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Médiathèque interactive de référence en accidentologie industrielle

Synthesis

June

Accidents involving fires at surface treatment facilities

Photo credits:

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Contents

INTRODUCTION

Purpose of the synthesis

The surface treatment sector has recorded an upward accident trend over the past few years.
The purpose of this synthesis is to analyse this based on information contained in the ARIA database on events in this business sector, and particularly feedback from them. The analysis also received input from BEA-RI (*Bureau d'Enquêtes et d'Analyses sur les Risques Industriels*, i.e., industrial risk investigation and analysis bureau, set up in December 2020) via findings recorded and lessons learnt in the course of its investigations. Fires occurring in surface treatment workshops often had spectacular consequences, particularly major property damage, even if there were no victims. They accounted for a good third of investigations carried out by BEA-RI in 2021.

Section 1 of the analysis focuses on an overview of accidents in the surface treatment sector over the past 20 years. It helps to assess the context in terms of affected businesses, the trend as to the number of accident events, the type of accident phenomenon most frequently encountered, and finally in terms of consequences.

The focus then switches to accidents involving fires from 2016-2021 at chemical and electrolyte surface treatment workshops in order to learn lessons and make recommendations based on causal analysis.

Principle and purpose of surface treatment[1]

Surface treatments are used to modify the surface physical and chemical properties of materials by giving them a specific appearance and characteristics.

Depending on the type of treatment, they are designed to improve, among other properties: corrosion resistance, wear resistance, friction behaviour, electrical properties, and even the appearance of the base metal.

These techniques mean a less noble material can be used by improving its properties locally. Surface-treated parts combine both the base material's own properties and the added surface properties. Though surface treatments add a relatively low thickness, rarely exceeding a millimetre and even as little as a few nanometres, several methods are used. The main surface treatments used can be divided into:
- **electrolyte treatment** (anodic oxidation by running a current between an anode and a cathode);
- **chemical treatment** (chemical plating, anodic oxidation, phosphate treatment, sulphurising, etc.);
- **dry treatment** (spraying, shot blasting, etc.);
- **wet treatment** (in a bath of molten metal).

For each of these techniques, a high degree of surface preparation is required to optimally add the properties expected from the chosen treatment (chemical preparation, i.e., degreasing and/or washing, or mechanical preparation, i.e., shot blasting, alumina blasting, and/or sand blasting).

For electroplating (galvanisation, cadmium plating, chromium plating, nickel plating, etc.), parts are prepared then immersed in a bath containing metallic salts used to add metal plating to their surface by applying an electrical current.

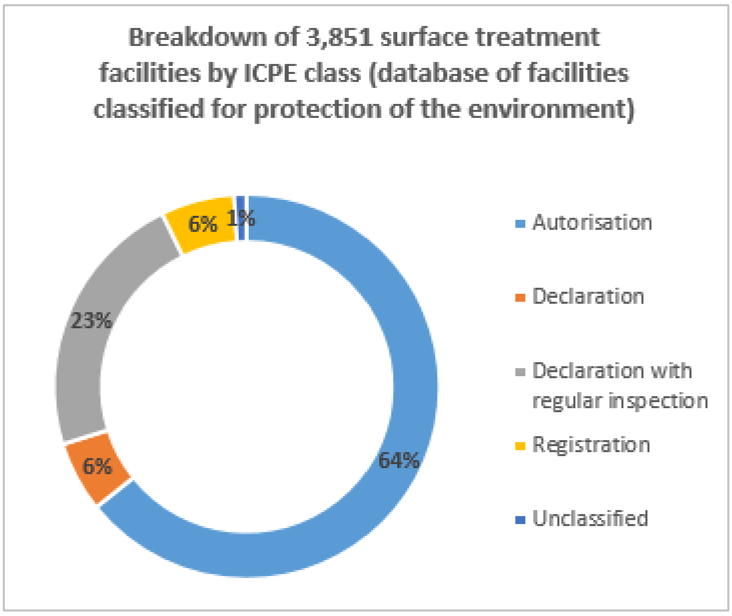
The quality of this plating particularly depends on the bath's chemical composition, which requires continuous monitoring of changes to manage the surface treatment process.

At the end of 2021, 3,851 surface treatment facilities were recorded in the national database of facilities classified for protection of the environment, under the following headings
- 2565 - Electrolyte or chemical metal coating or surface treatment
- 2567 - Galvanisation and/or tinning of metals
- 3260 - Surface treatment
- 3670 - Surface treatment of materials using organic solvents

[1] Definition taken from the website www.filab.fr

These can be either contractors whose main line of business is "toll" surface treating of metal parts or otherwise specific workshops on an industrial site focused on another business line (e.g., automotive, aircraft construction).

They can be broken down as follows:



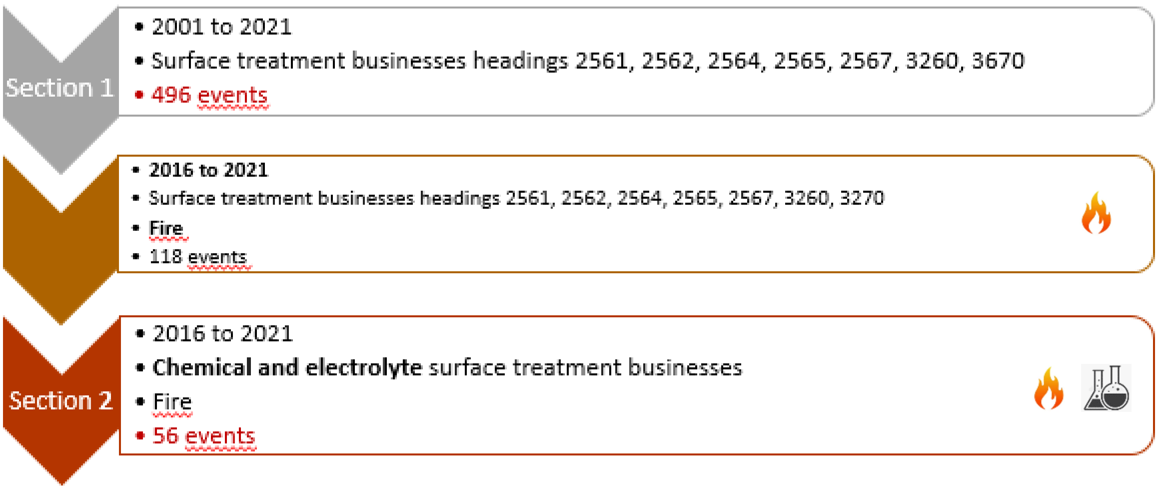
2 STUDY METHODOLOGY AND SCOPE

This synthesis is based on 2 event samples linked to the surface treatment (ST) business line, at facilities classified for protection of the environment under the following ICPE headings:

- 2561 - Hardened annealed, tempered metals and alloys
- 2562 - Industrial heating and treatment using molten salt baths
- 2564 - Surface cleaning, degreasing, and/or pickling using liquids
- 2565 - Electrolyte or chemical metal coating or surface treatment
- 2567 - Galvanisation and/or tinning of metals
- 3260 - Surface treatment
- 3670 - Surface treatment of materials using organic solvents

Section 1 of the synthesis provides a broad "snapshot" of events linked to the surface treatment business line under the headings listed above, recorded in the ARIA database from **2001 to 2021 inclusive, including all phenomena**. The resulting sample features **496 events**.

Section 2 of the synthesis provides more in-depth analysis of the lessons learnt from feedback on recent accidents linked to **fires** at **electrolyte and chemical surface treatment facilities** from **2016 to 2021 inclusive**. Out of the 118 events over these 6 years, 56[2] were identified more specifically as electrolyte or chemical surface treatment events. For 2021, this second section also received input in the form of feedback and recommendations from BEA-RI (*Bureau d'Enquêtes et d'Analyses sur les Risques Industriels*, i.e., industrial risk investigation and analysis bureau), which carried out five investigations in 2021 following fires at surface treatment facilities. This latest sample features 3 major accidents, according to directive 2012/18/EU or the "Seveso III" directive; ARIA 56568, ARIA 57333, and ARIA 57457, all three of which occurred in 2021.



Finally, as a reminder, the ARIA database is a high-quality database, populated with information reported by government services and the fire department, plus monitoring of the media, but it is not exhaustive, meaning that only trends can be identified.

[2] N.B.: several ICPE headings can be recorded for the same event, which accounts for why some events in the initial sample in which mechanical or thermal surface treatment caused the event were not taken into account.

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SECTION 1: 20-YEAR SURFACE TREATMENT ACCIDENT TREND (2001-2021)

As a reminder, the relevant ICPE headings are listed in § 2.

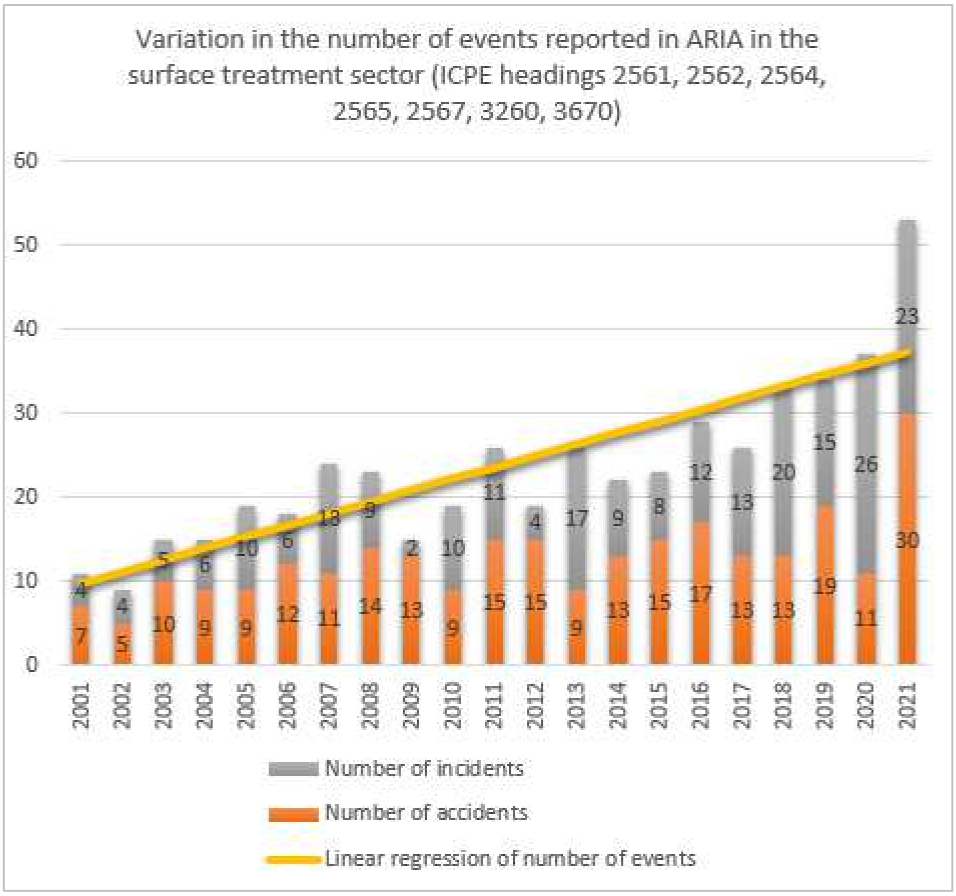
The main NAF code of businesses affected by accidents in this sector was the specific surface treatment business line code.

The following sectors were affected to a lesser extent: aircraft construction, steelworks, die trimming and punching, motor vehicle construction, and various metalworks sectors also providing surface treatment.

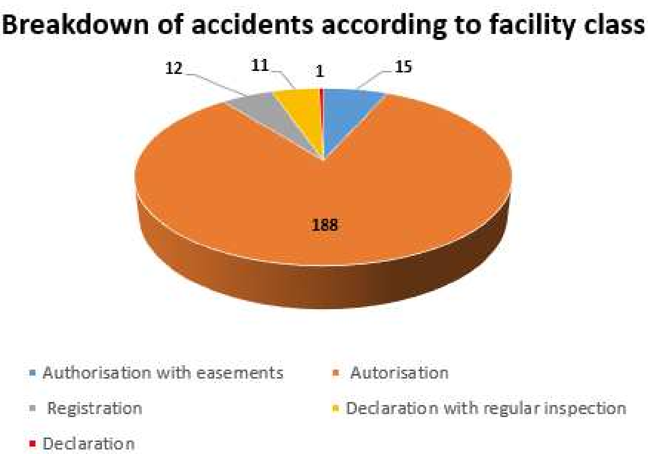
Level-4 NAF code	Main	Number of events
25.61	Metal treatment and coating	**192**
30.30	Air- and spacecraft construction	**27**
24.10	Steelworks	**23**
25.50	Die trimming and punching	**20**
29.32	Manufacturing of other motor vehicle equipment	**15**
25.94	Manufacturing of screws, nuts, and bolts	**14**
25.99	Manufacturing of other metal items	**14**
25.62	Industrial mechanics	**11**
26.11	Manufacturing of electronic components	**10**

N.B.: NAF codes for which the number of events was below 10 over the period 2001-2021 were not taken into account in the table.

According to information available in the BARPI ARIA database, there has been a noticeable increase in the frequency of events over the past 20+ years, and more specifically in 2021.



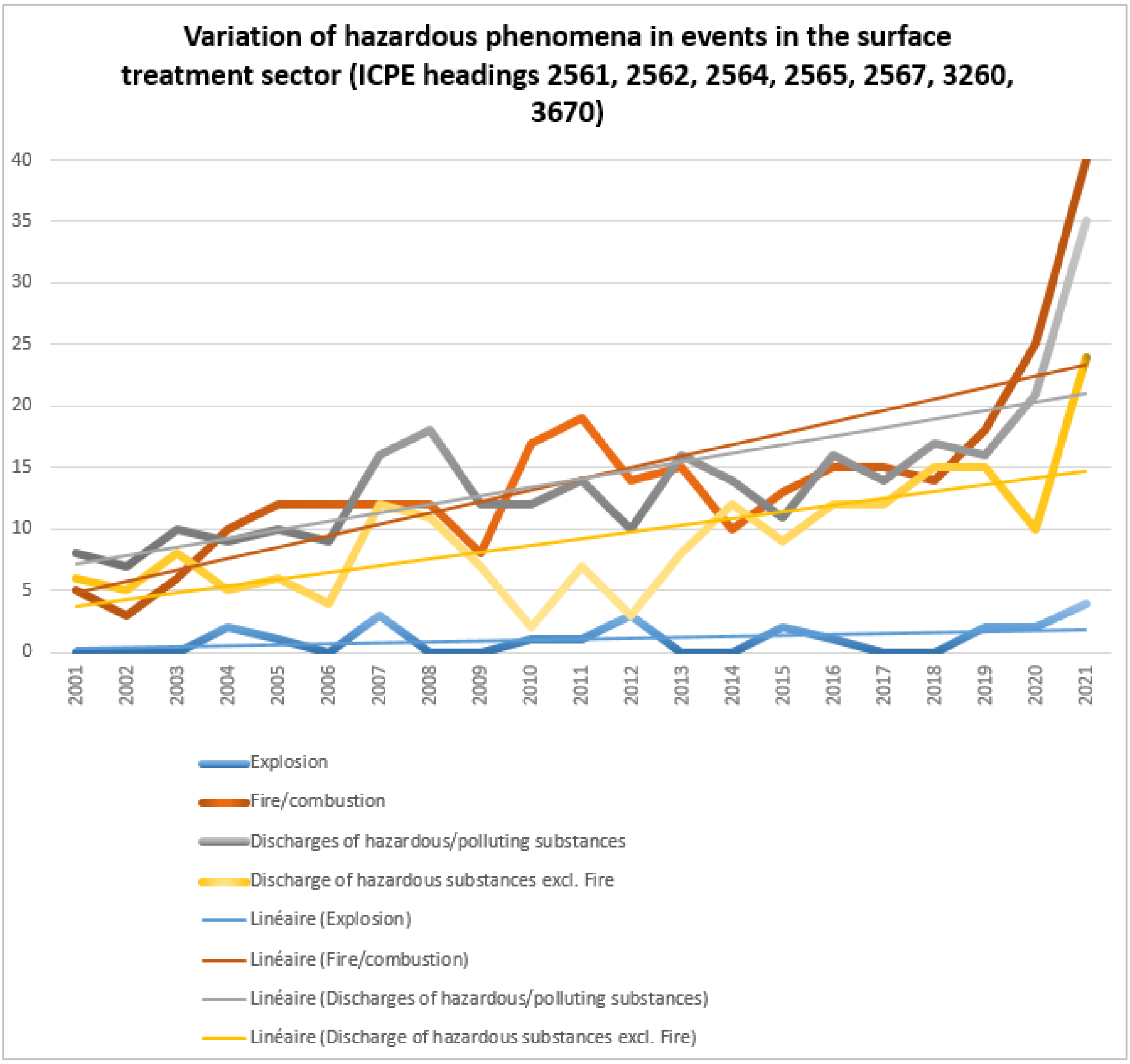
Though the majority of accidents occurred at facilities requiring authorisation, there were accidents at all categories of facilities.



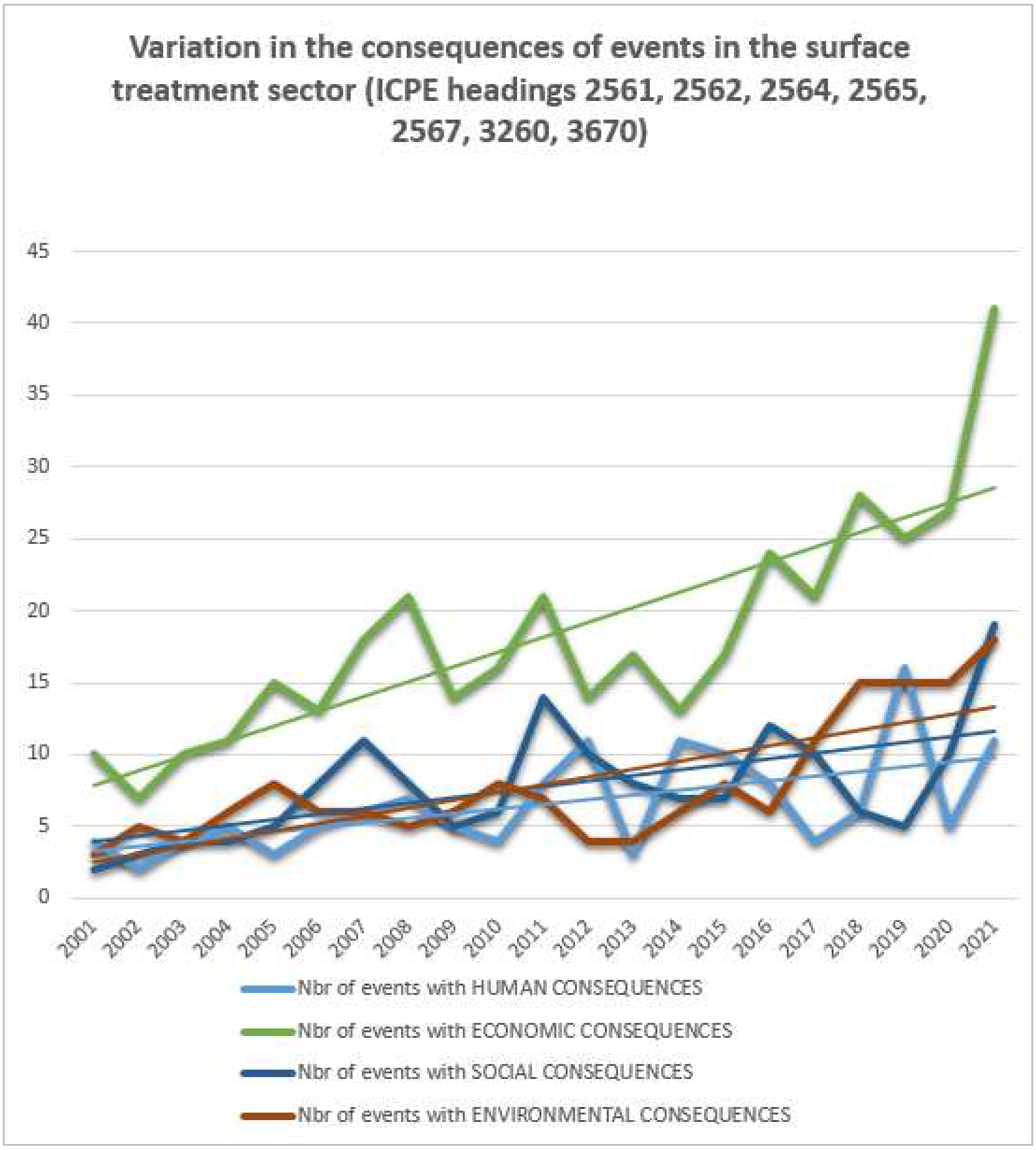
Fires and discharges of hazardous or polluting substances were the main phenomena involved in accidents in this business sector.

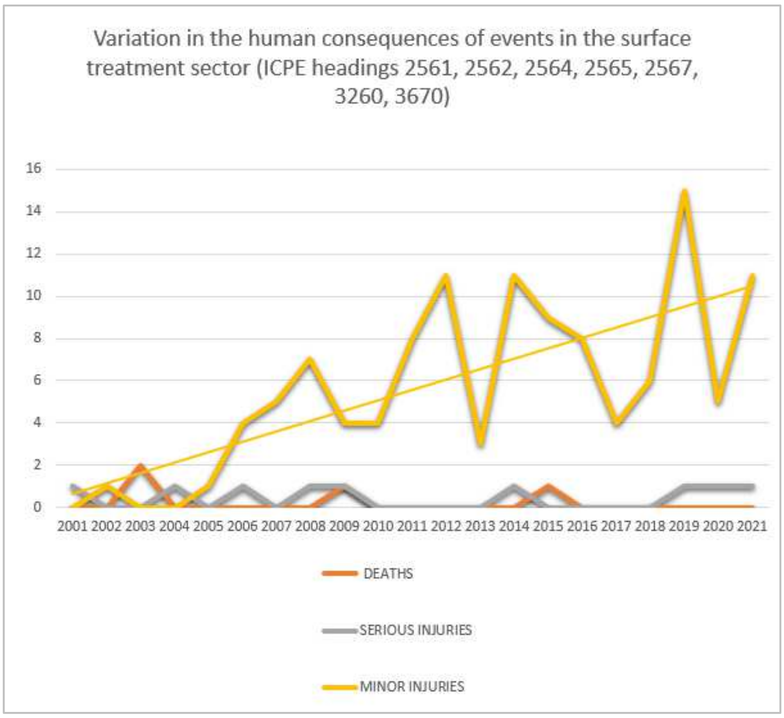
58% of event records mentioned fires, 58% discharges of hazardous or polluting substances (including discharges linked to fires), 38% discharges of hazardous substances (excl. discharges linked to fires) and 4% explosions.

The vast majority of events had economic consequences for the business (82%) and one third of events had human and/or social and/or environmental consequences (respectively 30, 35, and 36% of events).



The increase in the number of events had a similar knock-effect on each type of consequence.





Minor injuries were the most frequent human consequence.

However, there were five deaths in 20 years (4 accidents).

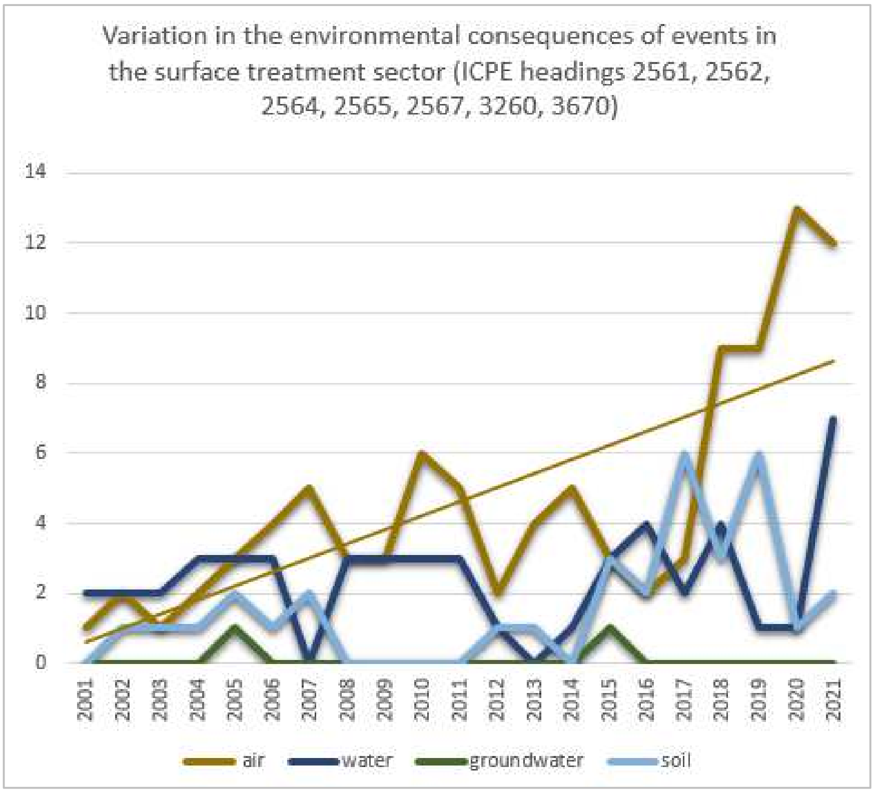
ARIA 24357: Fall into a retention tank (16/03/2003)

ARIA 24427: Fall by an employee into a tank of hot wax (11/04/2003)

ARIA 35709: Trichloroethylene intoxication at a metal coating business (05/01/2009)

ARIA 47271: Falling metal plate at a foundry (16/10/2015)

In terms of **environmental consequences**, air pollution was the most frequently reported environmental impact (21%) followed by water pollution (11%). Soil pollution was reported in 7% of events.



Finally, 65% of **social consequences** reported in the ARIA database were linked to employee lay-offs following the incident, accounting for 23% of events. 6% of surface treatment events required that the population be evacuated and 4% that they be locked down, due to the proven or potential toxicity of emissions from toxic products or smoke from fires.

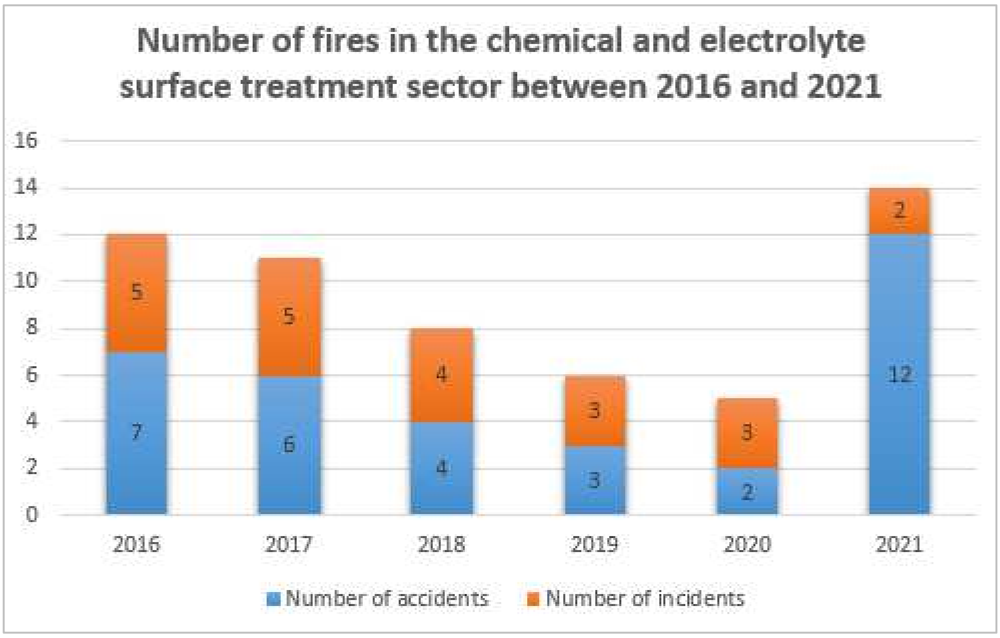
SECTION 2: FOCUS ON FIRES AT CHEMICAL AND ELECTROLYTE SURFACE TREATMENT FACILITIES SINCE 2016, PLUS ROOT CAUSE ANALYSIS

This section provides a more in-depth analysis of lessons learned from feedback on recent events linked to **fires** at **electrolyte and chemical surface treatment facilities**, from **2016 to 2021 inclusive**.

The following analysis focuses on 56 specifically identified events at electrolyte or chemical surface treatment businesses, excluding mechanical and thermal surface treatments.

2021: an exceptionally incident-hit year that bucked the trend

The number of fires in electrolyte or chemical surface treatment workshops fell between 2016 and 2020 but rose sharply in 2021 (6 times more accidents than in 2020).

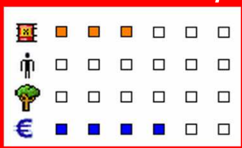


N.B.: there were 3 major accidents, in accordance with Directive 2012/18/EU or the "Seveso III" directive, the same year (2021): ARIA 56568, ARIA 57333, and ARIA 57457.

Their classification as major accidents was due to the severe economic consequences of the incident on these 3 Seveso sites, plus the involvement of hazardous substances. In all 3 cases, an electrical malfunction caused the fire.

Surface treatment-related fire on an air- and spacecraft construction site

ARIA 56568 – 10/01/2021 – Marignane (Bouches-du-Rhône)



At approx. 06.00 on a Sunday, a fire broke out involving 70m^3 of products used to treat materials with acid at a 1, 500m^2 warehouse, on an air- and spacecraft construction site near an airport. This warehouse contained surface treatment lines and spray booths. Detectors were triggered, alerting the fire department. Multiple chemicals at the facility complicated the emergency services' response. Firefighters set up 2 hoses on the roof, then 2 additional hoses and a foam cannon. The fire was brought under control at 10.25.

The section of the workshops housing the surface treatment facilities, i.e., a business line crucial for the site, was destroyed. There was an estimated €11m of property damage. 35 staff were laid off. 650m^3 of water used on the fire was collected in the firefighting water basin. In the evening, the operator decided to discharge 200m^3 of polluted water, exceeding the zinc emission limit value (ELV) in order to maintain storage capacity in case of failure of a surface treatment product retention tank, which would have been far more hazardous for the environment. The anti-pollution basin was treated by the site's decontamination plant. The retention basins and other polluted zones were pumped off by a specialist business. The operator took cyanhydric acid measurements every 30 minutes in order to be able to ask the fire department to lock down the zone in case of anomaly. Piezometric monitoring of underground water quality under the site was set up, as was off-site sampling to measure fall-out from the fire (soil and surface sampling).

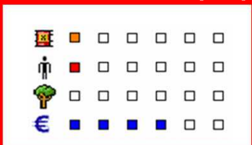
The fire was caused by an electrical fault, either in an electrical control cabinet located near the processing line, or directly affecting one of the treatment lines. This fire then spread to the remainder of the facility via Plexiglas anti-splash panels, acid vapour extraction ducts, and bath vats. It mainly spread via convection, facilitated by the acid vapour extraction system's venting and high combustible potential in the surrounding area. The lack of surface treatment line fire detection systems, limited smoke extraction on the premises, and the ceiling's construction format were contributing factors in the spread of the fire before the alarm was raised.

A BEA-RI (*Bureau d'Enquêtes et d'Analyses sur les Risques Industriels*, i.e., industrial risk investigation and analysis bureau) investigation was carried out.

For further information on this accident, view the BEA-RI report: HERE

Fire at a surface treatment business

Aria 57333 – 13/05/2021 – Bezons (Val-d'Oise)



At approx. 07.25, a fire broke out at a metal treatment business (ground floor: 3,200 m^2, total: 4 floors. There were a range of treatment baths containing cadmium, cyanide, and acids in the building. At 08.55, there was a flashover in the workshop and the fire alarm system was triggered. Electrical systems and air extractors were shut down. At 09.05, firefighters arrived on the premises. Various utilities were cut off (mains gas, water supplies). Water used on the fire was contained on site. Operating staff then arrived at 09.15. A security perimeter was set up and 4 people living nearby were evacuated. Road traffic was stopped. A nearby mosque was closed for the day. The fire department stated that the fire was contained at 11.34 and extinguished at 16.24. Three firefighters sustained minor injuries. There were traces of cyanide in water used on the fire (120m^3)...

The facilities had been secured (water supply shut off, bath heaters shut off) by a trained and qualified operator the day before the accident (information confirmed by surveillance cameras). The security guard's patrols until 06.00 had not identified anything abnormal. The fire broke out due to an electrical failure or electrical heating linked to a metal part left on the vat according to the investigation that was carried out. The line-type smoke detectors and optical flame detectors in the workshop were inoperative due to their inappropriate position following building work carried out a few months earlier. As a result, there was no fire detection for 90 minutes preceding the flashover on the line.

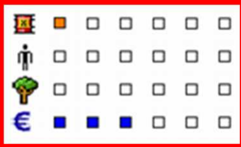
After this fire, the operator planned, among other measures, to:

- review the design of the workshops to shut off electrical supplies in production zones during non-production periods;
- modify the site closure procedure to record and check every stage of the process;
- reinforce the fire detection system with new detectors;
- double the containment basin to separate incompatible types of water used on fires (acids / cyanide);
- create several separate fire-walled compartments.

For further information on this accident, view the BEA-RI report: HERE

Fire on a surface treatment line in a munitions plant

ARIA 57457 – 11/06/2021 – La Chapelle-Saint-Ursin (Cher)



At approx. 12.30, a fire broke out on a surface treatment line in a 6,000m² non-pyrotechnical building on a munitions manufacturing site. The operator triggered its internal operating plan (IOP) at 12.40 and the Prefect the special response plan (SRP) at 13.14 due to potential risk of toxicity of combustion fumes spreading beyond the site perimeter. In accordance with the SRP, a nearby school was locked down. The main risk identified by the fire department was linked to the presence of acids and bases used for surface treatment discharged into the soil. 255 site employees evacuated to assembly points, and traffic on both a B road and railway lines was stopped for 1 hr. Firefighters extinguished the fire using 4 hoses at approx. 14.30.

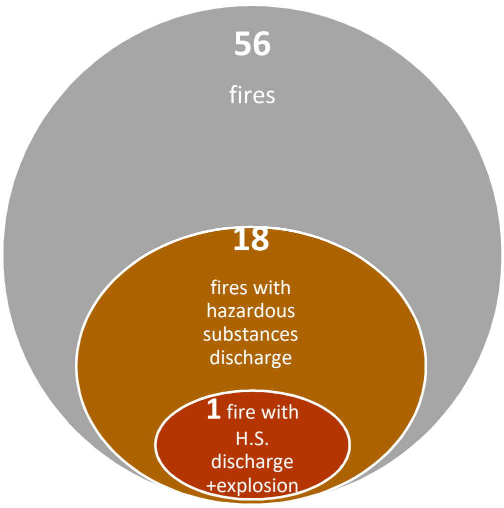
Atmospheric readings (sulphur dioxide) taken by firefighters did not ultimately reveal any toxicity. Water used on the fire was contained in the retention basin. A soil and plant sampling plan was put in place within 5 days to identify potential pollution.

It would appear that an electrical issue caused the fire.

For further information on this accident, view the BEA-RI report: HERE

Hazardous substances were discharged in 1/3 of fires at electrolyte or chemical surface treatment facilities.

Type of hazardous phenomena observed in 56 fires at chemical or electrolyte surface treatment facilities between 2016 and 2021



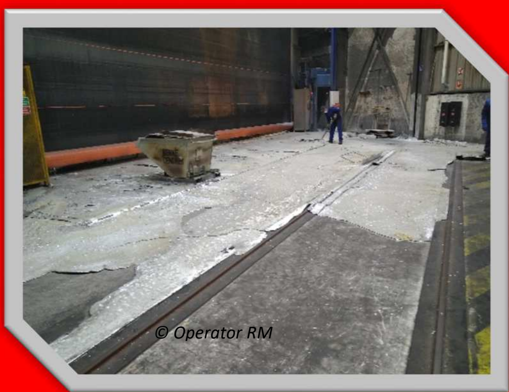
Only one explosion has been recorded since 2016 among the events linked to fires at electrolyte or chemical surface treatment facilities: ARIA 58199 – 25/10/2021 – La Rochelle (Charente-Maritime): explosion including splashing zinc and fire at a metal surface treatment business (see below).

Explosion including splashing zinc and fire

ARIA 58199 – 25/10/2021 – La Rochelle (Charente-Maritime)

At 19.10, at the end of the immersion of a part in a galvanizing bath, there was an explosion at a metal surface treatment business. **The explosion splashed 15T of zinc** over a 200m radius around the basin. As the zinc had been heated to 450°C, 3 fires broke out involving combustible materials located in this zone: PVC, electrical cables, a plastic looped carpet, a curtain tarpaulin, and an HDPE hose-based compressed air system. First responders brought these incipient fires under control until firefighters arrived. Production was shut down for 27 hrs. Waste generated included around 100kg of burned plastic and approx. 20kg of steel. Fumes emitted during the accident were partially extracted via the facility's zinc filter that was running. A set of electrical cabinets controlling an ash U-trough conveyor was destroyed.

The part involved was unsuitable for galvanization as no holes had been drilled in it. During immersion of a hollow body in molten zinc, if the body has not had holes drilled in it, the pressure increases sharply until the hollow body breaks. The pressure released by the hollow body generated a shock wave in the zinc bath and splashed zinc outside the tank. The event was due to **failure of the inspection line** checking customer parts from delivery to galvanization.



Systematically heavy economic and social consequences

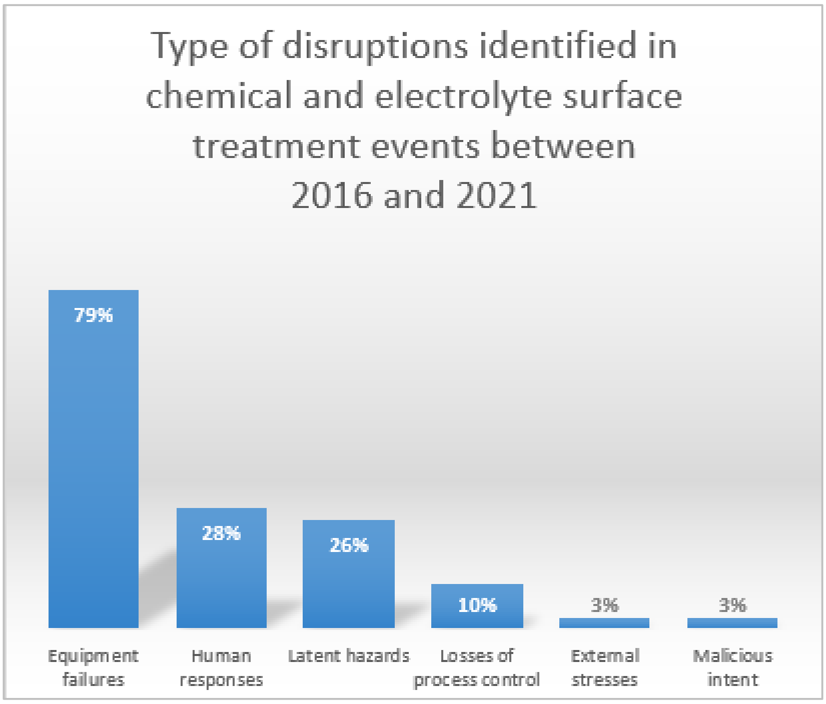
Practically all events had very significant economic and financial consequences (property damage and operating losses) and employees were laid off in half of all cases, due to destruction of production facilities.

In environmental terms, discharge of hazardous substances into the atmosphere linked to fires was observed in nearly 1/3 of events in this sample.

	Number of events (out of 56) with a set criterion	
HUMAN CONSEQUENCES	11	20%
Deaths	0	
Serious injuries	0	
Minor injuries	11	
ECONOMIC CONSEQUENCES	55	**98%**
Internal property damage	55	
External property damage	3	
Internal operating losses	21	
External operating losses	0	
SOCIAL CONSEQUENCES	30	54%
Lay-offs	24	
Incapacity to work (third parties)	0	
Homeless third parties	0	
Utility cut-off - drinking water	0	
Utility cut-off - electricity	1	
Utility cut-off - gas	0	
Utility cut-off - telephone	0	
Utility cut-off - public transport	0	
Other utility cut-offs	0	
Noise pollution	1	
Population evacuated	4	
Population locked down	5	
Security perimeter	14	
Blocking of traffic	8	
ENVIRONMENTAL CONSEQUENCES	21	38%
Air	16	
Water	3	
Soil	6	
OTHER CONSEQUENCES	0	0%

The main symptoms revealed by reports on accidents involving fires at electrolyte or chemical surface treatment facilities were: equipment failures, latent hazards, and inappropriate human responses

Disruptions were identified for 39 of the 56 events in the sample, i.e., a 70% identification rate, compared with a 78% identification rate for all events in the ARIA database over the same period.



N.B.: equipment failures were identified as disruptions in 79% of the 39 events reported out of the 56 in the sample (several different disruptions can cause the same event).

Equipment failure was the most frequent disruption causing these events : recorded in 76% of cases.

In 80% of cases, **electrical malfunctions** were at play:

- electrical contactor fault causing a bath motor to overheat (ARIA 49495, 52742);
- electrical fault causing a resistive heater to function continuously (ARIA 54857, 58273);
- electrical failure affecting an electric immersion heater or other treatment line equipment causing a fire to break out (ARIA 47964, 52811, 57457, 57333, 58106);
- electrical cable, cabinet or transformer catching fire (ARIA 48217, 49496, 49453, 50162, 51607, 51775, 56568, 57631, 57826).

Surface treatment **bath sensor failures** were often at fault. These failures can prevent the power supply of electric immersion or resistive heaters from being shut off. If the level is low in vats and the sensor does not detect this, the power supply is not shut off and the electric immersion heater continues to heat, and the vat may catch fire (ARIA 47697, 48648, 48663,51079, 52957, 53825, 53748, 56768, 57957). These malfunctions may be due to insufficient maintenance and inspections. The formation of sodium hydroxide crystals around the float was observed in one of the accidents. The proper functioning of this sensor was not checked when the bath was emptied (ARIA 47697).

Investigations after the fire confirmed that checking that equipment and facilities are in good order is an important technical safety barrier. In reports published this year, BEA-RI reviewed two types of specific surface treatment inspections:

- Inspection of the good order of electrical systems;
- Regular inspection of safety instrument line measurements (level sensor, fire detection, etc.).

Accident records demonstrate that some equipment frequently blamed for fires at chemical and electrolyte surface treatment workshops must be regularly inspected by the operator to prevent fires from breaking out:

- electrical systems (cabinets, inverters, connections);
- anti-condensation or resistive heaters;
- level sensors.

Temperature sensors and automatic low bath level heater shutoff systems must be reliable and regularly inspected.

Automatic bath vapour extraction systems can also be an aggravating factor when they function continuously during the incident, spreading hot vapours and flames. Its functioning must be controlled based on fire detection or must be able to be quickly shut off in case of fire.

Violent fire at a surface treatment business

ARIA 47697 – 18/02/2016 - Vendôme (Loir-et-Cher)

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At approx. 23.00, a fire broke out at a surface treatment plant. The fire detection system functioned. The duty manager and firefighters attended the site. The power supply was cut off and water systems sealed. Emergency services brought the fire under control at approx. 02.00 using water and foam.

The very aggressive fire gutted the surface treatment workshop and its treatment tanks containing 360m^3 of toxic products (hydrochloric acid, fluorinated bases, sodium hydroxide, etc.). Several connected premises including chemical stores, the maintenance room, and offices were affected by water used on the fire. A gas pipe on the front of the building exploded and landed 30m away in the car park. The steel frameworks bent down over the structures used to handle parts, which then caved in over the tanks. The neighbouring business, separated by a firewall, was not affected. Atmospheric toxicological readings were negative. Water used on the fire and pollutants were contained on site. The fire was put out at approx. 04.00. There were no injuries, but the production facility was destroyed. Approx. 30 staff were laid off. The cost of the damage was estimated to be €9m and production losses €2.3m.

It would appear that the fire broke out in a PVC degreasing bath that had been emptied for maintenance. An issue affected **the level sensor: it was stuck in its upper position, preventing the bath heater from shutting off even though a low level was detected**. It would appear that the formation of sodium hydroxide crystals around the float was the cause. Nobody checked that this sensor functioned when the bath was emptied. The timer used to automatically control heating was programmed to start the baths back up on Monday morning. Production decided to heat a specific bath on Thursday evening. This bath was on the same programme as the empty degreasing bath. As programmed, heating started at 23.00. The electric immersion heater was turned on in the empty bath and set light to the vat. The continuously functioning extraction system fanned the incipient fire and set the rest of the workshop on fire...

The operator drew up an empty tank securing procedure, including possible disconnection of the heating system at the electric cabinet by the maintenance department. The procedure also includes systematic checking of proper functioning of the level detector.


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Destruction of a surface treatment workshop in a fire
ARIA 47964 – 27/04/2016 – Autun (Saône-et-Loire)

At approx. 22.30, a fire broke out in a pickling workshop in the galvanization zone of an industrial boiler shop. The fire spread to the adjoining workshop, causing the destruction of 1,000m^2 of the building. The metal roof and its wooden framework were affected by the incident and collapsed. The workshop plus various adjacent premises were entirely destroyed. **The main extraction duct facilitated the spread of the fire.** Effluent poured into retention systems. Some retention systems, made from composite materials, were ineffective. They were burned in the fire. The site's systems were sealed with inflatable devices. The fire was extinguished at approx. 03.30 and monitoring was set up until 07.30. The next day, rubble was removed, and a folding canopy was set out over the retention tank pending recovery of the chemicals by a private company.

An electrical short-circuit on an electric immersion heater in one of the 12,000L plastic tanks containing 10% hydrochloric acid caused the fire.

The operator was planning to set up non-electric heating systems and modify their firefighting water retention system.

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Inappropriate human responses and latent hazards.

In a little below one third of events, incidents were linked to human responses and, in the same proportion, latent hazards, which can be combined or not with equipment failures.

An operator failing to shut off the heating system on a vat when emptying it or at the end of the day was a frequent example of a lack of **human response** potentially leading to a fire.

Surface treatment vats are often made from or covered with combustible material to deal with the corrosiveness of the chemicals they are required to contain. This is an example of a latent hazard which, combined with the aforementioned lack of human response, can result in an incident.

The latent hazards most frequently encountered in chemical and electrolyte surface treatment events are:

- Combustible composition of the treatment bath vat (PVC or stainless steel with polymer coating) combined with the use of heating systems and/or nearby electrical systems,
- Presence of combustible materials around baths (curtains, plastics, etc.),
- No automatic heating cut-off following detection of a low level of liquid in the bath.

Fire in a surface treatment workshop
ARIA 52811 – 27/12/2018 – Châtellerault (Vienne)

Shortly before 14.00, a fire broke out in acid baths containing several chemicals in a metal treatment plant for leatherworking accessories. The accident happened during the end-of-year leave shutdown period. A large plume of black smoke rose from the building. A security perimeter was set up and traffic stopped around the site. Firefighters extinguished the fire using water and foam at 17.30. Several tens of m^3 of water were used. Some of this water ran into sewer systems. The municipal WWTP's management was informed. Monitoring was put in place for 2 days. The fire destroyed $600m^2$ of the building's surface treatment workshop. The other parts of the building were spared. The 17 employees were laid off. The site filed for cessation of operation following the fire.

The fire was caused by a **short-circuit in an anti-condensation heater connection box. The heater continued to heat the bath, even though the liquid had evaporated. The temperature then increased until it short-circuited.** The heating zones had been cut off at the electrical control cabinet, but the cabinet's breaker had not been cut. The operator found that **nobody checked that the anti-condensation heaters did not function in the heating contactor's "stop" position.**

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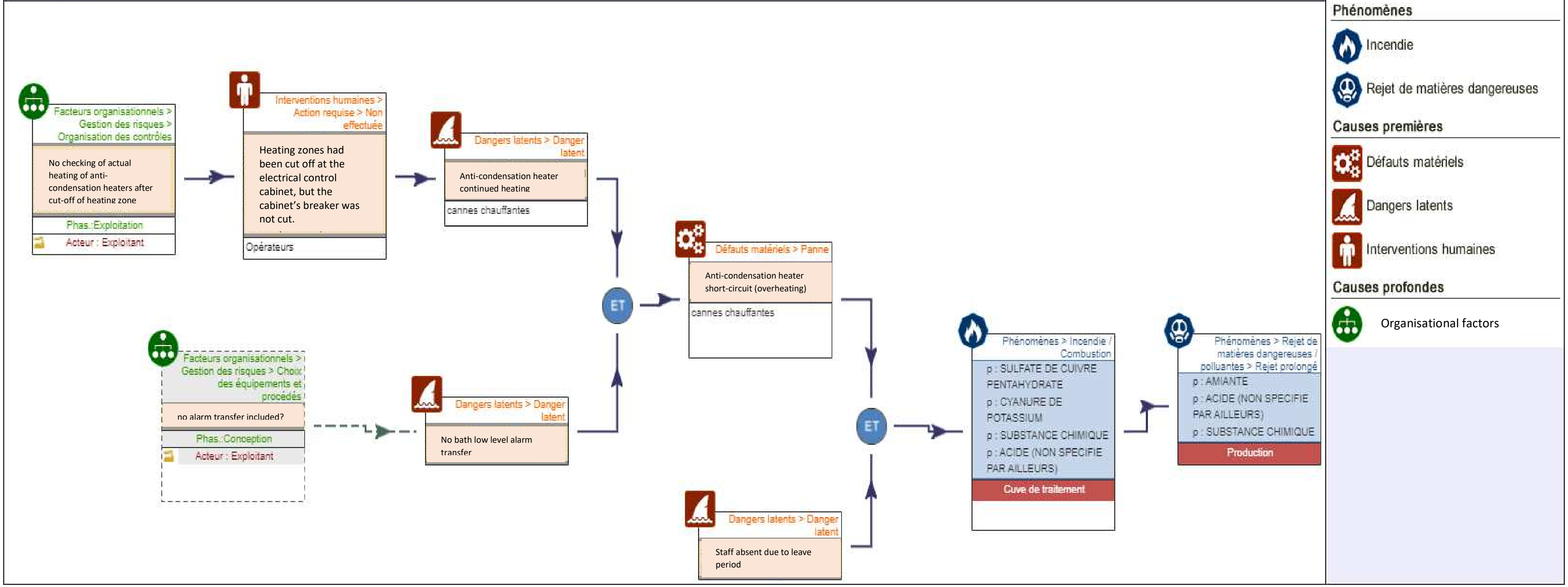
ARIA 52811 - Fire in a surface treatment workshop



Fire in a metalworking plant
ARIA 57957 – 10/09/2021 – Pamiers (Ariège)

At approx. 06.50, during emptying for cleaning in a metalworking plant surface treatment workshop, a fire broke out involving 21 tanks of 2,800L including 4 baths of 1,912kg of nitric acid, 2,638kg of hydrochloric acid, 1,440kg of hydrofluoric acid, and 4,000kg of ferric chloride. The fire spread to a 400m^2 building. The IOP was triggered, and staff were evacuated. A large plume of smoke, mainly containing hydrochloric acid, hydrofluoric acid, cyanhydric acid, nitrogen dioxide, and nitrogen oxide vapours, rose to a height of 60m. Firefighters fought the fire using foam cannons. Explosions were heard. A 400m security perimeter was set up, and 2 schools and a day hospital were evacuated. A secondary school, high school and 5,000 people were locked down. The water systems were sealed, but the water used on the fire containing acids overflowed and 1,000L/min poured into the ARIEGE threatening 3 drinking water pumping stations located downstream. These 3 plants were instructed to store water and use an alternative watercourse if pollution was confirmed. The pollution in the ARIEGE spread into the GARONNE. The French fishing federation was informed, and samples were taken. 23 people including firefighters were contaminated via inhalation or direct contamination and hospitalised. Support was requested from CASU (*Cellule d'Appui aux Situations d'Urgence*, i.e., emergency situation support unit). The fire was contained at 10.25 and the lockdown measures were lifted at 11.30. The fire was extinguished at approx. 21.15. 3,000m^3 of mix were removed in tanker trucks. Atmospheric measurements did not reveal any pollution. A water leak in the affected building increased the volume of contaminated water, and firefighters set up a plug in a nozzle.

Part of the ground floor, the mezzanine and all the upper floors burned. Outside, 1/8th of the building's metal cladding was burned. Products located in the affected zones, industrial equipment (plastic storage vats, tank and covering, ducts, pumps) and structural elements of the building were destroyed. The total volume of water used on the fire was estimated to be between 200 and 300m^3. 2 months later, the soil analyses and samples were found to be well below the applicable references values to assess sanitary risks.

Initial investigations indicated that it would appear that the fire broke out in one of the tanks, which had been emptied, but in which the resistive heaters, which had continued to heat, would appear to have caused the polymer coating of the tank to catch fire. It would appear that the vapour catchment system caused the fire to spread to the sodium hydroxide washer. It would appear that the fire then spread to the upper floors.

Organisational failures identified in several events

Disruptions such as the ones described above (equipment failures, inappropriate human responses, latent hazards) are deviations from an expected functional state that lead to a hazardous phenomenon.

These disruptions generally have less visible origins. These are the genuine "causes", sometimes called the "primary causes" or "root causes" of accidents. There are several types of root causes:

Organisational factors	These included working environment and risk management measures such as organisation of inspections, management of training and internal and external skills, procedures and instructions, risk identification, organisation of work and supervision, communication, user-friendliness, choice of equipment and processes, etc.
Human factors	These are factors for which organisation is not responsible that disrupt a site employee's physical / cognitive / mental capabilities.
Incalculable factors	These are factors causing a disruption that could not be predicted or managed by the organisation set up on the affected site. e.g., manufacturing defects.

It is the more in-depth analysis of the **root causes** of the accident that means lessons can be learned in order to put in place the most appropriate preventive measures to **reduce the risk of recurrence of the event**.

In terms of events linked to fires at chemical and electrolyte surface treatment facilities recorded in the ARIA database, the breakdown demonstrates that **risk management is affected** by both <u>choice of equipment</u> and <u>organisation of inspections</u>. <u>Staff training</u>, though not always explicitly blamed, also appears to account for multiple cases of inappropriate operator behaviour. As a matter of fact, completed investigations blamed operator **training and skill maintenance**, particularly **during sensitive operating phases (facility startup or shutdown)** or to prevent practices liable to generate high-risk situations (shunt management).

In terms of **emergency situation management**, feedback demonstrates that:

- failures can involve **alarm management** (transfer, late response);
- the effectiveness of an emergency response is based on **effective cooperation between the operator and emergency services**. This requires good knowledge of the premises and participants, which is gained through organising drills and drawing up emergency response procedures or plans.

Type of organisational causes	11 out of 56 events with a set criterion	ARIA number
Choice of equipment and processes	**7**	47556, 47697, 47755, 48663, 52811, 53495, 56768
Organisation of inspections	**6**	47697, 48663, 51987, 52811, 53495, 58199
Staff training and qualifications	3	47697, 51079, 58199
Risk identification	2	48005, 53495
User-friendliness	1	51079
Communication	1	48663
Individual human factor (carelessness, distraction, clumsiness, forgetfulness, etc.)	1	51987

- The fire broke out when resistive heaters immersed in 2 plastic tanks, which had been emptied by a maintenance technician before the weekend in preparation for maintenance work on these tanks, were turned on. **The technician thought they had opened the resistive heater power supply circuit breaker before leaving for the weekend but, according to the investigation report, the circuit breaker was closed**. The report specified that the circuit breakers were not set out on the switchboard in the order in which they were numbered and did not explicitly indicate their function. **Furthermore, the circuit breakers were not locked/tagged out using special dedicated clamps and padlocks** but instead using sticky tape and zip ties, which does not prevent another operator from closing the circuit breaker, believing that circuit had been broken accidentally. In addition, the investigative report stated that the **wiring of the system controlling the relay preventing the resistive heater from heating in case of a very low level in the tank had been reversed** in relation to the level controller output wiring diagram. This meant that, if the level was very low, the relay was excited, powering the contactor on the resistive heater power circuit and indicating a correct level to the automaton, meaning the resistive heaters turned on if the level was very low (ARIA 51079).

- It would appear that the fire broke out in a PVC degreasing tank that had been emptied for maintenance. There was an issue with the level sensor, which was stuck in the upper position, preventing the bath heater from being cut off if a low level was detected. It would appear that the formation of sodium hydroxide crystals around the float was the cause. Nobody checked that this sensor functioned when the bath was emptied. As programmed, heating started at 23.00. The electric immersion heater turned on in the empty bath and set light to the vat (ARIA 47697).

- The fire was caused by a short-circuit in an anti-condensation heater connection box. The anti-condensation heater continued to heat the bath even though the liquid had evaporated. The temperature then increased until it short-circuited. The heating zones had been cut off at the electrical control cabinet, but the cabinet's breaker had not been cut off. The operator found that nobody checked that the anti-condensation heaters did not function in the heating contactor's "stop" position (ARIA 52811).

LESSONS LEARNT FROM ACCIDENT FEEDBACK

Fires can occur at any type of surface treatment facility, of any size (small, medium, or big business), and in any regulatory facility class (authorisation with easements, IED authorisation, standard authorisation, registration, controlled declaration or declaration).

Special attention must be paid to safety equipment, if necessary with a certain level of redundancy, using different technologies as appropriate.

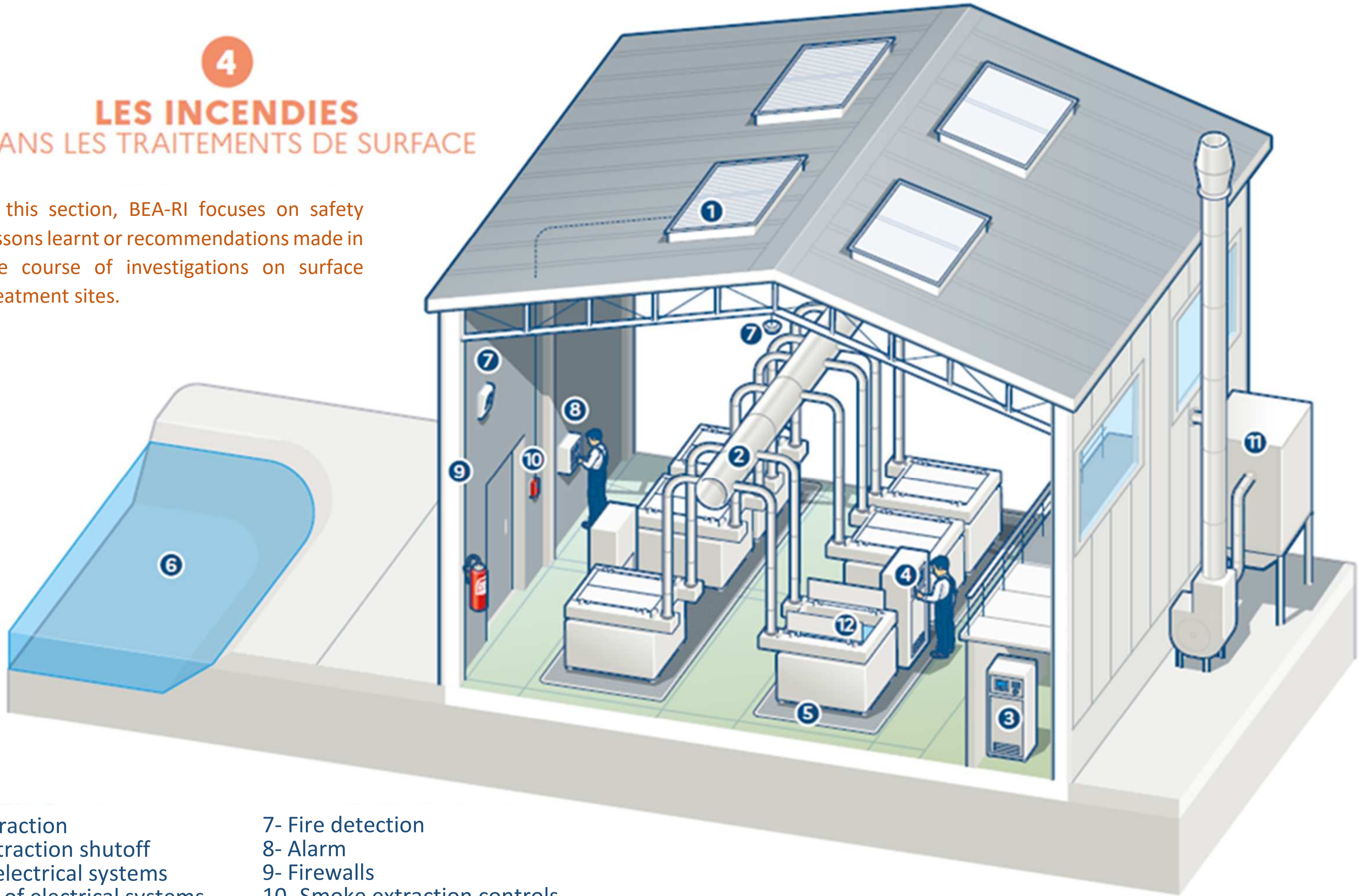
Safety recommendations and lessons have been synthetised in the following diagram. Please note that, though the recommendations made appear technically pertinent, some only reinforce the application of applicable regulatory provisions, and others are based on lessons learnt from analysis of, and investigations into, accidents.

BEA-RI (*Bureau d'Enquêtes et d'Analyse sur les Risques Industriels*, i.e., industrial risk investigation and analysis bureau) carried out several technical investigations following fires at surface treatment workshops. Their results consolidate the lessons learnt shared below.

10 January 2021 – Airbus Hélicoptères – Marignane (Bouches-du-Rhône)	View report
30 January 2021 – STI France – Escout (Pyrénées-Atlantiques)	View report
13 May 2021 – Protec Industrie – Bezons (Val-d'Oise)	View report
11 June 2021 – Nexter Munitions – La Chapelle-Saint-Ursin (Cher)	View report
10 September 2021 – Aubert et Duval – Pamiers (Ariège)	Coming soon

4 LES INCENDIES
DANS LES TRAITEMENTS DE SURFACE

In this section, BEA-RI focuses on safety lessons learnt or recommendations made in the course of investigations on surface treatment sites.



1- Smoke extraction
2- Vapour extraction shutoff
3- Design of electrical systems
4- Inspection of electrical systems
5- Retention systems
6- Firefighting water retention basin
7- Fire detection
8- Alarm
9- Firewalls
10- Smoke extraction controls
11 Vapour treatment system
12- Bath heating

1. Smoke extraction systems

By extracting hot fumes, these systems reduce the risk of fires spreading and facilitate the response of emergency services. In terms of ICPE regulations, the most recent standard was set by the ministerial order of 9 April 2019 relating to registration requirements for headings 2564 and 2565, which sets out several binding recommendations including easily accessible controls, smoke control coverage equal to or greater than 2% for a 1,600m² internal smoke extraction area, plus equipment meeting the NF EN 12 101-2 standard.

2. Vapour extraction shutdown

To prevent the formation of an explosive or toxic atmosphere and reduce emissions of hazardous substances during regular functioning, the regulations require bath vapour extraction and treatment. This extraction and treatment often continue to function outside working hours. However, these functions are provided by equipment mainly made from combustible material (plastic). This means it is important to stop vapour extraction in case of an incident to limit the risk of fire spreading via extraction of hot fumes. Vapour extraction systems can be controlled by the fire panel. BEA-RI recommends that this also be possible without involving fire detection systems, for instance by detecting the temperature increase in the extraction duct.

3. Design of electrical systems and equipment

All equipment at risk of electrical failure (at least LVDP and power cabinets) must, insofar as possible, be isolated in rooms separated from surface treatment workshops by 2-hour rated firewalls. Rectifiers, which are usually located near baths, can also be moved to a specific room. All connections and equipment must be accessible to facilitate inspection.

4. Electrical system inspections

There are two types of inspections: regulatory inspections, i.e., required by labour regulations, and so-called "contractual" inspections, i.e., required by insurers in some cases. BEA-RI recommends inspection of the whole facility in accordance with the APSAD R18 and R19 standards, particularly sections of the facility located near baths. If inspection using infrared thermal imaging of high-voltage facilities is not possible, ultrasound-based inspection can also be a good option.

5. Retention systems

They must remain tight and provide sufficient capacity, and special attention must be paid to guarantee they are not blocked. N.B.: they must be designed to collect acid and base runoff separately.

6. Firefighting water retention basin

This plays an essential role in managing water used on fires in case of an incident and helps to prevent environmental impacts by retaining polluted water used on fires. If there is a basin and it is sufficiently large, fires can be managed smoothly, but if it is too small, emergency responses become trickier. When this retention is in another part of the building, or an underground room, it is important to make sure that the basin maintains its storage capacity and does not turn over the years into a hazardous product storage room. This basin must be equipped with a system to easily contain water used on fires in case of use (closure valve identified and easily manoeuvrable, or lift pump power cut-off system).

7. Fire detection systems

The kinetics of surface treatment line fires are quite fast once combustion has begun. This means it is important to have an operational and effective fire detection system. “Operational” means the system is genuinely active and that over time and following accidental triggering some detectors have not been neutralised or concealed by modifications to the facilities. “Effective” means detectors positioned in the most appropriate locations and using complementary technologies if possible (e.g., point smoke and flame detection, line-type smoke detectors). It is also important to make sure it remains functional over time. This means a maintenance contract must be signed with a specialist business that will issue an inspection report every year.

8. Alarm

A fire detection system is linked to a fire safety control panel featuring several functions (audible warning, security guard alert, transfer to remote monitoring). A detection system without alarm transfer during unstaffed periods is ineffective. If there is no security guard or personal assistance and fire safety department, it is recommended to employ a remote monitoring company that can trigger emergency procedures established by the operator. It must be possible to take these actions as quickly as possible. Regular drills are recommended.

9. Firewalls

Whenever featured, firewalls demonstrated their usefulness. The general orders applicable to facilities classified for protection of the environment established requirements (REI 120 walls and floor) that the accident study does not call into question. Special attention must be paid to doors and windows (doors with the same fire-resistance rating) and cable routing. In case of fire, vapour extraction ducts can also spread fires (see point 2). When a duct runs through a firewall, a fire stop flap can prevent fire from spreading any further. If a fire stop flap cannot be installed, the duct can be made out of an incombustible material (special plastic, metal duct, etc.) in the zone in which it runs through the wall.

10. Smoke extraction controls

In accordance with the regulations (Art. 3 AM of 30/06/2006, heading 3260, Art. 13 AM of 09/04/2019, heading 2564 and 2565), manual controls to open smoke extraction hatches must be set up near entrances and be both clearly labelled and easily accessible.

11. Vapour treatment system

Vapour treatment units (generally made form plastic) required in accordance with regulations to route and treat emissions from treatment baths are highly potentially combustible in case of fire. This means it is preferable for these systems to be located outside the building or in a room separated from the treatment workshop by a REI 120 firewall.

12. Design of vats equipped with a heating system

The accident study demonstrated that electric immersion or resistive heaters used to heat baths can, due to their power or following failures, set fire to vat or plastic or rubber vat coatings within a few minutes if they are empty.

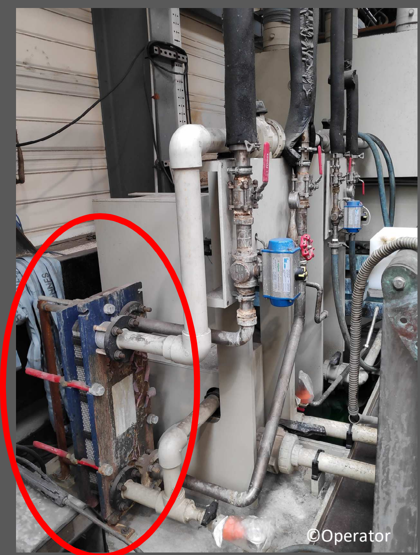
Special attention must also be paid to the design of these facilities in terms of interacting elements:

- type of products stored: flammable or not, likely to generate flammable or explosive decomposition products, requiring that a specific temperature be maintained or not;
- materials from which storage vats are made: flammable or not, required to resist the type of products stored;
- heating elements: essential or not, electric or using thermal fluid (vapour, hot water, heat transfer fluid, etc.), scaled for a given heating power.

This meant that several events resulted in operators opting to heat baths using circulating hot water and no longer heating using electric resistive heaters to reduce the risk of fire.

Technical spotlight: heating using hot water

Hot water loops can be used to heat baths to a temperature of 80-90°C. This can involve recirculation of the bath via a heat exchanger or plates immersed directly in the bath in which hot water circulates.
The boiler is set up in a separate room from the workshop.



Whatever the technology chosen, the choice must be made based on risk analysis.

Whatever the facility's design, regulations (Art. 6 of the order of 30/06/2006, heading 3260, and Art. 54 of the order of 09/04/2109, headings 2564 and 2565) require bath heating systems to be controlled based on the level of liquid in the tank. Level sensors must be serviced and inspected regularly. The choice of this equipment must be based on its reliability in relation to operating conditions and the opportunity to carry out systematic testing (e.g., float removal tests whenever used).

Furthermore, when immersion heaters are used for heating, stops must be set up to prevent heaters from accidentally popping up when parts are removed during treatment.

In addition to the presence of liquid in the tank, heating power must be regulated based on the temperature of the bath.

In terms of operation of these facilities, it is important for monitoring to allow viewing of all the facility's functioning and safety parameters via reports. The sensitivity of this type of facilities from a safety point of view means that some operators only use them when staff are present.

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DE LA TRANSITION
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