inspection & maintenance regime are put in place to ensure that the condition of the installation is and remains in order to warrant the reliability and availability of the installation. Therefore, inspection and maintenance is part of the integrity concept.

2. Failure of the control of the integrity of the installation

In 2019, RIVM (National Institute for Health and Environment) published a report "fifteen years of incident analysis". This report includes an incident analysis of 326 incidents over the period 2004-2018 and shows that sixty percent of the incidents took place during the regular business/process. The most incidents were reported within the process industry where the main cause was failure of the control of the integrity of the installation, i.e. inappropriate or no use of the safety function (145 cases). Thus, many accidents are related to the failure of the "integrity of the installation". In France, 1,014 SEVESO accidents were recorded between 2004 and 2018. Among the 646 accidents for which the root causes were identified, 430 involved a poor identification of risks, an inappropriate choice of equipment and processes or shortcomings in the organization of controls.

3. Measures Environment protection agency Noordzeekanaalgebied (ODNZKG)

The Environmental Agency NZKG accident investigation confirmed the findings of the RIVM report; the integrity of high-risk installations at Seveso companies is not sufficiently guaranteed. Therefore, the Environmental Agency NZKG invested in several measures to raise awareness among companies on how to safeguard the integrity of high-risk installations. To this end, a project team "integrity of installations" has been set up, consisting of permit issuers, legal employees, supervisor Seveso and an External Safety specialist. This project is currently still in progress and is therefore not included in this discussion.

It is noted that the integrity of installations has not received enough attention for all types of installations through legislation. At least not in the concept as we consider integrity. Within bulk storage, we know the term fit for purpose. This indicates that the storage tank is suitable for use for a certain substance and period. This mainly concerns the construction of the storage tank and the relationship with the properties of the substances stored therein. Fit for purpose for bulk storage is not comparable to the integrity of more complex installations. Therefore, it is important to ensure that the companies also draw attention to the integrity of installations. To this end, licensing (new and existing situations) and supervision (Environmental permit and Seveso inspections) are the available options.

Furthermore, to determine which installations, have a high risk, it is important to determine the prioritization of relevant installations. For prioritization the investigations required by law and by legislation, both the "quantitative risk analysis" (QRA) and the "lifespan of the installation" can be used.

4. Prioritization of relevant installations

4.1. Quantitative risk analysis (QRA)

All Seveso companies have the obligation to drawn up a QRA. Based on risk ranking points (part of the QRA) it is possible to select the installations that contribute to the location-related risk outside the establishment. These installations can be prioritized. By using this selection method, the focus is on the most relevant high-risk installations. By gaining experience and propagating the concept, companies can see the usefulness and necessity of this concept. We have presented the integrity concept to several companies of which two are already in the process of implementing the concept in their own operations.

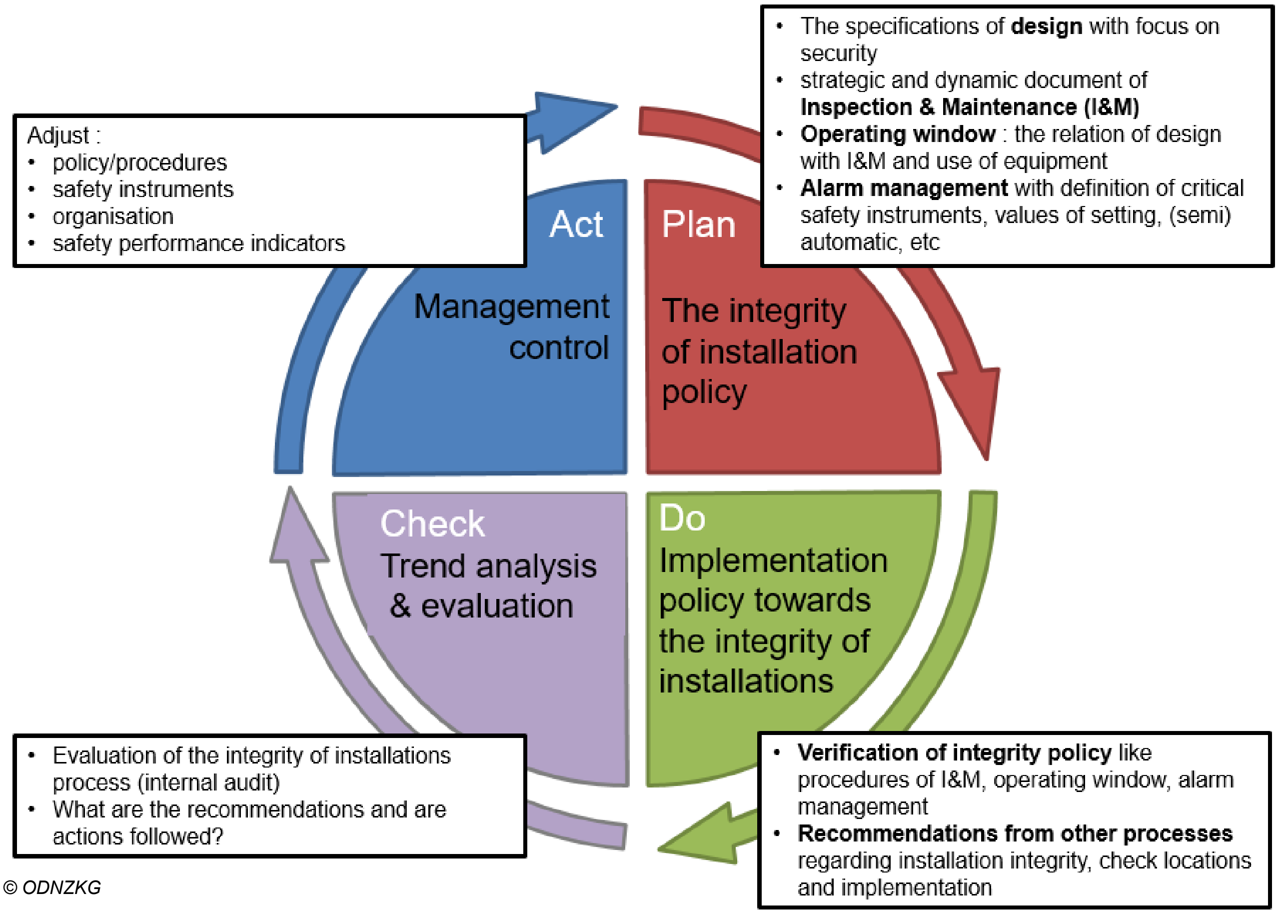
4.2. The lifespan of the installation

Another factor that can be used to prioritize the integrity is the service life of an installation. Installations have been given a lifespan from the supplier. However, it is not the case that installations whose lifespan has expired are "life-threatening". If the user demonstrates that the integrity is guaranteed, and attention is paid to the installation the lifespan may be longer. Vice versa, if the integrity is not guaranteed and little attention is paid to the installation, this may be a greater risk.

In practice, companies do not always appear to pay enough attention to this. The lifespan of the installation has overlap with aging, from the Seveso and inspection and maintenance from the environmental permit.

5. How integrity of installations could be inspected

In addition, inspectors can use the "Plan Do Check Act" (PDCA) in order to check whether the integrity of the installation is approved and fully guaranteed, namely;



The integrity of the company in order to comply with laws, regulations and own standards must not be separated from the integrity of installations.

It is noted that for the integrity of installations following factors are important:

- Design: standards, limits (pressure, temperature, flow…), safety-critical equipment, safety management system, internal audit, evaluations…
- Operation windows: in line with design, management/monitoring, process monitoring, changes and modifications, handling deviations & malfunctions, internal audits, evaluations …
- Inspection & Maintenance: I&M methodology and strategy, standards, certification handling failures & deviation, dealing with recommendations, internal audit, evaluations …
- Alarm management: fitting with design and use, priorization of alarms, automatic intervention, link with SMS, internal audit, evaluation …

These four items are also all aimed at the concrete implementation of the policy and assurance in internal systems of the company.

Short-form accident feedback

Short-form accident summaries on the topic of 'Integrity of installations'

Mercury rainwater tank rupture at a chemical plant

ARIA 51102 – 20/01/2018 – Tavaux (Jura) – France

At around 1:10 a.m. at a chemical plant, an opening formed in the upper portion of a vertical tank which was 96% full of rainwater containing mercury. The 628 m³ lined steel tank was used to collect excess rainwater. It had been disused for some time and had been returned to service following the shutdown of the site's detoxification station. Workers noticed the incident at around 4:30 a.m. during a monitoring inspection. The on-call managers diverted the tank's supply and recovered the water collected on the available base slabs and bund walls. In the end:

- 327 m³ was confined in the tank;
- 142 m³ was recovered through the collection;
- 134 m³ flowed into the River Saône (a flow of 65 g with a concentration of 0.49 mg/l of mercury).

An inspection conducted in May 2017 had found that the tank was damaged. The tank was subsequently scheduled to be removed from service by late April 2018. This date was intended to provide enough time to replace it by another existing tank. Pending this final removal from service, the tank has not been disconnected for a potential large stock of effluent to be stored. The operating instructions for the tank have been adapted (limiting the filling rate to 60%) and 2 other tanks were being used on a priority basis. However, following an unexpected shutdown of the wastewater treatment plant due to delivery issues since 14 January with one of the reagents used at the plant as well as to heavy rain, the tank had to be used and its limit was exceeded.

The operator implemented the following corrective actions since the incident:

- the tank was immediately and permanently removed from service;
- the two other tanks were inspected;
- the reagent supply strategy was revised (safety threshold for triggering orders, diversification of suppliers).

In May 2012, a mercury brine tank used by the electrolysis department had ruptured, sending 2.5 kg of mercury into the River Saône (ARIA 42346).

Hydrocarbon leak on a transport pipeline

ARIA 53583 – 19/04/2019 – Le Palais (Morbihan) – France

Caractéristiques de l'ouvrage :
- DN 100 (114,3 mm)
- longueur : 609,70 m
- pression maximale en service : 6 bar
- année de mise en service : 1968

At around 2:35 p.m., a hydrocarbon leak was suspected on a transport pipeline during a fuel transfer operation between the port of Le Palais and the storage tanks located in the Belle-Île oil depot. The leak was detected using a material balance technique performed during hydrotesting operations. The operator estimated that 2,700 litres of hydrocarbons had leaked (gasoline, diesel fuel and domestic heating oil). No trace of pollution was visible along the surface of the piping. Tests were conducted to locate the leak precisely. During these tests, a perforation was discovered on the lower generatrix of the pipeline.

Two weeks later, the Prefect of the Morbihan (department) issued an emergency decree to supervise the repair work and suspend the transfer of all hydrocarbons until the entire route could be tested for leaks. Two successive operations were undertaken to replace the pipes during the month following the suspected leak, but the leak tests proved unsatisfactory. The operator concluded that other leaks were present and decided to replace piping over a longer stretch of the line.

An analysis of the damaged piping highlighted small areas of "pitting" type perforation caused by an internal corrosion mechanism. These zones had not been detected when an in-line inspection pig had passed through in February of the previous year. Its detection accuracy was insufficient in relation to the small size of the defects (less than 5 mm).

Generally speaking, the piping's internal wall showed signs of widespread wet corrosion associated with the system's operating method, which consisted of filling it with seawater or freshwater between oil hydrocarbon transfer operations.

A sampling programme revealed significant marking of soil and underground water in the leak zone and downstream. Cleanup operations began in 2020 and will continue at least into 2022. Several techniques for treating the polluted soil were retained, as well as pumping and treating of underground water. The total cost of the operation was estimated at more than €800k.

The repair project, which is still pending validation by the local authority, is estimated at €1.8 M. In the meantime, an alternative solution to unload the tanker by trucks was set up to supply the oil depot.

If the feed piping is overhauled, the operator plans to modify its operating methods, particularly by using nitrogen to inert the line between hydrocarbon transfer operations.

Fire in the distillation unit of a refinery

ARIA 54828 – 14/12/2019 – Gonfreville-L'Orcher (Seine-Maritime) – France

A fire was detected in the refinery's distillation unit through an alarm sent in the control room at 3:38 a.m. Some flames of a height of 50 m were visible at around 4.00 a.m in an area of 4,000 m^2 affected by the blaze.

The fire was located in an area containing crude oil booster pumps, distillate booster pumps, condensers, an analyser shelter and pipes. The unit's emergency stop in the control room was activated at 3:39 a.m. The supply of the subdivision load line was disconnected, the unit was isolated, and the permanent protection means in the zone were activated. Between 300 and 600 m^3 of flammable substances were menaced by the zone on fire. From 3:44 a.m., the site's internal firefighting resources were put into operation in order to put out the fire and cool down specific installations in addition to the fixed ones. At 4:00 a.m., the internal contingency plan (POI) was initiated, a safety perimeter was established, and the road leading to and from the site was shut. The fire brigade was called in to provide reinforcement and to take air samples around the site (H_2S, SO_2, NO_2 and VOCs). At around 8 a.m., the Prefecture recommended that the population in the surrounding area and employees of neighbouring businesses remain indoors. The extinguishing water was collected into specific tanks already present on the site. Floating barriers and absorbant socks are set-up in the canal, directly to the end of pipe of the water discharge. The fire was brought under control shortly after 8 a.m. As the network of atmospheric measurement stations had not detected anything, the decision was made to lift the shelter-in-place recommendations at around 10:25 a.m. At 11:30 a.m., the main body of the fire was extinguished. A gas leak was still burning at around 4:30 p.m. By 6 p.m., the last secondary body of flames was extinguished, and the firefighters continued cooling down the area throughout the night. The internal contingency plan was halted two days later at 2:25 p.m.

No injuries were reported on or off the site. A diffuse plume of smoke was visible, and the smell of hydrocarbons could be detected in the neighbouring municipalities (up to 8 km away), although there was no soot in the surrounding area. A slight hydrocarbon sheen was observed in the canal. Aqueous effluents were pumped and processed by the site installations. The distillation unit was partially destroyed (approximately 50 m x 50 m). Gas flaring episodes were also necessary.

A fuel leak occurred on a dia. 3" pressure tap tube, on a hollow tubular support. The operator had reported corrosion on the support 3 years earlier. The support was planned to be replaced during the regulatory break but it had not been done. The ignition source was not clearly identified. Before the fire started, the 20% LEL (lower explosive limit) alarm was triggered 6 times, without the production operators noticing. Due to the shutdown of some of the units, the production operators had filtered the alarms so that only the alarms relating to the processes of the unit being restarted were displayed. This filtering hid fire and gas detection alarms.They had interpreted the flashing light signal in the control room as a “process” alarm, knowing that these signals were not explicitly dedicated to fire and gas alarms.

Gas leak on a pipeline

ARIA 56502 – 10/08/2018 – Cologne – Germany

A leak was discovered at a gas pipeline containing an acute toxic (cat. 3) and flammable mixture of nitrogen, carbon monoxide, hydrogen, oxygen, methane as well as particles including sulphur and operating at a slight overpressure (37 mbar). The leakage originated from a hole measuring 50x25 cm in the pipeline routed at a height of 10 m. Due to difficulties in accessing the pipeline and the lack of automatic shut-off devices, the gas leakage continued over a period of 6 hours.

An estimated 38 t of residual gas (density of 0.5 kg/m^3, temperature 250 °C) was released. Due to the amount of gas lost, the incident was notified as 'major accident'.

The event highlighted problems concerning safety management and awareness. The initial expert assessment identified corrosion as the cause of the leak, resulting from an accumulation of sulphur particles combined with a simultaneous condensation reaction at a dead end of the pipeline. In addition, no inspection program existed to control the integrity of the gas pipeline system and no responsibility had been defined for the monitoring.

The competent authority closed down the operation of the affected pipeline including the section connected to it and prohibited short-term repair work. An inspection was conducted on-site and 2 successive expert assessments were ordered. The successive expert assessments contained the following recommendations:

- installation of automatic pipeline disconnection devices;
- improvement of the pipeline accessibility;
- an evaluation of the existing systematic hazard analysis;
- an assessment of the facility's Safety Integrity Level classifications;
- a comparison between the authorised configuration and the as-built configuration;
- an evaluation of the measures already defined;
- identification of further hazards for the residual gas system;
- establishment of a leak management procedure;
- recommendations to improve the installation safety.

The installation of automatic shut-off devices for the gas system was regarded necessary to limit releases in the event of a leak. Moreover, the measures undertaken following the incident are subject to continuous monitoring by the competent authority.

Avoid cognitive tunnelling

Cognitive tunnelling is the phenomenon where we can become overly focused on information that confirms our first hypothesis regarding the current situation, at the expense of information that should alert us that we are actually on the wrong track. The brain tends to fixate on a frequent, reassuring incident rather than on a serious, stress-inducing accident.

This cognitive tunnelling has been the cause of many accidents in the aeronautic, rail, nuclear, medical and technological fields. Analysis of these accidents has been instrumental in developing technical and organisational barriers to avoid cognitive bias from occurring.

The possible solutions include:

- *specific procedures to prevent the operator from becoming trapped in a cognitive tunnel;*
- *an external view that will not have this cognitive bias.*

A risk analysis specific to each facility, and each organisation must be conducted to define their barriers specific.

1. Presentation of the film: Release of VCM in a chemical plant

In 2018, an event in a chemical plant led to the accidental release of approximately 3 t of vinyl chloride monomer - VCM. The release continued for more than 6 hours. This duration raises certain questions as to how this event took place: Why did it take 5 hours to identify the origin of the VCM leak? Why didn't the operators think about the outlet at fault? Why didn't their search efforts lead them to the source?

The operators on duty that night had to deal with two problems.

The release continued for 6.5 hours as the valve in question was not identified immediately. In addition, technical difficulties did not facilitate efforts to locate the leak: the crew on duty was looking for failures of compressor by-pass valves, which regulate the level in a gasometer, and searching for leaking autoclave valves in the workshop.

The gasometer, acting as a buffer during degassing of the VCM autoclaves, had reached its low level. The operating crew had interpreted this level as a possible failure of the compressor by-pass valves. The gasometer's operating trend curve was not available in the control room. The operators had to wait for the analysis by the maintenance crew, who had access to a standardised view of the process allowing for quick identification of possible failures. In addition to this, the gasometer's alarm sheet was incomplete. It indicated only that “poor compressor control” might be due to failure of the by-pass valves. Experience had shown that this fault has already occurred. Owing to the phenomenon known as 'cognitive tunnelling', the operators' attention remained focused on this idea.

Concerning the leaks on the valve of the two autoclaves, the crew on duty assumed that these leaks were the source of the VCM detections in the workshop.

The crew focused its attention on these leaks while following the designated procedure in this situation. VCM detections continued despite operations to retighten the leaking valves. The crew on duty was keenly aware of the risk of occupational exposure and continued to search for the leak, but could not find the valve in question. It was not identified as a potential source of VCM release. 'Cognitive tunnelling' was also at issue here.

This event resulted in the release of approximately 3 t of VCM, without any health or environmental consequences.

Following the accident, the operator reviewed its risk analysis and updated the "gasometer low level" alarm sheet. All the possible causes were thus identified and taken into account to widen the operators' scope of investigation in such a situation and avoid cognitive tunnelling from reoccurring.

The operator modified the mimic panel's views and the alarm management processing in the PLC to provide operators with the most relevant information.

2. Conclusion and recommendations

The difficulty in anticipating cognitive tunnelling is that it can occur when working in a stressful situation, mainly when several tasks are being performed simultaneously and when experienced personnel conduct routine operations. In addition, procedures are often poorly written or incomplete, leading to errors in movements, decision-making or interpretation by one or more operators.

Operators must fully understand the process and/or equipment and monitor all parameters continuously to ensure the process or equipment operates correctly. Compliance with the procedures and the ability to analyse all the signals, despite the signal on which his attention is focused, should make it possible to avoid cognitive tunnelling and make the right decisions to avoid an accident.

An outside perspective during a crisis can help detect these biases, which distort reality by excluding certain parameters. The concept of bringing in an outside perspective to get an unbiased view already exists in nuclear safety and many other fields. Numerous measures to anticipate and recover from misinterpretation have been tested and implemented in other fields (air, rail, medical). These measures should be developed and systematised in all sectors at risk (ergonomics, pre-job briefing, removal of useless information from the field of view, supervision and outside perspective, etc.).

Accidental mixing of chemical products in a dairy

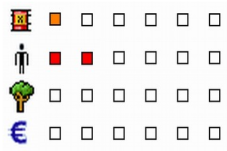
29/06/2020

Bras-sur-Meuse

France

Agri-food
Transfer
Exothermic reaction
Explosion
Gaseous release

THE ACCIDENT AND ITS CONSEQUENCES



At 9:38 a.m., an explosion occurred in a dairy on the facility's nitric acid receiving tank during a chemical product transfer operation. A significant cloud of rust-coloured gas (nitrous vapours) formed following the explosion, prompting the evacuation of personnel from the dairy and a company neighbouring the premises. Five people were taken to hospital, while the nearby waterway and neighbouring road were cut off to traffic.

Firefighters arrived at the site at 9:44 a.m. and began cooling down the tank with 2 hoses. The firefighting water was recovered in the plant's water tank.

At around noon, a crew of 4 firemen managed to close the valve at the tank's base, but the likely presence of residues from the 2 products resulted in another explosion that blew the valve more than 20 m away.

In mid-afternoon, the emergency rescue services and the operator identified large whitish crystals that had precipitated at the bottom of the tank. The following day, a specialised firm was able to transfer the contents of the tank into four 1,000-litre containers.

The dairy resumed its activities on 2 July after installing a mobile, temporary tank to replace the nitric acid tank.

THE ORIGIN AND THE CAUSES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Being of foreign origin and having a poor understanding of French, the truck driver arrived at the site with a load of ammonium thiosulphate intended for an agricultural cooperative in another department neighbouring the Meuse. He had mistakenly entered the wrong site into his GPS and headed for another site of the same cooperative, which was located next to the dairy.

When he arrived at the site, he missed the entrance and entered the dairy instead of the agricultural cooperative; he was met by an operator waiting for a nitric acid delivery. The operator receiving the shipment did not take sufficient care to verify the delivery slip detailing the contents of the tanker truck. He showed the driver where the loading station was located, then left to don his PPE.

Without waiting for the operator to return, the driver connected his lorry to the unloading station and started the transfer pump. After just a few minutes, a violent and highly exothermic reaction occurred between the ammonium thiosulphate in the truck and the 53% nitric acid in the tank.

The explosion resulted in the ejection of the manhole cover. The driver was able to close the unloading valve and flee the area.

ACTIONS TAKEN

With a view to allowing activities to resume, the Classified Facilities Inspection authorities was present on the site on June 29 and conducted a visit on 2 July. On 3 July, a prefectoral decree was issued to allow the installations to start up again, on condition that the operators receive additional training.

On 6 July, a more extensive inspection of the dairy's technical and organisational facilities was conducted. On August 28, 2020, the prefect notified the operator of an additional prefectoral decree concerning its operation and was issued formal notice regarding various non-conformities.

The operator undertook various corrective measures following this accident:

- padlocks were installed to prevent drivers from opening valves;
- systematic validation and verification of unloading operations by two operators;

- additional signs and indications near valves for product identification purposes;
- installation of a windsock;
- an audit of the procedures governing the delivery of chemical products and reminders to personnel of the safety rules, notably regarding chemical product deliveries.


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LESSONS LEARNT

In this accident, the probability of a driver making two cumulative destination errors was extremely low and was not considered in the danger studies. However, the accident occurred because the site's organisation, particularly regarding product deliveries, did not enable this initial human error of external origin to be corrected. The dairy operator was focused on the fact that a delivery of nitric acid was expected, so was convinced that this truck contained the expected product. Therefore, he did not check the content of the delivery and its intended destination (cognitive tunnelling).

It thus appears that control and operational procedures are indispensable barriers at all industrial facilities to prevent failures coming from their environment, which, in this case, was the delivery of a chemical product, provided that these measures and procedures are observed. Technical measures (on-line monitoring of the product's pH with automatic shutdown if the pH is other than expected, etc.) or organisational measures (presence of the dangerous goods transport safety adviser, etc.) can strengthen the lines of defence to offset the risk of cognitive tunnelling.


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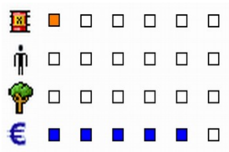
Explosion of a boiler in a steel plant
10/10/2016
Fos-sur-Mer (Bouches-du-Rhône)
France

Steel industry
Start-up
Boiler
Explosion

THE ACCIDENT AND ITS CONSEQUENCES



A gas boiler exploded at 11:13 p.m. during a restart phase in a steel plant. After 12 unsuccessful attempts to ignite the boiler between 7 and 11 p.m., malfunctions in the burner ignition sequence led the shift foreman to shunt the flame detection system on the first 2 burners despite this action being prohibited by the operating procedure. An explosive atmosphere formed in the combustion chamber.

During the 13th ignition attempt, the boiler exploded, causing considerable material damage. However, the accident resulted in no human casualties or environmental effects.

THE ORIGIN AND THE CAUSES

The accident occurred in a challenging economic context. Steel prices had been dropping since September 2015. This situation was linked to Chinese surplus production being sold in Europe at low prices, which resulted in a decrease in the site's activity and put considerable pressure on the availability of the production facilities.

> The power plant consisted of four 200-MW steam generators (215 t/h of steam, 80 bar, 500 °C). Mixed type boilers were used, offering the possibility to burn a variety of liquid fuels (tars, naphthalene fuels, steel gases). Their role is to fuel two turboblowers (TB: hot air) that supply the two blast furnaces. At least 2 SGs are needed to supply the 2 TBs. These SGs were also used to supply 4 turbo-generators (TG) for back-up electrical production and participated in the site's steam production. Seawater is used to cool the TBs and TGs via an exchanger that conveys the calories to the steam production's freshwater network.

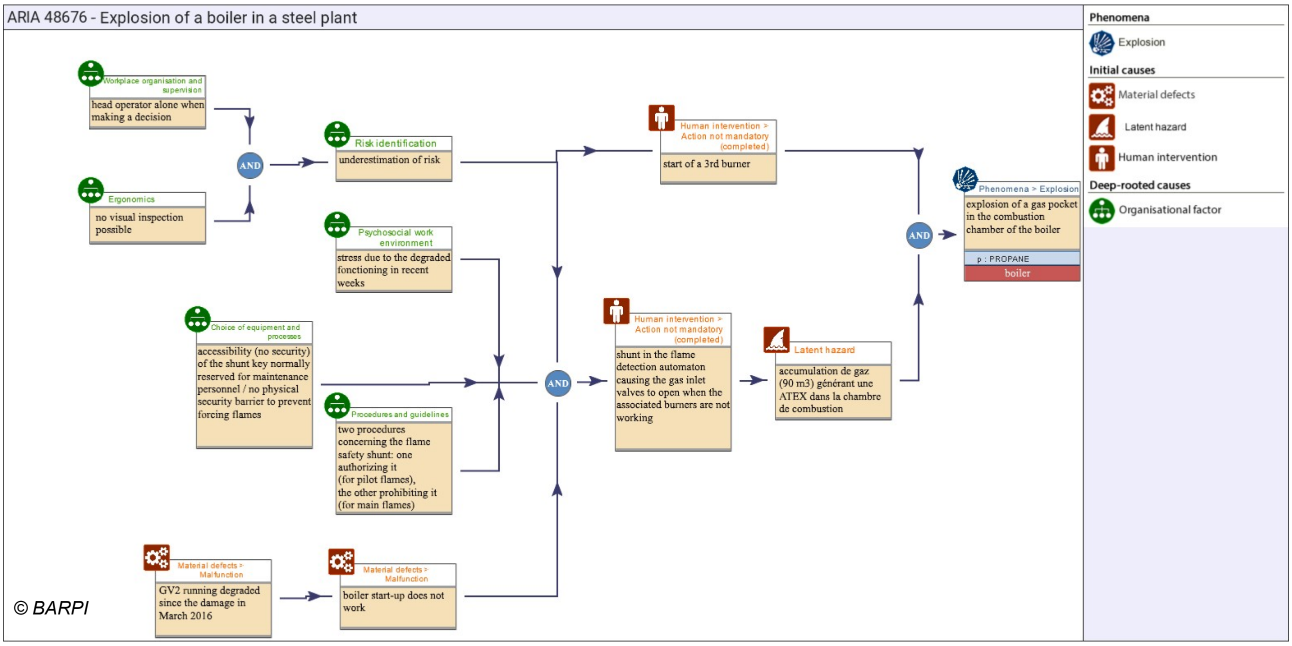
For several weeks, the plant's operation had been affected. On 18 March, one of the boilers exploded following a loss of electrical power from the transformer (ARIA 47992). The explosion also resulted in a massive introduction of seawater into the (seawater-cooled) condensers. This event added a large quantity of chlorine and oxygen to the system and accelerated corrosion of the pipes, which had already been weakened by a degraded water supply. The boiler that had been damaged during the first event then had to be shut down for 14 months.

The 3 remaining boilers were subjected to a considerable workload and experienced several pierced tubes in the following months, particularly in July (ARIA 48395), leading to the alternating shutdown of the boilers. As a result of these shutdowns, certain strategic units also had to be taken off line (including the blast furnaces that supply the steelworks with cast iron).

Feedback from the accident of 18 March led the operator to review its boiler start-up procedure and the implementation of a safety system testing protocol. This procedure integrates flame detection with the automatic closure of the steel gas supply valve if the main flame has gone out. The burners are then successively ignited when the main flame is detected. However, shunting the flame detector for the first burner is prohibited.

Following work on one of the boilers (SG2), the restart procedure was not conducted properly during the restarting tests undertaken on 10 October. At the time of the accident, the site's production was based solely on a single boiler (SG4) and restarting SG2 was a priority. The shift foreman was alone to make decisions (no supervisory staff is present at night) in a stressful situation like the one described above.

The economic impacts for 2016 included a production loss of 700,000 tons, the cost of temporary installations (in order to continue operations), evaluated at €30 million, and the total cost of repair/reconstruction of the boilers at €50 million.



ACTIONS TAKEN

Another inspection visit was conducted. The recurrence of accidents and incidents encountered over the span of just a few months led to a report proposing that an Emergency Measures Order be issued, requiring:

- an in-depth analysis of the causes (including human factors) so that the operator can take all measures to ensure the safe and reliable operation of its combustion installations, particularly during the transitional shutdown and start-up phases, which are the most critical in terms of safety;
- shutdown of SG1, 2 and 3, and rendering their return to operation contingent upon a damage inventory, an assessment of the pressure equipment, checks and tests on the availability and correct operation of safety equipment, the definition of measures to prevent safety devices from being unlocked and the identification and implementation of measures taken to ensure the safe operation of the installations (including the start-up and shutdown phases, and normal operation).

Throughout 2016, inspections had been conducted on 24 March (disregard for TLVs, accident report, history of regulatory inspections and maintenance, summary of power outages), on 12 July (thorough inspection on the subject of power loss) and on 26 July (atmospheric releases).

The last responses to the Emergency Measures Order were received on 18/02/2019, allowing SG2 to restart (following SG1 on 17/02/2017 and SG3 on 22/10/2017).

LESSONS LEARNT

The operator modified the procedures for testing the igniters, installed flame cameras on the boilers and secured access to the key used to shunt the flame detection sensors on the burners. Studies have also been conducted on how to secure the PLCs, employees have been reminded that it is prohibited to shunt the main flame of the 1st burner, and annual safety refresher training is provided to the boiler operators.

The operator also foresees the refurbishment of the 4 steam generators, including new safety systems and overhaul of the steam production system. The operating procedures were reviewed, and emphasis was placed on compliance with the defined procedures.

This accident highlighted the importance of following procedures and conducting tests during the start-up and/or shutdown phases. Regular reminders of these procedures are necessary through regular staff training, and securing the process (locking, etc.) should prevent human error from occurring, as was the case with this event. The operator, having been placed in a stressful situation with no safety barrier, focused on the need to restart the boiler at any cost, became a victim of cognitive tunnelling, which did not allow him to measure the potential consequences of these acts. In the end, the operator shunted the flame detection system on the first 2 burners despite this action being explicitly prohibited in the new operating procedure.

Fire of flared diesel fuel in a refinery

07/10/2018

Donges (Loire-Atlantique)

France

Refining
Alarm
Control room
Start-up
Degraded mode

THE ACCIDENT AND ITS CONSEQUENCES

At around 11 a.m., while the hydrodesulphurisation 2 (HD2) unit in a refinery was in the process of being restarted after a maintenance intervention, liquid diesel fuel burst into flames at the flare outlet. A significant amount of flame and a plume of black smoke were visible from outside the site. Hydrocarbons were spilled onto the ground and a fire broke out at the base of the flare. After 10 minutes, crews at the site were able to stop the supply of diesel fuel to the flare, which put out the flame. The fire at the base of the flare was brought under control at 11:50 a.m.

The operator did not initiate its internal emergency plan, and the restarting process resumed in the afternoon.

An estimated 42 m³ of hydrocarbons had been sent to the flare, and the fire had spread over approximately 30 m² at the base of the flare stack (brush). Iridescence was visible on the surface of the pool surrounding the facility. The network of air quality sensors (SO_2, NO_X, notably in the form of dust) installed around the refinery did not record levels exceeding regulatory thresholds.

Flares or flaring systems are considered safety equipment in certain industrial facilities.
During transitional phases or accidental situations, they allow large quantities of excess flammable gasses to be burned off and to thus prevent overpressure. Such equipment is not designed to burn liquid compounds.

THE ORIGIN AND THE CAUSES

The refinery operates two hydrodesulphurisation units: HD1 and HD2. Unit HD1 was in service, while unit HD2 was being restarted after a maintenance intervention. The control room features two consoles, one operating both hydrodesulphurisation units, while the other manages the platform's utilities. On the morning of the event, the both operator consoles were occupied:

- the HD unit console was busy managing a load change on HD1 resulting from a full storage tank and restarting unit HD2;
- the utilities console was having to manage simultaneous activities: a temporary shutdown of hot oil that had occurred the day before, a critical steam balance on the platform and monitoring of wastewater treatment performance characteristics.

The chief operator was in the control room, providing support to the utility console.

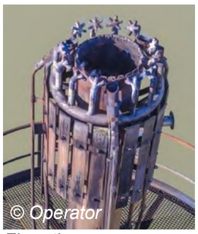

© Operator
Ignitiation gas oil flare outlet

While the load operations were underway on HD1, the console operator brought a vacuum drying column on line to finalise the unit's restarting process. Although the operators are familiar with this operation, it is not mentioned in the specific restarting procedure. It was not considered as critical by the operators. However, it is expected that in the shutdown phase, the bottom level of this column will fill up due to condensation following the loss of the vacuum. Its design does not allow it to be purged before being brought back online and the restart procedure does not identify the risk of the flare tank overflowing. When this column was put into service, the high level alarm appeared. The console operator was having to concentrate on several operators at the same time and acknowledged the alarm while increasing the column's discharge rate. However, the discharge rate was less than that entering the equipment. The material balance between the incoming flow and the outgoing flow was not displayed on a single mimic diagram view. The column overflowed and the liquid diesel fuel flowed toward a buffer tank upstream from the flare. The high level alarm on this tank was triggered. At this point, the operator acknowledged the alarm and checked that the drainage pump was in operation. The pump's output was also insufficient. The tank's high level alarm was briefly activated, but then disappeared. The emergency drainage pump, slaved to the very high level, did not start. An external operator contacted the control room to report the smell of gas near the flare. The chief operator, busy with operations on the utilities console, came to check the HD units console for any operational discrepancies. Seven minutes later, another external operator called the control room to report flames and liquid spilling from the flare. The second pump on the buffer tank upstream from the flare was manually started and the column was bypassed, stopping the overflow of liquid from the flare.

In addition to the design of the process, this incident allowed the operator to highlight how the operators were distracted, notably by defects in the alarm management system:

- the technician assigned to the restarting operations was having to handle major problems on another unit at the same time. Consequently, he did not notify his shift supervisor, who was also busy with other duties;
- several alarms were either inactive or faulty: some alarms did not work, while others were incorrectly configured or generated numerous false alarms;
- the alarm management procedure did not include instructions for simple alarm acknowledgements;
- a discrepancy between the flare tank's level and the high level triggering the tank's first recovery pump had existed for more than 2 months. The console operator had become accustomed to seeing the flare tank's level alarm come on several times per shift. Moreover, the column's vacuum pressure sensor was configured only to detect a loss of vacuum and not a possible rise in column pressure;
- although identified as an essential safety barrier, the operator did not correctly interpret the very-high-level alarm on the tank owing to his high level of stress (cognitive tunnelling).

ACTIONS TAKEN



Flare tip

An inspection of the flare structure by an expert and visual checks by drone confirmed that the entire flare stack had not been damaged. Modelling of the outflow concluded that there was no thermal effect outside the site's perimeter and that none of the refinery's equipment was damaged.

Following the incident, additional actions were conducted to confirm the integrity of the systems (tests on the flare system, additional inspections, interventions on the instruments and system modifications).

LESSONS LEARNT

The operator implemented the following actions after the accident:

- risk analyses were drafted to decide upon the scheduling of the activities for each unit. For example, on the hydrodesulphurisation units, an analysis is now conducted when a variation in load quality is expected on one unit while the other is in a transitional phase;
- thoroughness in terms of the restarting procedures, notably to re-evaluate the risk of overflow or over-filling;
- technical reviews of alarms that were found to be inactive or faulty: coupling of an alarm to the pressure sensor of the flare tank, display of the material balance on the same mimic panel view;
- correction of the difference between the flare tank's level and the high-level triggering the first recovery pump;
- render the supervisory mimic panels more ergonomic to facilitate the detection of abnormal situations;
- integration of the feedback from this event into operator training and presentation to the refinery's various crews;
- launch of a project to improve alarm management to spearhead the development of a tool to extract alarm statistics in order to analyse and process recurring alarms to verify their relevance and level.

General communication has been organised within the site, and experience feedback is shared among the crews. The console operator and the chief operator voluntarily presented the event and the lessons learnt to the shift crews. Site management reiterated the importance of checking steady states before each transitional and/or critical operation and of clarity in shift change reports, particularly during extended operations spanning several shifts.

European scale of industrial accidents
Graphic presentation used in France

This scale was made official in 1994 by the Committee of Competent Authorities of the member States which oversees the application of the Seveso directive. It is based on 18 technical parameters designed to objectively characterise the effects or consequences of accidents: each of these 18 parameters include 6 levels. The highest level determines the accident's index.

Further to difficulties which stemmed from the attribution of an overall index covering the consequences that are completely different according to the accidents, a new presentation of the European scale of industrial accidents with four indices was proposed. After having completed a large consultation of the various parties concerned in 2003, this proposal was retained by the Higher Council for Registered Installations. It includes the 18 parameters of the European scale in four uniform's groups of effects or consequences:

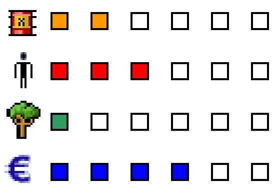
- 2 parameters concern the quantities of dangerous materials involved,
- 7 parameters bear on the human and social aspects,
- 5 concern the environmental consequences,
- 4 refer to the economical aspects.

This presentation modifies neither the parameters nor the rating rules of the European scale.

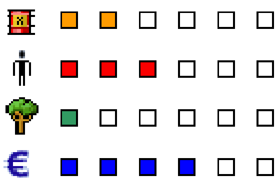
The graphic charter:

The graphic charter adopted for the presentation of the 4 indices is as follows:

Dangerous materials released
Human and social consequences
Environmental consequences
Economic consequences



When the indices are yet explained elsewhere in the text, a simplified presentation, without the wordings, can be used:



The parameters of the European scale:

	Dangerous material released	1	2	3	4	5	6
Q1	Quantity Q of substance actually lost or released in relation to the « Seveso » threshold *	Q < 0,1 %	0,1 % ≤ Q < 1 %	1 % ≤ Q < 10 %	10 % ≤ Q < 100 %	De 1 à 10 fois le seuil	≥ 10 fois le seuil
Q2	Quantity Q of explosive substance having actually participated in the explosion (equivalent in TNT)	Q < 0,1 t	0,1 t ≤ Q < 1 t	1 t ≤ Q < 5 t	5 t ≤ Q < 50 t	50 t ≤ Q < 500 t	Q ≥ 500 t

* Use the higher "Seveso" thresholds. If more than one substance are involved, the higher level should be adopted.

Human and social consequences		1	2	3	4	5	6
H3	Total number of death: including - employees - external rescue personnel - persons from the public	- - - -	1 1 - -	2 – 5 2 – 5 1 -	6 – 19 6 – 19 2 – 5 1	20 – 49 20 – 49 6 – 19 2 – 5	≥ 50 ≥ 50 ≥ 20 ≥ 6
H4	Total number of injured with hospitalisation ≥ 24 h: including - employees - external rescue personnel - persons from the public	1 1 1 -	2 – 5 2 – 5 2 – 5 -	6 – 19 6 – 19 6 – 19 1 – 5	20 – 49 20 – 49 20 – 49 6 – 19	50 – 199 50 – 199 50 – 199 20 – 49	≥ 200 ≥ 200 ≥ 200 ≥ 50
H5	Total number of slightly injured cared for on site with hospitalisation < 24 h : including - employees - external rescue personnel - persons from the public	1 – 5 1 – 5 1 – 5 -	6 – 19 6 – 19 6 – 19 1 – 5	20 – 49 20 – 49 20 – 49 6 – 19	50 – 199 50 – 199 50 – 199 20 – 49	200 – 999 200 – 999 200 – 999 50 – 199	≥ 1000 ≥ 1000 ≥ 1000 ≥ 200
H6	Total number of homeless or unable to work (outbuildings and work tools damaged)	-	1 – 5	6 – 19	20 – 99	100 – 499	≥ 500
H7	Number N of residents evacuated or confined in their home > 2 hours x nbr of hours (persons x hours)	-	N < 500	500 ≤ N < 5 000	5 000 ≤ N < 50 000	50 000 ≤ N < 500 000	N ≥ 500 000
H8	Number N of persons without drinking water, electricity, gas, telephone, public transports > 2 hours x nbr of hours (persons x hours)	-	N < 1 000	1 000 ≤ N < 10 000	10 000 ≤ N < 100 000	100 000 ≤ N < 1 million	N ≥ 1 million
H9	Number N of persons having undergone extended medical supervision (≥ 3 months after the accident)	-	N < 10	10 ≤ N < 50	50 ≤ N < 200	200 ≤ N < 1 000	N ≥ 1 000

Environmental consequences		1	2	3	4	5	6
Env10	Quantity of wild animals killed, injured or rendered unfit for human consumption (t)	Q < 0,1	0,1 ≤ Q < 1	1 ≤ Q < 10	10 ≤ Q < 50	50 ≤ Q < 200	Q ≥ 200
Env11	Proportion P of rare or protected animal or vegetal species destroyed (or eliminated by biotope damage) in the zone of the accident	P < 0,1 %	0,1% ≤ P < 0,5%	0,5 % ≤ P < 2 %	2 % ≤ P < 10 %	10 % ≤ P < 50 %	P ≥ 50 %
Env12	Volume V of water polluted (in m^3) *	V < 1000	1000 ≤ V < 10 000	10 000 ≤ V < 0.1	0.1 Million ≤ V< 1 Million	1 Million ≤ V< 10 Million	V ≥ 10 Million
Env13	Surface area S of soil or underground water surface requiring cleaning or specific decontamination (in ha)	0,1 ≤ S < 0,5	0,5 ≤ S < 2	2 ≤ S < 10	10 ≤ S < 50	50 ≤ S < 200	S ≥ 200
Env14	Length L of water channel requiring cleaning or specific decontamination (in km)	0,1≤ L < 0,5	0,5 ≤ L< 2	2 ≤ L< 10	10 ≤ L < 50	50 ≤ L< 200	L ≥ 200

* The volume is determined with the expression Q/C_{lim} where:

- Q is the quantity of substance released,
- C_{lim} is the maximal admissible concentration in the environment concerned fixed by the European directives in effect.

Economic consequences		1	2	3	4	5	6
€15	Property damage in the establishment (C expressed in millions of € - Reference 93)	0,1 ≤ C < 0,5	0,5 ≤ C < 2	2 ≤ C< 10	10 ≤ C< 50	50 ≤ C < 200	C ≥ 200
€16	The establishment 's production losses (C expressed in millions of € - Reference 93)	0,1 ≤ C < 0,5	0,5 ≤ C < 2	2 ≤ C< 10	10 ≤ C< 50	50 ≤ C < 200	C ≥ 200
€17	Property damage or production losses outside the establishment (C expressed in millions of € - Reference 93)	-	0,05 < C < 0,1	0,1 ≤ C < 0,5	0,5 ≤ C < 2	2 ≤ C < 10	C ≥ 10
€18	Cost of cleaning, decontamination, rehabilitation of the environment (C expressed in millions of € - Reference 93)	0,01 ≤ C < 0,05	0,05 ≤ C < 0,2	0,2 ≤ C < 1	1 ≤ C < 5	5 ≤ C < 20	C ≥ 20

TECHNOLOGICAL ACCIDENTS ON LINE

For the past 20 years, the ARIA (Analysis, Research and Information on Accidents) website has given the general public access to its database of technological accidents and incidents, as well as numerous publications presenting the lessons learnt from analysing these events.

The search engine of the ARIA website, in both its French and English version, allows to consult all the summaries of these events and to meet the expectations of Internet users, making BARPI the **"Interactive reference media library specialised in industrial accident studies"**.

Users can access:
- nearly 55,000 accident summaries (sequence of events, consequences, circumstances, disturbances, root causes – both proven and suspected – actions taken and lessons learnt);
- nearly 300 detailed and illustrated accident report presenting accidents of unique informative interest;
- summaries of accident statistics either by topic or by industrial sector, e.g. automated mechanisms, corrosion, fine chemicals, pyrotechnics, confined spaces, lightning, hydrogen, gas boiler rooms, sensors;
- a multicriteria search function to find information on accidents occurring in or out of France;
- saved requests and automatic notification by email should a new element arrive in your fields of interest.

Please feel free to consult the website on a regular basis, as the database expands every year by some 1,300 accidents plus a wide range of publications!

ARIA
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www.aria.developpement-durable.gouv.fr

Industrial accidents database:
www.aria.developpement-durable.gouv.fr

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