MINISTRY OF THE ENVIRONMENT, ENERGY AND THE SEA



Overview of accident statistics on waste management facilities

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Abstract

Waste management activities are not only a potential source of chronic risks (atmospheric pollution, olfactory or noise nuisances, etc.), they may also be responsible for the risk of accidents. Waste handling/treatment activities are more prone to accidents in proportion to the increased "upstream" risks of collection, sorting, transfer, etc. Fire appears to be the most frequent hazard, which seems logical, given the combustible and sometimes flammable nature of waste. The consequences of accidents occurring at waste management facilities are, on the whole, less serious than those stemming from events arising in most other industrial sectors.

Despite the diversity and heterogeneity of waste processed at collection and treatment facilities, recurrent accident scenarios are nonetheless identifiable: loss of process control (self-ignition, reaction due to incompatibility), ignition due to an exogenous factor (hot spots, malicious acts), loss of equipment confinement causing environmental pollution, etc. Some ten primary scenarios are analysed in this document.

In focusing on the causes giving rise to accidents, it appears that the "pattern of failure" is often quite similar: beyond a triggering incident taking place at the process or instrumentation level, the actual operational drift can generally be traced back to inappropriate human actions. The causes of such actions may themselves be explained by shortcomings at the organisational level (outdated procedures and guidelines, insufficient employee training, inadequate risk identification, etc.).

In tackling each of these accident situations, progress can be achieved in preventing the recurrence of similar events. Recommended accident prevention measures will be proposed for each scenario.

Introduction

The waste management sector is complex and multifaceted: little overlap exists between the activity of a metal waste recycling company, a methanisation unit and a plant producing recovered solid waste fuels. There are approximately 5,900 firms in France categorised under the NAF 38 business code: "Waste collection, treatment and disposal; recovery" (source: INSEE Office of Statistics, 2013).
The accidents arising in these facilities are as varied as they are frequent. The waste sector currently ranks as the 3rd most accident-prone industry.

This summary is intended to provide an overview of France's waste sector accident trends: key statistics, identification of recurrent accident scenarios, analysis of the primary causes of recorded events, plus recommendations. The data presented are illustrated by accidents extracted from the ARIA database ("Analysis, Research and Information on Accidents") managed by the BARPI Office.

The present document offers all readers interested in this topic a glimpse of the characteristics of accident trends underlying the waste management sector. Its purpose is to raise awareness of the operations or circumstances that are particularly risk sensitive, and to recommend preventive or protective measures that may be anticipated to counter these risks.

The key statistics and lessons contained in this study are derived from an analysis of French accidents but are in large part applicable to the waste treatment industry in other countries as well.

The summaries of all accident examples cited in this document may be found on the BARPI website: http://www.aria.developpement-durable.gouv.fr/find-accident/?lang=en *under their corresponding number (ARIA XXXXX).*

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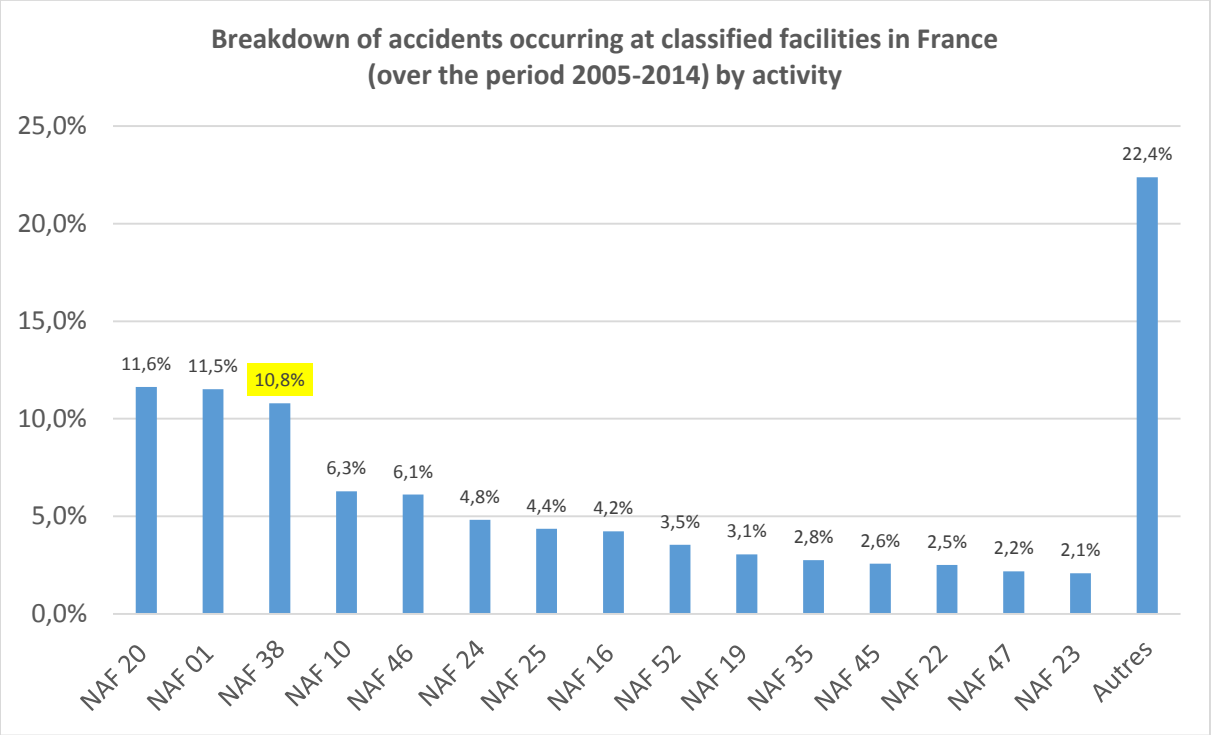
Waste sector: A large volume of accident reports…

According to the data contained in the ARIA database,[1] for France, **the activities of waste collection, treatment and reuse (all of which fall under NAF business code 38) occupy 3rd place[2] in the ranking of the most accident-prone activities**.

As shown in the following histogram, activities classified under NAF code 38 account for nearly 11% of all accidents occurring over the period 2005-2014.



NAF 20	Chemical industry	**NAF 52**	Warehousing
NAF 01	Crop production and livestock breeding	**NAF 19**	Coking and refining
NAF 38	Waste collection, treatment and disposal	**NAF 35**	Electricity production and distribution
NAF 10	Food processing industries	**NAF 45**	Automobile industry
NAF 46	Wholesale trades	**NAF 22**	Rubber and plastic product manufacturing
NAF 24	Metallurgy	**NAF 47**	Retail trades
NAF 25	Manufacture of metal goods	**NAF 23**	Manufacture of non-metal mineral products
NAF 16	Woodworking, manufacture of wood items		

[1] Database accessible at: http://www.aria.developpement-durable.gouv.fr/find-accident/?lang=en

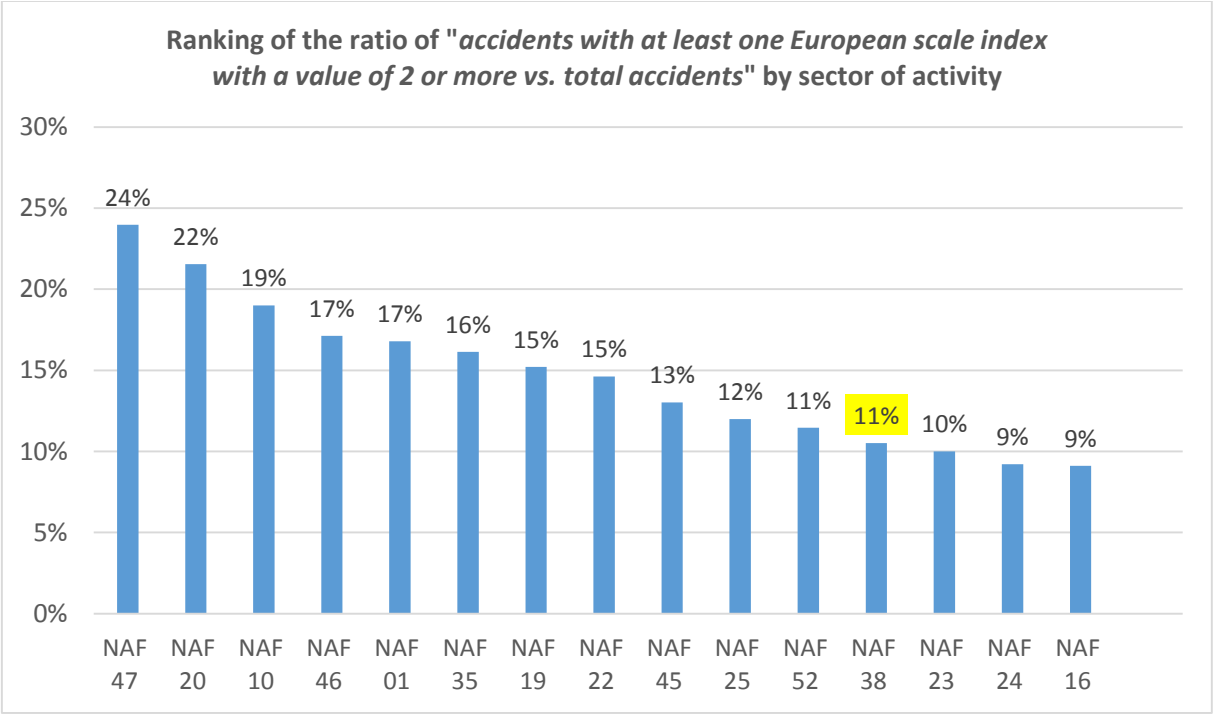
[2] This number has been calculated for accidents occurring in France between 1 January 2005 and 31 December 2014 at classified facilities with special environmental protection status.

… yet proportionally small in terms of consequences

The reference used when describing the seriousness of consequences due to accidental events is the "European scale of industrial accidents."[3] This scale is based on the four following indices, each of which is divided into 6 levels:

- Hazardous substances released
- Human and social consequences
- Environmental consequences
- Economic consequences

On the whole, out of all accidents recorded at classified facilities between 2005 and 2014, regardless of the activity, some 15% scored at least a 2 on one or more of the 4 scale indices. As for the classified facilities designated by NAF code 38, only 11% of the accidents registered a "2" on one of the scale indices. **The waste management sector comes in at just 12th place in the ranking of "serious" accidents, whereas it occupies 3rd place in the ranking of total number of accidents.**



NAF 47	Retail trades	**NAF 45**	Automobile industry
NAF 20	Chemical industry	**NAF 25**	Manufacture of metal goods
NAF 10	Food processing industries	**NAF 52**	Warehousing
NAF 46	Wholesale trades	**NAF 38**	Waste collection, treatment and disposal
NAF 01	Crop production and livestock breeding	**NAF 23**	Manufacture of non-metal mineral products
NAF 35	Electricity production and distribution	**NAF 24**	Metallurgy
NAF 19	Coking and refining	**NAF 16**	Woodworking, manufacture of wood items
NAF 22	Rubber and plastic product manufacturing		

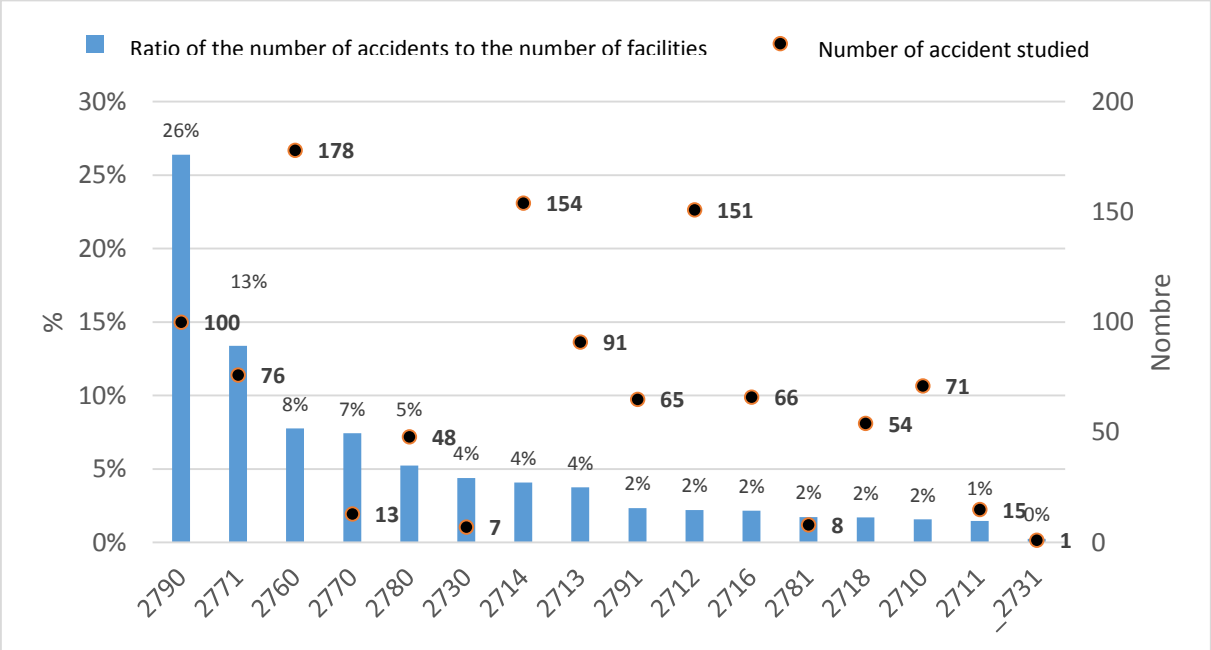
[3] Further details on the scoring protocol inherent in this scale are available at the web address: http://www.aria.developpement-durable.gouv.fr/outils-dinformation/echelle-europeenne-des-accidents-industriels/

Higher accident frequency in treatment activities

By drawing correlations between the breakdown of accidents by type of waste management activity and the number of facilities of each type, it is apparent that **waste treatment activities are the most accident-prone. The frequency of accidents occurring at treatment units is higher as a proportion (relative to the total number of facilities) than that of accidents in installations devoted to waste transfer/consolidation/sorting.**

The treatment of hazardous waste (excluding heat treatment) tops the ranking of activities most at risk of accidents, followed by heat treatment and storage activities for both hazardous and non-hazardous waste.

The activities of sorting/handling/consolidation account for a large number of accidents, yet these remain relatively small compared with the number of facilities involved. For these particular activities, the ratio of number of accidents/number of facilities does not exceed 4%.



2790	Treatment of hazardous waste	**2791**	Treatment of non-hazardous waste
2771	Incineration of non-hazardous waste	**2712**	Automobile scrapyards
2760	Landfill	**2716**	Handling/consolidation/sorting of non-hazardous waste
2770	Incineration of hazardous waste	**2781**	Methanisation
2780	Composting	**2718**	Handling/consolidation/sorting of hazardous waste
2730	Treatment of animal by-products	**2710**	Dumpsites
2714	Handling/consolidation/sorting of paper, plastics	**2711**	Handling/consolidation/sorting of WEEE
2713	Handling/consolidation/sorting of metals	**2731**	Storage of animal by-products

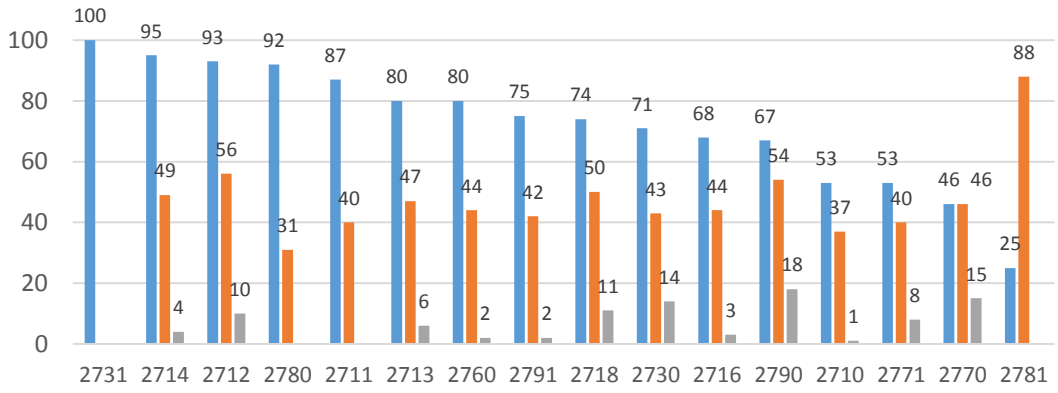
Note: In the above graph, the 27XX numbers associated with each activity correspond to the headings defined in the French nomenclature for classified facilities with an environmental protection designation.

The strong predominance of fire among the hazardous phenomena observed

As is the case for all classified facilities taken as a whole, the most widely encountered hazardous phenomena in the waste sector are fire and the discharge of hazardous or polluting substances. Fire is involved in nearly 80% of all accident occurrences in this sector, which is significantly above the average rate of fire outbreak among classified facilities.

In 45% of the cases, a fire outbreak is combined with the discharge of hazardous or polluting substances. This is especially true for the smoke generated during a fire when hazardous or polluting compounds are present.

Hazardous phenomenon	Percentage of accidents by phenomenon[4]	
	Waste sector	All environmentally sensitive facilities
Fire	**78%**	62%
Discharge of hazardous/polluting substances	**47%**	49%
Explosion	6%	8%
Other phenomena[5]	12%	8%



2731	Storage of animal by-products	**2718**	Handling/consolidation/sorting of hazardous waste
2714	Handling/consolidation/sorting of paper, plastics	**2730**	Treatment of animal by-products
2712	Automobile scrapyards	**2716**	Handling/consolidation/sorting of non-hazardous waste
2780	Composting	**2790**	Treatment of hazardous waste
2711	Handling/consolidation/sorting of WEEE	**2710**	Dump sites
2713	Handling/consolidation/sorting of metals	**2771**	Incineration of non-hazardous waste
2760	Landfill	**2770**	Incineration of hazardous waste
2791	Treatment of non-hazardous waste	**2781**	Methanisation

[4] The total obtained exceeds 100% since several hazardous phenomena may be involved in a single accident.

[5] "Other phenomena" refers in particular to near accidents and workplace accidents.

In analysing the breakdown of hazardous phenomena vs. type of waste management activity, it appears obvious that **fire plays the most predominant role, excluding methanisation.**

Accident seriousness: Disasters are indeed rare

The data given above takes into account the number of events, independently of their seriousness. Yet, a whole series of gradations is possible: from simple incidents without any consequences, to accidents causing severe repercussions.

Consequences of accidents occurring at waste management facilities, 2005-2014

		Full sample analysed	Accidents related to hazardous waste management activities	Accidents related to non-hazardous waste management activities
HUMAN CONSEQUENCES		**15.2%**	**21.9%**	**13.2%**
including:	Deaths	1.1%	1.65%	0.94%
	Serious injuries	1.9%	4.13%	1.29%
	Total injuries	14.6%	21.1%	12.8%
ECONOMIC CONSEQUENCES		**50.6%**	**57.4%**	**48.8%**
including:	Internal property damage	47.2%	53.3%	45.6%
	Internal operating losses	18.1%	19.8%	17.6%
	External property damage and operating losses	2.4%	2.9%	2.2%
SOCIAL CONSEQUENCES		**21.2%**	**25.2%**	**20.3%**
including:	Redundancies	5.6%	6.2%	5.4%
	Worker disability (third party)	0.4%	0.4%	0.4%
	Utility shutoffs (drinking water, electricity, gas, etc.)	2.3%	2.5%	2.2%
	Population evacuated or confined indoors	5.8%	7.0%	5.4%
	Safety perimeter or traffic interruption	20.5%	26.4%	19.0%
ENVIRONMENTAL CONSEQUENCES		**40.1%**	**41.3%**	**40.1%**
including:	Atmospheric pollution	34.8%	36.8%	34.5%
	Surface water or groundwater pollution	5.7%	7.0%	5.4%
	Soil contamination	3.1%	3.3%	3.0%
	Adverse impacts on wild flora or fauna	1.2%	0.8%	1.3%

22.5% of accidents produce no noteworthy or even known consequences.
Should an accident cause damage, in most cases it is mainly economic or environmental in nature.

- Over half of the accidents surveyed wind up causing either property damage or operating losses. Third parties are only affected in 2.4% of the cases, reflecting the fact that the spread of hazardous phenomena, by and large, remains within site boundaries.
- 40% of accidents release pollution, atmospheric in most instances (fire smoke).

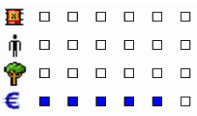
In human and social terms, these accidents are generally "lighter", with just 1% of cases involving loss of life and slightly above 5% resulting in redundancies. Emergency crews' on-site response to accidents, in contrast, often takes a long time, involving safety perimeters and the evacuation/confinement of neighbours in more than 20% of all cases.

In addition to these average values for the entire accident sample studied, the type of waste being handled can also be analysed. We can see that those accidents involving hazardous waste, representing 22% of the total sample (i.e. 242 accidents out of 1,094), typically produced more serious consequences. This finding is especially notable for both human consequences (e.g. injuries in 21% of the cases for "hazardous waste" accidents vs. 13% for "non-hazardous waste" accidents) and economic consequences (property damage and operating losses in 57% of the "hazardous waste" accident records vs. 49% for the "non-hazardous waste" accidents).

Moreover, beyond these average indicators focusing on the severity of consequences, it is worth citing a few events given the magnitude of the damages caused.

- <u>Fire at a non-hazardous waste incineration plant (ARIA 44544) with dire economic consequences:</u>

No. 44544 - 2 November 2013 - 13 - FOS-SUR-MER

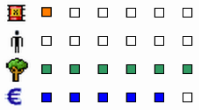


Fire broke out around 2:30 am inside the 2,000-m² sorting building at a waste treatment facility in service since 2010 on an isolated, 18-ha parcel located at an industrial/port zone. Within just a few minutes, the flames stoked by the wind fanned the blaze to a compost storage and maturation zone (4,000 tonnes covering 8,000 m²). Incandescent cinders were suctioned by the fans used to lower building pressure, spreading the fire to the air treatment and deodorisation unit (with biofilters spanning 3,000 m²). In less than an hour, the fire had reached another sorting zone (5,000 m² of floor area containing plastics). The outbreak continued its course via conveyor belts crossing the firewalls and the glued-laminated wood frame covering these walls; burning timber fell to the ground, igniting 2 household waste pits (27,000 m³ over a 20-m thickness) around 6:30 am.
[…]
Both the primary and secondary sorting units, as well as the biofilter and the 3 buildings housing these facilities (18,000 m² in all), were destroyed. Two digesters and the incinerator could be salvaged; around 6 am, an incineration line (primary air inlet to a furnace) was damaged by a CO

explosion subsequent to the furnace shutdown 3 hours prior. **Property damage and production losses reached into the tens of millions of euros.** A portion of the waste typically treated on-site had to be routed to other centres. The site operated at 85% capacity for 18-24 months.
[…]

- Fire at a wood recycling centre (ARIA 35035) with dramatic environmental and economic consequences:

No. 35035 - 22 August 2008 - 42 - SAINT-CYPRIEN



At a wood recycling plant set up at the former site of an electrical transformer recovery firm, a fire of unknown origin broke out around 4 am on a 2,000-m² wood stockpile.
[…] The Classified Facilities Inspection authorities observed that the wood, stored in a quantity above that authorised in the site declaration, was potentially exposed to chemical products. Seven days later, an emergency administrative order prescribed on-site groundwater analyses in addition to testing the soils in nearby agricultural zones.
[…]
A specialist body installed air quality measurement equipment. The analyses revealed major atmospheric emissions of dioxins and polychlorobiphenyls (PCB). Veterinarian services sampled milk at a neighbouring farm. Contamination was observed in excess of the regulatory limit values for marketing staple foods (European regulation 1881/2006/EC); the farm was sequestered.
Investigations were gradually expanded to 2 km beginning in March 2009, and then out to 5 km by April. On 25 May 2009, the monitoring zone was extended to 40 municipalities by Prefectural order, ultimately involving 42 municipalities by August 2009. In all, 914 farms were assessed. **Clean-up protocols were introduced and 2,255 animals had to be slaughtered (cows, sheep, pigs and horses).** The bone meal was burned at a local cement plant; the animal fat potentially contaminated with PCB was treated in Belgium. Nearly 187 m³ of unpasteurised milk had to be discarded.
[…]
Given the amount of **pollution clean-up work, evaluated at near 2 million euros,** and the fact that the St Cyprien site had subsequently been deemed improperly operated and forced to liquidate by court order on 23 July 2010, only a public body was empowered to ensure site security and propose a more durable management solution.
In January 2011, 3 farms were still partially sequestered. France's Agency for Food Health and Safety, consulted on several occasions, issued measures aimed at limiting the contamination risks within the food supply chain. The investigations (including analyses), animal and product destruction plus **compensation were appraised at 4.5 million euros** at the end of January 2011.
[…]

The principal accident scenarios

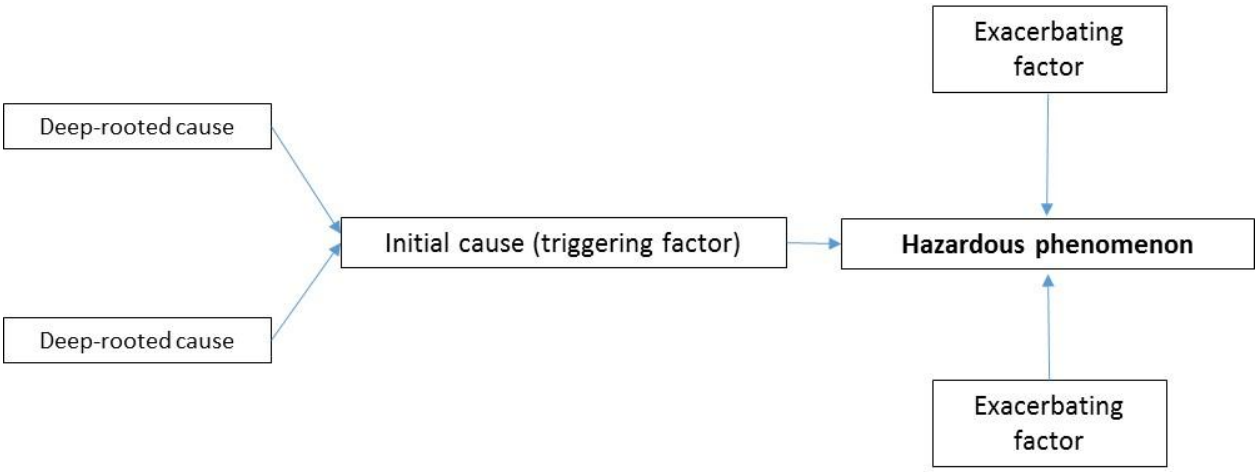
Despite the obvious impossibility of describing all the accident configurations potentially encountered within the various types of waste management facilities, several recurrent patterns are worth mentioning in the present summary.

The main scenarios described on pages 14 to 34 of this document pertain to general cases that may be observed across a wide variety of waste management units.

As a complement and for purposes of illustration, accident scenarios specific to certain activities (incineration, storage, composting, treatment of animal by-products) are presented as well, in pages 35 to 46. These scenarios are not applicable to all installations since they are directly correlated with the type of waste being handled and processes implemented.

For each accident scenario, examples will be provided. In the summary of each accident, the cause-related elements have been highlighted in yellow while any elements related to measures adopted have been highlighted in blue.

The primary cause[6] (i.e. triggering factors) and deep-rooted causes[7] which were identified as the potential origin of the accident will both be presented. Exacerbating factors[8] will also be indicated. The corresponding depiction takes the form of a "tree", as shown below.



[6] A primary cause is a factual occurrence, sometimes referred to as a "disturbance", affecting the operations of facilities and leading to a hazardous phenomenon.

[7] A deep-rooted cause is a factual occurrence leading to a primary cause, which in turn precedes a hazardous phenomenon. A primary cause can thus stem from one or more deep-rooted causes linked either simultaneously or consecutively.

[8] An exacerbating factor is a causality chain that magnifies the consequences of an event without modifying its nature. In the absence of this exacerbating factor, the event would still have taken place.

The key to the pictograms in these causal trees is given below.

	External event
	Deficient equipment
	Loss of process control
	Inappropriate human action
	Malicious act
	Scheduling of inspections
	Workplace organisation and supervision
	Choice of equipment and processes
	Training
	Operating procedures
	Risk identification
	Acknowledgment of feedback

A few examples are given below of preventive or corrective measures that may be deployed to avoid the occurrence of a similar accident for each basic accident scenario.

Note that this study is focused on the accidents arising inside waste management facilities. Nonetheless, accidents may also occur:

- upstream of the waste management installations:
  - at the actual site of waste production (examples: ARIA 41941, 47013);
  - during transport to waste consolidation and treatment sites (examples: ARIA 15096, 42729, 46755);
- downstream of such installations (examples: ARIA 45355, 36872).

➢ Fire subsequent to the self-heating of warehoused waste

This scenario comprises the cases of self-heating/self-combustion of waste warehoused at facilities dedicated to waste consolidation/transfer/sorting, but also for waste warehoused upstream of a treatment activity like incineration.
Not included herein are phenomena arising in units at dedicated composting and landfill sites, where waste degradation is an integral part of the treatment process.
The cases identified pertain to warehousing in skips, tanks, bulk storage at a warehouse, on an unloading platform, outdoors (e.g. wood chips, aluminium).

Self-heating of stored waste

Examples:

Example inside a sorting/transfer/consolidation facility handling non-hazardous waste

No. 44177 - Classified Facilities - 5 August 2013 - 51 - FAVEROLLES-ET-COEMY
Inside a company authorised to sort regulated non-hazardous waste, fire broke out around 8 am in a wood chip stockpile. Over 6,000 m³ of wood and other combustible waste (plastics) were present on-site. Given the prospect of a "smouldering conflagration" difficult to extinguish, fire-fighters planned on separating out the uncompromised wood and spreading a pile of ignited wood in order to fully extinguish the fire sources. […]
A Prefectural order for emergency measures was issued to supervise the effort to secure the site, prohibit the arrival of new waste, and ensure compliance with warehousing rules (the authorised upper threshold of combustible wood and waste was set at 1,400 m³).
This accident was due to self-combustion of the crushed wood resulting from its bulk storage over a long period. The facility operator explained that the maximum regulatory threshold had been surpassed by a wide margin subsequent to a decline in client orders.

Example at a hazardous waste consolidation facility

ARIA 43206 - 29 October 2011 - 28 - LUIGNY
Around 1:45 pm, a motorist reported smoke emanating from a Seveso-rated company collecting used solvents that was closed for the weekend. The fire reached a half-full, 30-m³ outdoor skip containing wet rags and non-hazardous filters. Fire-fighters flooded the skip with foam and then moved it with a forklift to avoid any risk of fire spreading to the adjacent building. First responders then spread out the contents using a small backhoe before sprinkling the residue. The intervention lasted until 6 pm. The solid waste was sent to a specialised handling facility, while the extinction water was treated on-site. Classified Facilities inspectors and municipal officials were duly informed of the incident.
The smoke release occurred more than 24 hours after the skip had been closed. The sudden flashover actually happened when fire-fighters opened the skip to flood it with foam. The self-heating of waste may have caused this incident. The operator modified its protocol: skips containing fouled materials were to be emptied prior to any period of closure. The resources on hand for moving skips were catalogued, and the possibility of a more robust monitoring system was examined.

Example pertaining to the warehousing of animal by-products

ARIA 32198 - 4 September 2006 - 91 - ETAMPES

At a rendering plant that had been idle since Saturday 2 September, the site watchman noticed at 3 am a fire outbreak within the 100-tonne stockpile of bone meal stored inside a (300 m²) warehouse. He alerted his supervisor, who in turn notified local fire-fighters. The blaze was brought under control in 2 hours. The 150 m³ of extinction water confined in the pre-treatment basin at the site's wastewater plant were reinjected into the industrial process and sterilised. A property damage claim was filed. The partial destruction of the ceiling on a 100-m² room prevented transforming animal products treated at the plant's rendering facility. Since the floor of the warehouse was sealed, no groundwater or soil pollution was to be feared. Bone meal ignition temperature is approximately 160°C. Weather conditions at the time of this incident did not portend spontaneous combustion. Given that the storage temperature did not exceed 60°C, only the input of hot bone meal exiting the process could explain the sudden rise in temperature. However, the lack of any meal input during the 24 hours preceding the fire outbreak greatly reduces the likelihood of the self-combustion hypothesis. However, animal fat mixed with bone meal could have lowered the combustion point of the mix. While awaiting treatment, a fat/bone meal mix had been stored for 4 weeks, which was quite atypical for the facility. Such exceptional storage conditions resulted from a malfunction of the programmable controller removing fat from the meal that, according to the operator, was due to lightning striking the site around 14 July. The police conducted an investigation. The facility's internal emergency plan under development at the time would take into account the consequences of this accident.

Example at a metal waste collection centre

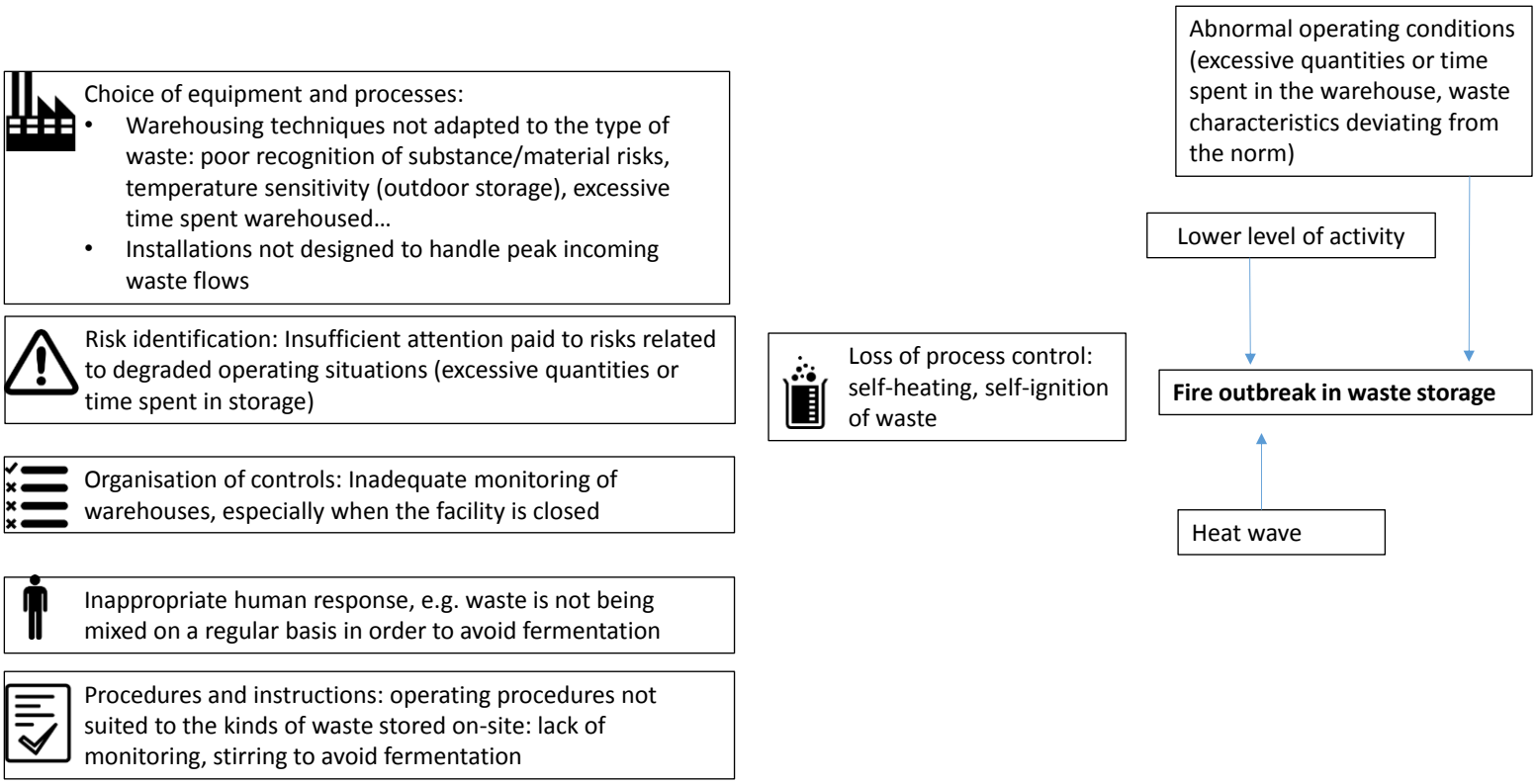
ARIA 46819 - 6 July 2015 - 21 - CHENOVE

Around 8:20 am at a company involved in collecting metal waste, fire broke out in a storage cell containing 100 tonnes of cast iron shavings, most likely coated with cutting oil residue.
[…]
Metal machining residues are susceptible to self-heating due to the lubricants used in the process. The hot day of the accident contributed to this heating process. Classified Facilities inspectors found several instances of non-compliance in the way the site was being managed:

- Presence of waste not listed in the permit notice (e.g. wood, mix of combustibles unrelated to any metal treatment operations);
- A site encumbered with cast iron shavings, both ferrous and non-ferrous metals exceeding the regulatory storage heights. According to the facility operator, the shavings had accumulated on-site because the recycling facility where they were to be sent was not operational. As for the other metals, the situation observed had resulted from the extended down time of several machines (shears, grinder), coupled with difficulties experienced in shipping waste due to a shortage of lorries and railcars.

Inspectors requested the operator to increase the frequency of its safety rounds during hot weather periods. Moreover, it was required to store the shavings in skips rather than cells, in ensuring direct contact with the floor, in order to avoid contaminating the water being discharged into the public storm drain network.

Causal analysis:



Recommendations:

- Prohibition of certain high-risk waste (e.g. crushing residues and WEEE pollution clean-up debris) or special warehousing precautions (isolation from other waste categories);
- Strengthening of the incoming waste acceptance and control procedure, in association with an appropriate operator training course;
- Expanded verifications prior to periods of site closure;
- Deployment of a monitoring service during periods of site closure;
- Inclusion of the risks of exothermic reactions between certain types of waste as part of warehousing protocols (e.g. dry screening debris, milled wet waste materials);
- Modification of operating procedures: limitation of the length of static storage, increasing the frequency of rotation/mixing as needed, special procedure during heat waves (e.g. increased frequency of temperature control);
- Enhanced acceptance verification procedure.

➢ Fire linked to the unplanned presence of a potentially flammable material during warehousing or an operation conducted on the waste

This scenario encompasses the cases of accidents tied to the presence of an "unexpected" waste:

- in the sense that this type of waste was prohibited on the site;
- or else because it revealed characteristics not compliant with what had been expected, given that a task assigned to the waste management facility had not been performed correctly.

The accidents considered herein may occur while waste is being warehoused, most often in bulk (e.g. outdoor warehousing of WEEE, in a pit, skip), or at the time of an operation conducted on the waste using a specific machine (e.g. a rotary screen).

Propane bottles found mixed to the waste in a shredder

Examples:

Example at a dump site

No. 44259 - Classified Facilities - 2 September 2013 - 45 - INGRE

At a dump site closed to the public, a bag containing chlorinated pellets (TCCA / DCNa?) ignited around 7:15 pm, releasing a tremendous amount of smoke. Fire-fighters arrived at the scene within 15 min and extinguished the fire. Their intervention lasted until roughly 8 pm. An individual had left the bag next to the tank used to collect hazardous household waste without site employees taking any notice.

The next day, these pellets were transferred to a specialised waste destruction facility. The site's sorting and verification guidelines at closing time were reiterated during an operations meeting held among dump site personnel.

Example at facilities for handling/consolidating/sorting electrical and electronic waste (WEEE)

ARIA 42682 - 30 August 2012 - 67 - STRASBOURG

NAF code 38.32: Recovery of sorted waste

Fire broke out around 11:40 pm on an outdoor stockpile consisting of some 100 tonnes of discarded electrical appliances (the plastics portion) over a 300-m² area; the site watchman and a passing motorist notified the authorities. The watchman attempted to battle the blaze using the facility's fire hose while awaiting backup from municipal fire-fighters; upon reaching the scene around 12:20 am, a large smoke plume was rising. The fire-fighting crew sprinkled the waste heap with 2 hoses, one of which was mounted on a ladder.

Two crane operators arrived at the site at 3:30 am, making it possible to use the site's equipment to clear the waste and gradually extinguish the blaze. At 4 am, the retention basin overflowed and a slight iridescence was visible at the harbour. Responders set up a dam and extinguished the fire by 6:30 am. German authorities were informed of the pollution risk.
Since a water supply catchment was located nearby, the facility operator proceeded over the next few days to examine samples from the on-site and nearby piezometers for hazardous substances originating from the extinction water. The aim was to evaluate the pollution risk, and (as needed) determine the protective measures to be implemented. The 750 m³ of extinction water were pumped during a 12-day period and discharged by a specialist firm.
The waste consisted of crushing residue and debris from manually cleaning up a mix of small electrical appliances. A short-circuit or heating caused this fire outbreak (battery/capacitor/electrical wires overlooked when sorting). The operator decided to no longer accept this kind of waste at the site. In addition, a camera inspection was performed on the facility's underground utility lines in order to verify their seal.

Example relative to a warehouse activity upstream of an incineration plant

ARIA 44192 - 11 August 2013 - 13 - FOS-SUR-MER

At a household waste incineration plant, fire broke out at 2 am: at the time when the grapple skidder picked up waste to feed the furnace, the contents ignited. The technician quickly unloaded the burning waste inside the furnace, but some of the incandescent waste fell back into the pit, generating several outbreaks of fire at the pit surface.
The site's water spray system and 2 stationary water cannons were activated; arriving at 2:20 am, fire-fighters added 2 hoses to the fight. The unit's 2 energy recycling lines were shut down. The various fire sources were extinguished by 8 am; the intervention ended at 12:30 pm.
Given the spontaneous ignition of waste upon being grabbed, the site operator assumed the presence of pyrotechnic waste or a flammable aerosol among the household waste. He wrote to the local authorities reminding them of the ban on sending such waste.

Example relative to a facility consolidating metal waste

ARIA 46703 - 1 June 2015 - 24 - BOULAZAC ISLE MANOIRE

Around 8:15 pm, at a metal recovery centre, an employee observed a fire outbreak inside a storage cell containing 50 m³ of lightweight automotive shredder residue.
[…]
This residue, deposited in the cell around 8 pm, had been produced from the day's crushing activities. According to the facility operator, the fire may have been caused by the presence of a piece of incandescent rebar or a piece of incandescent foam in the pile of residue.
The operator introduced a series of complementary measures to avoid the occurrence of another similar event, including:

- sprinkling the residue every day at the end of the day;
- limiting the quantities of residue stored on-site by increasing shipping frequency.

The operator also reminded employees of best practices in this field during a meeting convened on the subject of safety.

Causal analysis:

Organisation of controls:
- Insufficient warehouse inspections, especially before periods of closure
- Insufficient controls prior to conducting high-risk operations (e.g. crushing)

Risk identification: Inadequate recognition of risks associated with poor knowledge of the type of waste present at the site

Training: Technicians not properly familiar with the instructions and procedures for sorting/verifying incoming waste

Procedures and instructions: Inefficient procedure for accepting (incoming controls) and sorting waste

Inappropriate human response:
- Unauthorised waste left by a third party
- Incomplete waste sorting prior to warehousing or to a crushing operation

Lower level of activity

Fire tied to the unplanned presence of potentially flammable waste

Recommendations:

- Training personnel on the risks related to an incomplete sorting of waste (e.g. presence of residual capacitors in the crushed WEEE material flows);
- Awareness and reminder of the rules for upstream actors (individuals using dump site services, local authorities, other waste producers);
- Enhanced protocol for accepting and inspecting incoming waste;
- More widespread verifications prior to site closure periods (especially dumps) and implementation of a monitoring system;
- Expanded controls before conducting operations on waste (e.g. crushing).

➢ Accident subsequent to an unexpected chemical reaction during hazardous waste warehousing or handling

This scenario corresponds to the cases of toxic substance emissions, fire or explosion following an unexpected chemical reaction, e.g. an exothermic reaction due to incompatibility. Such reactions may arise either when warehousing hazardous waste or during its handling (including transfer operations).

Fire of hazardous waste following and incompatibility reaction

Examples:

Examples occurring at hazardous waste treatment facilities

ARIA 35036 - Classified Facilities - 23 August 2008 - 62 - BILLY-BERCLAU

Yellow smoke was released around 7:20 pm inside a waste sorting firm specialised in the repackaging of plastic containers (plastic barrels and tanks), located in an industrial zone. Classified Facilities inspectors indicated that this nitrogen oxide smoke was accompanied by a heat release causing a rise in temperature up to 70°C.

The incident stemmed from an overflow of residual products, soda-based for the most part, within a 1,000-litre tank containing acid on the bottom despite being cleaned with water (total liquid volume: 400 litres). First responders divided the liquid contents into several containers and cooled them. This operation took 5 hours to complete. The polluted liquids were held in the retention basins at the facility, which subcontracted the waste disposal mission to a specialist firm.

The site operator provided the Classified Facilities inspectorate with a report on the circumstances surrounding the accident and initiated an employee refresher training on chemical risks.

ARIA 43204 - 18 October 2012 - 45 - COURTENAY

A technician with a company specialised in recycling fouled chemicals packaging emptied the remainder of 2 small (bulk) containers that had previously held an aluminium chloride and iron-based flocculant (pH =1) in the central suction tank. He then drained this tank into a "clean" container slated for destruction; however, this latter vessel still contained residue of 13% sodium hypochlorite. The reaction between the 2 incompatible products triggered a gaseous release. Stressed by the smoke being emitted and experiencing a feeling of suffocation, the technician removed his mask, thus exposing himself to even more vapours. Another employee also felt ill.

Several causes were highlighted: no guidelines had ever indicated use of a clean container to collect the residue of the central suction system; the safety sheet for aluminium chloride-based products was not forwarded by the client; and the danger symbols for this product on the container did not correspond to those listed on the product safety sheet. Moreover, the

technician had not placed his mask properly (lack of training in mask use), and the chemical risk training was incomplete. The operator adopted the following measures:
- renewed employee training in chemical risks;
- renewed training on wearing individual protective gear;
- deployment of individually-assisted ventilation for the 2 technicians assigned to suction the fouled packaging
- reorganisation of the fouled packaging warehouse according to chemical compatibility;
- self-inspection procedure of packaging upon receipt (correspondence between the product safety sheet and the waste acceptance certificate);
- procedure to follow when draining the suction system with control of the "clean" container.

ARIA 44417 - 25 July 2013 - 78 - LIMAY

Reddish (NO_2) smoke was released around 1:30 pm inside a company treating hazardous waste; in-house responders wearing individual protective gear stopped the release by flooding the reactor used to neutralise the waste. The operator confined plant employees and notified neighbouring companies and the local Prefecture; the plume dissipated 20 minutes later, without causing any consequences of note.

Three days earlier, the contents of a lorry containing nitric acid waste had mistakenly been deposited into the "ferrous tank", resulting in an initial NO_2 plume. The technician had identified the malfunction, halted the transfer operation and emptied the remainder of the lorry "into the lagoon" with additional dilution in water. The ferrous tank contents were then neutralised using lime within a dedicated reactor. Difficulties were encountered when transferring tank contents to the reactor due to "regular dismantling" of the transfer pump. Activation of the stirrer once the transfer had ended caused this gaseous release, estimated at 0.1 tonnes of NO_2, which could not be confined since the washing column was undergoing maintenance.

The operator increased the waste analyses to be handled by the supplier and then upon acceptance at the facility, with an additional analysis should the waste be rerouted to the ferrous tank and/or should the stirrer be put to use. Moreover, the operator planned on installing a reactor specifically to treat nitric acid.

ARIA 35435 - 6 November 2008 - 38 - CHASSE-SUR-RHONE

Fire broke out around 6:50 pm at a hazardous waste treatment centre. The heat released broke a fuse wire above the shelves containing combustibles in the storage building, thus tripping an alarm relayed to the control room. Site technicians and a supervisor quelled the flames within a few minutes using foam extinguishers. The operator nonetheless notified the emergency services, given that the cell contained various substances originally disposed at dump sites: bleach jars, sludge with neutral hydroxides, acid solutions, oxygenated water, and big bags of plastic pellets above the crate containing pellets. The 5 individuals present at the time were briefly intoxicated.

The day before, the site had received a 400-litre plastic crate containing combustibles collected from waste dumps. This crate also contained carefully arranged cans of sodium chlorate, which completely concealed the presence at the bottom of the crate of a few trichloroisocyanuric (TCCN) acid pellets used to treat pool water. The investigation conducted by the operator revealed that since the pellet packaging was not properly sealed, TCCN acid debris would have mixed with a reducing agent (a grease-soaked rag). A redox reaction would have slowly triggered, causing a gradual temperature rise until reaching the self-ignition point of the crate plastic (400°C). The accident resulted from a lack of visual control of the contents at the bottom of the crate by the employee responsible for incoming waste, though the control procedure in effect did not call for emptying the crate. The risk of exothermic hazard with the TCCN pellets

did not appear in the site's safety report despite such pellets being received on a regular basis for destruction. The operator revised the site's pellet acceptance procedure and prohibited their warehousing on weekends. Given that this item had proven to be a source of numerous on-site accidents, the operator also established a flow diagram in order to formalise pellet acceptance and treatment.

ARIA 39768 - 22 November 2010 - 02 - BEAUTOR

Around 4 pm, a tanker lorry was delivering used ethanol to a Seveso-rated solvent retreatment site when the shutoff valve of the material transfer pipe system broke with a violent detonation, fracturing an employee's leg.

[...]

The investigation performed by the site operator showed that a chemical reaction within the unloading pipes had caused a quick rise in pressure along with a break at the level of the manual closure valve. This reaction was due to the presence of concentrated nitric acid in the pipes, which in turn reacted violently with the used ethanol being transferred to the bulk storage tanks. This acid stemmed from an industrial test, aimed at neutralising the ethanol odours, conducted shortly before the accident in the compromised pipe, whereas no testing protocol had been formalised following conclusive laboratory tests.

Causal analysis:

Chemical reaction during hazardous waste warehousing / storage

Procedures and instructions:
- Insufficient waste acceptance procedure (e.g. no verification of batteries received at the facility)
- Inappropriate sorting procedure (case of household hazardous waste), potentially leading to prolonged contact between incompatible substances
- Procedure poorly adapted to hazardous waste storage (extended storage, during periods of closure, without monitoring and without any compensatory measures)

Organisation of controls:
- Lack of adequate verification of contents in receptacles coming from waste suppliers
- Weak monitoring, especially during closing times

Choice of equipment and processes: Protocol for storing highly hazardous waste not up to date

Risk identification: Poor perception of risks associated with waste being managed on-site (limited awareness of potential reactions between various types of waste, risk of exothermic reaction not systematically identified even for regular incoming waste), giving rise to inappropriate installation configuration and operating methods (no emergency management for treating certain types of waste so as to avoid their extended on-site presence)

Loss of process control: Mixing incompatible products

Fire subsequent to an exothermic reaction of stored hazardous waste, without adequate monitoring

Lower level of activity

Weather conditions (precipitation - case of outdoor storage zones)

Chemical reaction during hazardous waste handling / transfer

Training: Employees and subcontractors inadequately trained in chemical risks, label reading; no critical assessment of waste delivered by either the transporter or receiving site

Workplace organisation and supervision: Technicians not properly supervised

Procedures and instructions: Insufficient waste acceptance and transfer procedures and not suited to the variability of the items received; ineffectual procedure for cleaning tanks and transfer equipment

Organisation of controls:
- Deficient controls on packaging conditions and techniques for incoming hazardous wastes
- Inadequate controls on the cleanliness of containers prior to their filling, transfer, etc.

Risk identification: No awareness of the importance of drawing up identification sheets; risk of exothermic reaction not addressed in safety reports; lack of familiarity with container product/material incompatibility; sensitive waste left without monitoring and sometimes under substandard safety conditions (outdoors, in the rain)

Choice of equipment and processes: An installation configuration devoid of any physical barrier to a hazardous mix; inappropriate choice of container type or storage locale; unsuitable method for transferring incoming waste

Inclusion of feedback: no acknowledgment of accidents occurring at the waste supplier's place of business or in similar configurations, insufficient information sharing between waste producer, shipper and treatment facility

Inappropriate human response:
- More precaution required when handling hazardous substances / performing an unanticipated handling operation due to:
  - negligence, lack of concentration (transfer into the wrong tank, etc.);
  - poor understanding of the nature and danger of the waste;
  - erroneous interpretation of a label
- Failure to execute a required task (tank cleaning)
- Mistake / malicious act by an upstream actor (e.g. transporter responsible for waste delivery)

Loss of process control: Mix of incompatible products

Release of toxic substances / Explosion subsequent to an unexpected chemical reaction while handling hazardous waste

Recommendations:

- Training of the various responders (technicians, watchmen, etc.) in chemical risks, wearing individual protective gear;
- Improvement of the acceptance procedure (e.g. comparison drawn between the product safety sheet and the waste acceptance certificate);
- Optimal supervision by means of waste handling (transfer/dispensation) procedures;
- Enhanced controls of container cleanliness (absence of residue) / efficiency of cleaning operations prior to material transfer;
- Physical isolation of incompatible products (use of separate premises, with cabinets as needed);
- Improvement of monitoring / sorting upon acceptance in order to route the waste to the appropriate warehouse cells;
- Modification of operating procedures: no warehousing of products that exhibit higher risk during periods of closure (weekends), complete ban on the warehousing of certain high-risk waste (e.g. batteries still fitted with their cables);
- Expanded verifications before periods of closure and enhanced surveillance during such periods;
- Depending on the typology of the waste involved, modification of the transfer technique in order to limit risks (e.g. transfer of used acids from bulk containers using stationary pumps rather than a transfer process that relies on compressed air);
- More efficient controls prior to initiating the transfer operation;

- Coordination pursued with waste producers on identifying substances in a way that avoids confusion: labelling, differentiation between types of containers / couplings with respect to the products;
- Communication addressed to the supplier and shipper, training in the risks of incompatibilities both between products and between products and materials at the various stages throughout the supply chain;
- Revision of the risk analysis (safety report) to incorporate accident patterns (inclusion of the risk of placing incompatible products in contact with one another).

➢ Ignition subsequent to poorly supervised hot spot works

This type of event can arise at any kind of waste management facility. Fires resulting from poorly supervised works are especially frequent within installations handling scrap vehicles, metal waste, and electric and electronic waste. It is quite common that a fire breaks out subsequent to the projection of sparks from cutting/welding operations undertaken without adequate precautions near the storage of metal objects soaked in flammable substances.

Examples:

Example at a non-hazardous waste incineration plant

No. 34628 - Classified Facilities - 14 May 2008 - 78 - GUERVILLE

Fire broke out around 11 pm at an incineration plant inside the hopper feeding a household waste crusher. The alarm was sounded by the foreman, who witnessed large smoke plumes on a video screen. The blaze was brought under control by fire-fighters after a 2-hour battle. The extinction water was stored in the site's retention basin.

During the afternoon preceding the outbreak, repairs were being performed on the hopper, requiring hot spot works. A hot work permit was issued. A residual hot spot had no doubt been created between the chain and the casing subsequent to the projection of a welding spark, despite the regular sprinkling of this working zone. Restarting the hopper gradually reactivated the residual hot spot, until its ultimate ignition.

Subsequent to this fire, the operator adopted the following measures: systematic disassembly of all protective casings on the crusher feed hoppers during hot spot works and more extensive sprinkling of the works zone in the crusher room.

Case at a facility sorting/transferring/consolidating non-hazardous waste

No. 45124 - 31 March 2014 - 18 - BOURGES

Around 2:30 pm, a (welding) maintenance operation was underway at a paper refuse sorting centre when an incandescent drop fell into the pit of the mechanically-powered conveyor belt. Fine particles of paper and cardboard accumulated inside ignited. The employees present in the vicinity extinguished the outbreak using a water hose; fire-fighters were called out of precaution but their response was not necessary. The site operator scoured the pit and sent the burned or wet waste to a certified facility for disposal. The maintenance operation had required a hot works permit and a prevention plan, but both the inspection and preliminary cleaning of the conveyor pit had been overlooked. The operator completed the control and cleaning procedure prior to initiating maintenance.

ARIA 39074 - 14 September 2010 - 78 - EPONE

NAF Code 38.32: Recovery of sorted waste

Subsequent to a delivery lorry breakdown, a tank containing 1 tonne of titanium turnings had been in an extended period of transit since the morning at a metal recycling site. A hot works permitting procedure needed to be applied in the event of being carried out adjacent to a

flammable zone. Ignoring this procedure as well as the verbal instructions, an employee cut out a piece of rebar near the tank. Around 1 pm, a spark reached the tank and immediately ignited the titanium turnings imbibed with solvent. Facility employees tried in vain to put out the blaze using extinguishers, then successfully extinguished it with dry sand extracted from the reserves. Fire-fighters were called as a precaution since the site was open to the public. Instructions were distributed to limit both the time titanium turnings were being handled on-site and public access was restricted to a certain zone of the centre.

ARIA 35115 - 8 September 2008 - 86 - ITEUIL

At a non-hazardous waste sorting centre, fire broke out around 1:45 pm following the projection of sparks originating from the flame cutting of metal parts within a wooden container containing various types of waste. The fire was brought under control by site personnel with a powder extinguisher. Three propane gas bottles and a frame of oxygen bottles used for metal part cutting operations were separated from one another.
Subsequent to this accident, the facility operator adopted the following organisational measures: placement of the container assigned for flame cutting operations at a remote location; and replacement of the wooden container by a sealed PVC model capable of containing a water reserve intended to bathe potentially ignitable waste.

Examples at an automobile scrapyard

ARIA 43723 - 24 April 2013 - 65 - ANGOS

On the premises of a company specialised in collecting metal waste and dismantling scrap vehicles, at around 11:30 am, an employee was using a blowtorch to free a metal strip sandwiched against the pushbutton on a press when a spark ignited a heap of WEEE waste (electrical and electronic equipment). Flames quickly spread to the car bodies. This blaze covered 400 m² and released a sizeable black smoke plume; 3 nearby residents had to remain indoors.
[…]
Use of a blowtorch within a tight space had been decided at the last minute, with no hot works permit being issued.

Causal analysis:


Organisation of controls: Insufficient controls in place both before and after the execution of hot spot works


Workplace organisation and supervision: Oversight and supervision unsatisfactory around working zones


Risk identification / Training: Unfamiliarity with the risks related to hot spots, technicians' incomplete grasp of instructions


Choice of equipment and processes: Inappropriate configuration of installations leading to inadequate separation between work zone and waste storage


Procedures and instructions: Shortcomings in procedures, e.g. no preventive sprinkling, no verification of facility cleanliness prior to conducting a welding operation


Inappropriate human response: Hot spot works carried out without the proper expertise

Fire subsequent to hot spot works

Recommendations:

- Better identification of risks when issuing the hot works permit;
- Improved control and cleaning procedures prior to conducting maintenance works (absence of all waste, containers emptied and cleaned nearby);
- Reinforcement of the applicable procedure throughout the period of hot spot works;
- Removal of recurrent hot spot works zones (e.g. the flame cutting station) from the area devoted to waste storage;
- Isolation of zones designated for the use of tools capable of generating hot spots with respect to warehousing zones;
- Protection of storage facilities (e.g. choice of materials or type of containers to limit risks: tank fitted with a water reserve to extinguish a fire quickly).

➢ Accident (fire, discharge of hazardous/polluting substances) subsequent to malicious acts

Waste management installations are frequently the target of malicious acts. This is especially true in the case of facilities collecting waste with some material recycling potential and a recognised resale value (metals, WEEE, etc.). Completely isolated sites are more vulnerable to these kinds of attacks. We also note cases of malicious acts against sites whose presence is deemed unacceptable by local residents (e.g. incinerator, methanisation unit).

Wire fence cut by intruders

Examples:

Example at a waste dump site

No. 45709 - Classified Facilities - 9 June
Around 4:30 am, an individual called in a fire at a waste dump. Fire-fighters observed that the incident had taken place at the site watchman's quarters, which were also being used to store non-ferrous metals, textiles and recycling materials. The fire was extinguished at 6:30 am by deploying 4 water tanker lorries (as the closest fire hydrant was located 200 m from the site boundary); the intervention was completed by 7:45 am.
The police investigation focused on criminal leads. The building had been forcibly entered via the utility room (the wall around the secure door frame had been destroyed by a chisel). The intruder stole objects intended for recycling before setting the room on fire.
The site operator set up a monitoring system (camera linked to a motion detector).

Example at an automobile scrapyard

ARIA 38989 - 18 September 2010 - 68 - ILLZACH
While stealing automobile parts around 4:45 pm, 2 perpetrators set fire to an automobile scrapyard. The flames spread among a stockpile of 800 vehicles (450 tonnes) heaped onto a 1,000-m² parcel, resulting in a large column of black smoke. Traffic was suspended on the adjacent rail line, and competitors at a petanque (boules) tournament held 300 m away had to be evacuated. A crew of 70 fire-fighters extinguished the blaze on the morning of 19 September using 5 hoses, including 1 cannon. The retention basin filled with 900 m³ of water polluted by burned plastics was at risk of overflowing and polluting the Rhine; river samples were extracted. The site's confinement had proven to be inadequate, as a portion of the extinction water had been channelled to the Rhône-Rhine canal by gravity flow.
The 2 perpetrators were immediately arraigned and sentenced to 2 months of prison without parole for one of them and 100 days of community service for the other.

Example at a waste storage facility

Fire outbreak inside a cell at an underground waste disposal facility
ARIA 32129 - 9 June 2006 - 27 - LA CHAPELLE-REANVILLE
NAF Code 38.11: Collection of non-hazardous waste
Fire broke out around 6 pm in one of the two honeycomb units in Cell No. 1 at an underground waste disposal facility.
[…]

A blaze had ignited at the very same spot on 27 June 2004 and 20 June 2005. Site access was unobstructed; the protective fence could be easily climbed by stepping up on the piezometric well apparatus. Indications of human ingress were found in the grass. The hypothesis of arson seemed the most plausible. The Prefectural order issued after the previous fire mandated the cell's separation into 2 honeycomb units, plus the installation of a permanent monitoring system for the cell as a backup to the rounds currently being performed. However, the contract with the video surveillance firm was cancelled on 20 April 2006. Since then, the videos had been recorded from the watchman's bungalow at the site entrance. During the post-accident inspection, it became apparent that the recordings had ceased on 22 May 2006. After cancelling the surveillance contract, the watchman's rounds were organised: 3 times at night during the week, and 6 times per weekend day.
[…]
Various measures were requested, including the re-installation of a video surveillance system and a sturdier fence.

Causal analysis:

Rather than analyse causes in the strict sense of the term, the vulnerabilities are described below, including those which perpetrators use to commit malicious acts.

Organisation of controls:
- Insufficient fence maintenance and access restrictions
- Lack of proper site monitoring during idle periods

Risk identification:
- Closed sites without effective security
- Protection of vulnerable equipment not commensurate with potential threat

Experience feedback: No attention paid to relayed alerts or experience feedback

Malicious acts for various reasons (theft, protest against an installation considered harmful, act of revenge by disgruntled former employee)

Fire, deliberate discharge of hazardous or polluting substances

Recommendations:
- Install and reinforce fences, and regularly verify their structural integrity;
- Make access control procedures more robust;
- Secure closed or derelict sites: locked out entrances, all residual waste evacuated;
- Implement or enhance instrumented monitoring systems: anti-intrusion alarm, remote surveillance/video surveillance, systems with motion or heat detection;
- Deploy or upgrade site monitoring services (raise the frequency of rounds; ensure the watchman is accompanied by a guard dog);
- Reorganise and secure the warehousing of "sensitive" waste: relocation far from the site boundaries, elimination of open-air storage, if possible, etc.;
- Build awareness in order to avoid intrusions or unintentional harmful acts, e.g. informing dump site users of the risks inherent in discarding prohibited objects;
- Adopt preventive measures to avoid adverse impacts on the natural environment in the event of a malicious act.

➢ Pollution of the natural environment subsequent to a leak, overflow of a fluid storage tank or malfunction of effluent treatment facilities

Pollution of the natural environment may be caused by a dispersion of substances directly originating from the particular waste treatment process (leachates, digestate, etc.) or by polluting products like hydrocarbons.

Runoff of polluting substances in a ditch

Examples:

Example at a facility sorting/transferring/consolidating non-hazardous waste

No. 39892 - Classified Facilities - 14 October 2010 - 44 - LA CHEVROLIERE

Around 4:30 pm, a hiker detected an abnormal whitish colouration in a pit fed by the GRANDLIEU Lake (a designated Natura 2000 zone). He notified the local authorities, which in turn alerted the emergency services. This municipal pit collected rainwater from the adjacent industrial zone, which accommodated a facility specialised in washing large industrial plastic packaging. The whitish discharge stemmed from this site's stormwater discharge point and polluted the pit over a 120-m length. The municipal response crew installed a downstream dam to limit pollution of the lake water. The investigation conducted by the Classified Facilities Inspectorate indicated that the contents of a tank had overflowed onto a zone where rainwater typically ran off. This water was normally treated prior to discharge, but the site's rainwater lift pump was inoperable (electrical malfunction) and could not channel effluent to the activated charcoal treatment zone. The effluent discharged therefore only underwent a screening prior to a gravity flow discharge into the environment, and the operator failed to use the inflatable plug system to prevent pollution from exiting the site.

Example at an automobile scrapyard

ARIA 42617 - 24 April 2012 - 40 - DAX

Around 2 pm, hydrocarbon pollution was discovered around two water retention basins. The watercourse feeding these basins also showed signs of iridescence. The pollution source was identified at the discharge pipe of a recycling company specialised in metal reuse and salvaging scrap vehicles. Following heavy rains, two underground tanks used to recover miscellaneous fluids overflowed into the ditch due to a defective float. The site operator commissioned a specialist firm to pump the tank's hydrocarbons and agreed to clean up the environmental damage.

Example at a methanisation unit

ARIA 45391 - 5 June 2014 - 32 - AUCH

A sludge and liquid digestate storage tank, without any complementary retention, overflowed around 8 am at a methanisation (biogas) unit. The material spread over the ground, flowed along the embankment bordering the road and reached the storm drain network. Site personnel noticed the leak at 8:30. The tank contents were transferred into another vessel in order to stop the spill. The operator erected a sand bund wall to patch the leak. The effluent and washing water were routed to a

stormwater storage basin in the industrial zone, considerably increasing its suspended solids (SS) concentration. The tank overflowed again on the morning of 9 September.
After these events, the operator cleaned the parcels fouled by these flows and sent the waste to a specialised centre for treatment. The stormwater basin was drained and then scoured. The pumped water was reused within a designated company process.
The tank had overflowed due to foaming. The level detection had remained insensitive to the presence of foam induced by a polymer present in the liquid digestate; hence, no high level alert was sounded.
Subsequent to this event, the operator undertook the following:
- plugging the stormwater basin overflow outlet by means of an inflatable system;
- draining and isolating the tank responsible for discharging the pollutant material.
Classified Facilities inspectors also requested that the operator draw up an assessment of the site's other storage vessels capable of polluting the natural environment and, should a non-compliance be detected, plan a series of corrective actions. In particular, the storage tanks needed to be fitted with a retention basin.

Example at a storage facility

ARIA 44243 - 8 June 2013 - 64 - SAINT-PEE-SUR-NIVELLE
During the night of June 8 to 9, the combination of heavy rainfall (94 mm) and obstruction of a stormwater discharge pipe upstream of the site caused the gravity flow of rainwater into the first leachate storage basin of a household waste burial facility (ISDND designation). This basin, already nearly full due to the exceptional rainfall during the previous days and months, overflowed into a second basin that was also nearly full (holding a combined 1,000 m³ of residual water), resulting in runoff downslope into a pond.
[…]

Causal analysis:

Organisation of controls:
- Insufficient monitoring of liquid waste storage containers, leachate basins or other equipment with the potential to cause a pollution incident
- More robust controls needed for pollution prevention devices (scrubber, oil separator, valves, etc.)
- Condition of the sealant system (geomembrane) not adequately controlled

Choice of equipment and processes:
- Lack of structural features to combat pollution (retention basin)
- Suboptimal storage tank design (e.g. incorrectly sized overflow vents), level probe malfunctions, etc.

Training: Technician without proper understanding of the operating principle for the various tank valves

Equipment deficiency:
- on a sealant system item (e.g. geomembrane, retention basin)
- overflow of a settling basin-oil separator, defective float, etc.

Inappropriate human response: Valves left open

Malicious act: Deliberate discharge of polluting substances

External event: precipitation leading to the overflow of a waste storage tank, hydrocarbons, etc.

Loss of process control: Polymer causing the untimely foaming of digestate

Water or soil pollution

Recommendations:

- Stronger control and maintenance procedures applied to discharge treatment systems;
- More robust safety equipment associated with the storage facilities: larger vent diameter, high level alarm relay to the on-call technician;
- State-of-the-art control and maintenance of the relevant equipment: settlement tank, oil separator, float, etc.;
- Ongoing monitoring of the leachate basin level in order to avoid overflows during rain events (adaptation of treatment capacity to better match the flows);
- Installation of aquatic pollution protection systems, e.g. plugging of the stormwater basin overflow outlet via an inflatable system;
- Improved procedures for limiting adverse environmental impacts in the case of a loss of confinement: efforts required to ensure a more reactive response.

➢ Machinery fire subsequent to an electrical or mechanical problem

All waste management facilities, especially those relying on a great number of machines and equipment (sorting, treatment, recycling, etc.) are prone to fire erupting on the equipment as a result of defects (e.g. electrical malfunctions or mechanical heating).

Cables burnt after a fire of electrical origin

Examples:

Case of a non-hazardous waste treatment plant

No. 35995 - Classified Facilities - 19 March 2009 - 74 - GROISY

At a metal waste recycling company, fire broke out around 4 pm on the electrical board of a press and spread to the hydraulic mechanism; 1 employee sustained burns to the forearm and required hospitalisation. Fire-fighters extinguished the blaze with a 500 litre/min variable-flow hose and 2 foam hoses. The extinction water was recovered in an on-site confinement basin. No leak was observed on the 6,000-litre hydraulic oil tank or on the 10,000-litre used oil tank.

Case of a hazardous waste incineration plant

No. 39658 - 27 January 2011 - 13 - FOS-SUR-MER

An electrical fire broke out around 6:30 am in a utility room of an industrial waste incineration plant containing a 50% sodium storage facility. The operator notified first responders using the direct phone line and activated the site's internal emergency plan.

[…]

The ignition appears to have been caused by the electrical resistances for the heating of tanks during cold spells in order to prevent the sodium from crystallising.

The site operator proceeded to: install smoke detectors in the sodium storage room, modify the sodium concentration during winter (30% instead of 50%) to mitigate the crystallisation phenomenon during cold spells, and maintain heating at > 5°C in the utility room.

Causal analysis:

Organisation of controls: Inadequate maintenance and monitoring of equipment, to a point of preventing the early detection of deterioration / vulnerability

Choice of equipment and processes: Deficient equipment protection (e.g. electrical cabinets)

Procedures and instructions:
- Equipment operating procedures not compliant with manufacturers' specifications
- Insufficient control and maintenance conditions stipulated in the procedures

Risk identification: Lack of sufficient awareness of the risks associated with machinery, including elements not directly involved in the waste management process; no steps in place to manage facility ageing

Faulty equipment: electrical or mechanical problem

Equipment fire

Recommendations:
- Improvement of the equipment verification and maintenance programmes to better manage their ageing, prevent their deterioration and spot defects as early as possible;
- Regular electrical inspections
- Compliance with the equipment operating protocols, manufacturers' instructions (avoidance of excessive loads, etc.) to avoid the occurrence of malfunctions or blockages capable of leading to heating.

➢ Presentation of a few scenarios specific to certain activities

Composting

Self-heating of a stockpile of screening refuse (ARIA 35496)

Fire on a stockpile of compost or compostable waste

The accident scenario here is comparable to similar ones encountered in waste consolidation/warehousing activities, but the causes giving rise to the hazardous phenomenon differ due to the procedures specific to treating compost.

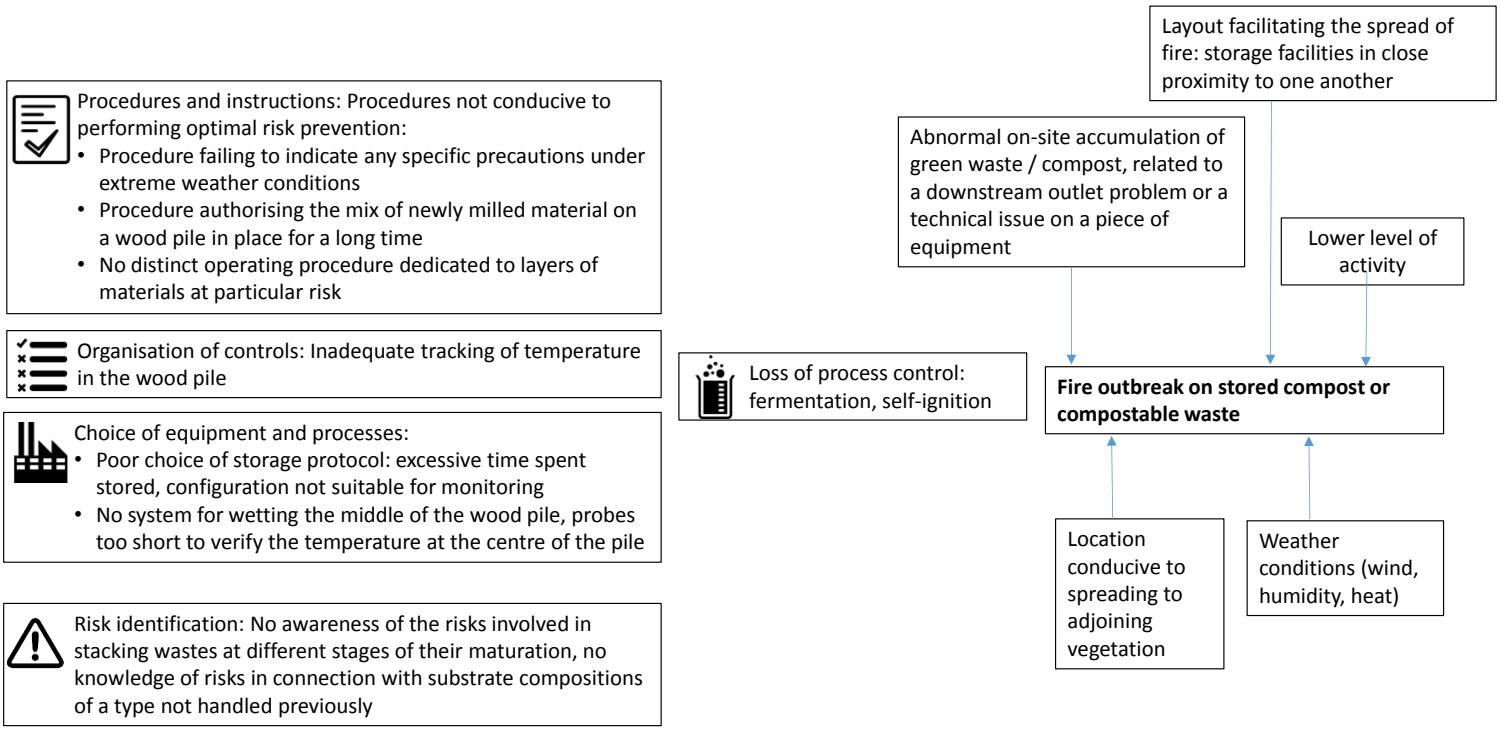
Example:

ARIA 45868 - 20 September 2014 - 91 - WISSOUS

On a Saturday around 3:30 pm, the watchman at a paper recycling plant noticed a whitish plume of smoke rising from the neighbouring green waste recycling company (closed that day). Fire-fighters reached the scene before the site's operator. The smoke originated from the flameless outdoor combustion of a pile of wood chips of 100/150 mm (intended to feed biomass boilers). Fire-fighters used the site's fire water reserve and extinguished the blaze at around 7 pm. The site's tyre charger was used to isolate the substances affected by the fire from the rest of the pile. A monitoring system was installed by the operator for the following night in order to avoid any recurrence of fire.
The extinction water was held in the retention basin. The combustion residue was incorporated into the compost, and analyses verified that the compost still respected the standard.
Weather conditions may have caused the outbreak: a 20 km/h wind, low humidity, temperature above 27°C having stimulated the onset of fermentation. The temperature reading of the heap from the previous day was normal (readings recorded every other day on the wood pile). It was still possible however that the reading had not been taken at the centre of the pile due to its width, which prevented detection of the resumed fermentation.
The operator modified the piles (transformed into triangles 4 m wide and 3.5 m high and no longer in the wider tubular form) and their isolation distances (1 m between each pile) in order to facilitate temperature control readings in the middle of the pile. Moreover, the fire water reserve indication was improved.

Other examples: 35796, 45868, 45722, 46021

Causal analysis:



As regards the "weather conditions" type of exacerbating factors mentioned above, we note the example of rainfall: humidity accelerates the degradation of waste (methanisation) and makes it more flammable.

Recommendations:

- Isolation of the waste capable of reacting with one another (very dry screening debris, wet milling waste);
- Modification of the operating procedures: limitation of the time spent in static storage, increased frequency of returning and sprinkling the materials, more frequent temperature controls during unfavourable weather conditions, modification of the shape of piles, greater safety distances, ban on mixing milling residue at the various stages of fermentation;
- Acquisition of devices adapted to performing controls (e.g. sufficiently long temperature probes).

Incineration

The focus here is on the incineration process (for either hazardous or non-hazardous waste) in the strict sense of the term. Accidents occurring during waste warehousing and prior to their combustion are treated as generic scenarios (e.g. waste ignition before being inserted into the incineration furnace, related to the accidental presence of non-compliant waste or the extended storage of fermentable waste under inadequate safety conditions).

Explosion within the copper furnace of a hazardous waste incinerator (ARIA 45127)

Explosion caused by inadequate procedures for controlling and maintaining combustion / smoke treatment equipment or inappropriate structural detailing

This scenario pertains to cases like explosions subsequent to a disaggregation of clumps of dust or substances (fouling), clogging in the waste loading hopper prompting the formation of CO combined with an undetected malfunction in the temperature probes, etc.

Example:

ARIA 45999 - 7 September 2014 - 63 - CLERMONT-FERRAND

On a Sunday inside a non-hazardous waste incinerator, a major pressure surge occurred around the furnace combustion chamber. This surge caused: the automatic safety devices to trigger on the installation; a spattering of waste at the outlet of the slag extractor, opening of the safety rupture discs located underneath the incineration furnace grating; and opening of the boiler expansion vessel hatch. Untreated smoke was thus discharged for several minutes via the rupture discs and expansion hatch. This release was noticed by local residents.

[…]

The incinerator operator conducted an analysis of the event in conjunction with the builder. The pressure surge appears to have been caused by a large quantity of materials falling onto

the furnace grating and inside the slag wells. These falling objects exerted a "piston" compression effect on the gas contained in the slag wells.
The operator performed comprehensive maintenance of the boiler expansion hatch. During the subsequent programmed shutdown, the operator proceeded to open the boiler in order to visualise the zones where ash was clumped. No anomaly was apparent but it was noted that the boiler was clogged with soot and so it was cleaned. Some of the combustion regulation parameters were modified (height of waste layer on the initial rollers, primary air regulation, mapping of the secondary air intake, furnace depressurisation).
Moreover, to better ensure technicians' safety, the operator: oversaw closure of the guillotines located inside the slag wells for all works carried out in front of the extractors (in order to avoid personal injuries in the event debris is sprayed), installed chains to hold the skips in place and prevent any tipping, and created a protected pedestrian crossing.
An explosion, followed by fire, had already occurred in this incineration furnace just a few months prior (ARIA 45433).

Other examples: ARIA 34973, 45433

Causal analysis:

Organisation of controls: Insufficient control and maintenance of smoke combustion and treatment equipment
- Insufficient inspections, thus failing to detect flaws before they degenerate
- Insufficient verifications of the effective operation of safety equipment (e.g. temperature sensors)

Choice of equipment and processes:
- Poor building layout, poor choice of plant equipment
- Technical options preventing risk mitigation (e.g. soda concentration and temperature)
- No servo-control of equipment operations to safety measure operations, detectors missing at critical locations

Risk identification: Unfamiliarity with inherent risks, e.g. those associated with the fouling of equipment

Faulty equipment: Hopper clogging, temperature probe malfunctions

Inappropriate human response: Inadequate cleaning of equipment (boiler)

Explosion of smoke combustion or treatment equipment

Recommendations:

- Structural modifications
- Technical modifications: adaptation of the combustion parameters
- Improvement of installation safety through optimised servo-controls.

Incineration furnace explosion due to the presence of non-compliant waste

This scenario pertains to the case of explosion when the furnace contains exogenous non-compliant waste (which should not have been sent via this treatment stream) or non-compliant waste with respect to the specifications authorised at the outset (whereby waste preparation handling, conducted on-site prior to incineration, has been incorrectly performed).

Example:

ARIA 33535 - 29 August 2007 - 51 - REIMS

NAF Code 38.11: Collection of non-hazardous waste

Around 8:30 pm, an explosion occurred inside furnace no. 1 of a municipal waste incineration plant. Non-compliant waste (gas bottle, munitions) seems to have caused the explosion. Pressure loss led to a large water leak in the boiler and necessitated the emergency shutdown of line no. 1. A portion of the incinerator smoke was discharged into the atmosphere without any treatment. The household waste was buried at a dumpsite until the furnace was repaired.

According to the plant operator, the explosion in the furnace deteriorated the boiler tubes over a 30-cm height (value recorded during the initial survey inspection).

Other example: ARIA 45127

Causal analysis:

Organisation of controls: Insufficient verification of the type of waste prior to placement inside the furnace

Procedures and instructions: Inappropriate operating protocol for preparing waste (e.g. failure to completely drain bottles that had contained hazardous products)

Inappropriate human response:
- Dispatching of prohibited waste to the incinerator by an upstream actor
- Inadequate verification of incoming waste, improper preparation of waste for incineration

Explosion inside an incineration furnace due to the presence of non-compliant waste

Recommendations:
- Modification of the control procedures for waste inserted into the furnace
- Modification of the operating protocol for preparing hazardous waste before insertion into the furnace.

Release of toxic substances subsequent to the accidental mix of incompatible products during the transfer of reagents used to purify burned gases

Like in the majority of industrial activities, material transfers may prove to be a risky step if the substances involved are potentially hazardous. There are recurring cases of accidental mixing leading to toxic releases during the delivery by external shippers of reagents vital to facility operations (e.g. hydrochloric acid, sodium hypochlorite).

Examples:

ARIA 43406 - 19 November 2012 - 77 - VAUX-LE-PENIL

A driver was delivering a 25% hydrochloric acid (HCl) solution at a household waste incineration plant around 8 am. The lorry was transporting three 1,000-litre bulk acid tanks and one 10% sodium hypochlorite (NaClO) bulk container within the same compartment. After connecting the transfer hose to the plant's acid tank, he mistakenly hooked up the other end to the sodium hypochlorite container intended for another client and initiated the transfer. As 200 litres were transferred, the site's agent in charge of materials delivery noticed around 8:15 am a chlorine (Cl_2) release from the tank and proceeded to check the filling level. He suspended the operation and sounded the alarm. Despite wearing individual protective gear (cartridge mask), the driver felt ill from the release but managed to clear out of the transfer zone on foot. Notified by the operations manager, fire-fighters and the municipal police arrived on the scene. A safety perimeter was established within the transfer zone. It was decided to let the reaction end on its own since no operable stirring mechanism would worsened it. The driver remained under observation at the hospital and was issued a one-week work leave. The 1,500 litres of on-site HCl were fouled and had to be removed for destruction; the tank was thoroughly rinsed. The ion-exchanging resins used to prepare the site's demineralised water were rendered unusable. The operator called on a mobile demineralisation unit (lorry-operated) to cover for the time it took to replace the resins. It was observed that the HCl and NaClO bulk tanks are identical and feature the same transfer couplings. Moreover, the driver's mask was inefficient, as the cartridge had already been used for several days. The supplier implemented a checklist procedure prior to all transfers performed on a client's premises and circulated an internal memo regarding this accident.

Other example: ARIA 44469

Causal analysis:

Training:
- Unfamiliarity with the risks of product incompatibility
- No critical review (by either the shipper or the operator of the incinerator receiving the transferred products)

Procedures and instructions: Transfer procedure failing to specify verifications to perform, precautions to take

Organisation of controls: Insufficient control over transfer operations, inadequate supervision of the tasks conducted by both the shipper and incinerator facility operator

Choice of equipment and processes: Technical choices that introduce risks of errors (e.g. lack of differentiation in the packaging of various products, deficient labelling)

Inappropriate human response: delivery technician error during the transfer operation, e.g.:
- connection error
- wrong product transferred

Release of toxic substances subsequent to mixing incompatible products while transferring reagents

Recommendations: Accidents are typically associated with an error that can be traced back to the chemical product supplier (labelling error, inappropriate packaging) or the driver assigned the delivery (handling error). Consequently, the incineration plant operator's only course of action is to reinforce controls and supervision during the critical transfer step and encourage upstream partners to implement their own measures (procedures, training, etc.) to avoid encountering such problems.

- Working in coordination with chemical product suppliers on substance identification so as to avoid confusion: tagging, differentiation of types of containers/types of couplings based on the product;
- Communication on risks with both the supplier and shipper;
- Training in the risks of incompatibility both between products and between products and materials along the various steps of the supply chain;
- Improvement of controls prior to beginning the transfer operation.

Falling into the waste pit

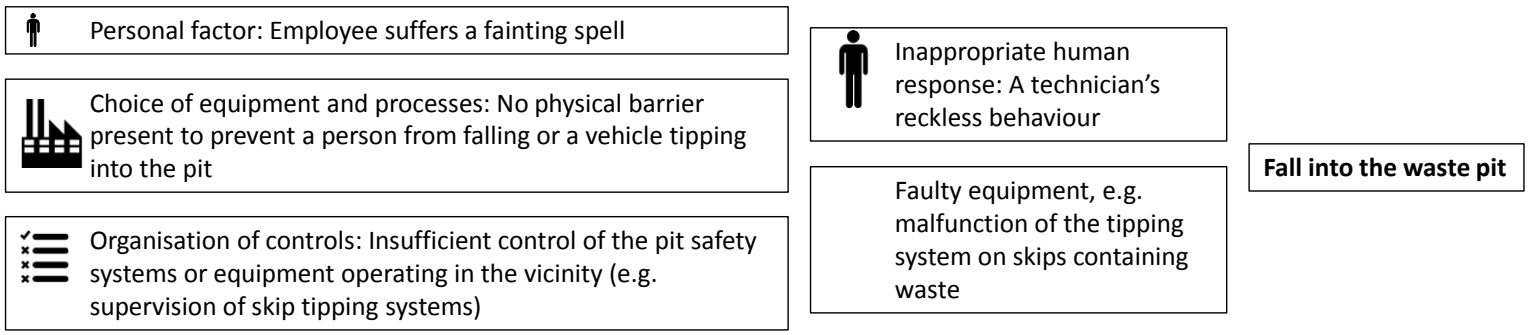
The accident statistics on incineration installations include several workplace accidents, particularly the case of falling into the waste pit.

Example:

ARIA 32381 - 18 October 2006 - 91 - VILLEJUST
An employee fell 4 meters to his death into a waste pit at a household waste incineration plant. The young man was found unconscious and died 1 hour after first responders removed him from the pit. The cause of death was undetermined, but the waste fermentation process was releasing toxic gases, including CO and H2S. His fall might have occurred due to fainting.

Other example: ARIA 33612

Causal analysis:



These events are often correlated with a combination of personal factors (lack of vigilance, fainting, etc.) as well as equipment factors (malfunction of the lorry tipping mechanism, absence of systems performing the role of physical barrier to prevent the risk of falling).

Recommendations:

- Improved tipping system controls;
- Introduction of physical protection barriers.

Landfill

Damage to the geomembrane and geotextile during a fire at a landfill (ARIA 42875)

Fire subsequent to the ignition of waste in a storage cell or honeycomb system

The scenario described in this section relates to scenarios with similar degradation mechanisms potentially encountered in waste consolidation/handling activities. However, highly specialised configurations related to both hazardous and non-hazardous landfill sites warrant a distinct review.

Example:

ARIA 34556 - 31 December 2007 - 78 - BRUEIL-EN-VEXIN

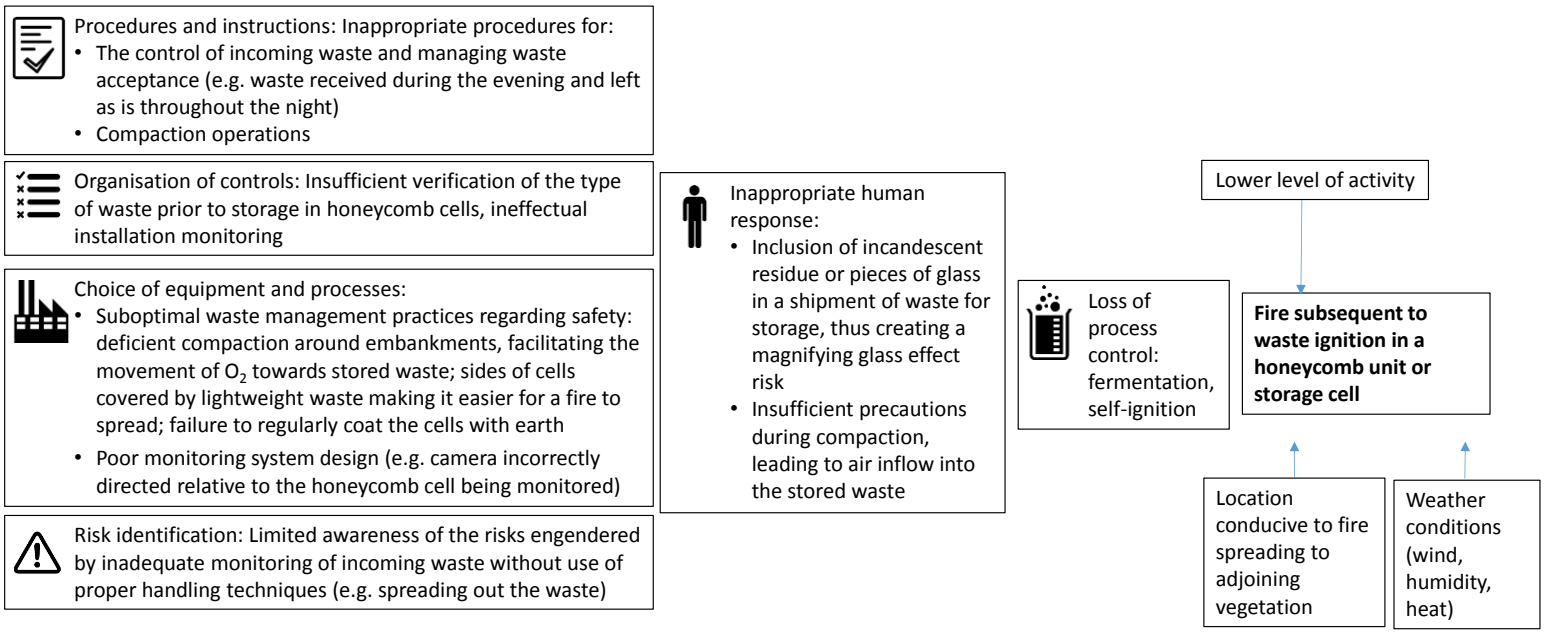
Around 7 am, fire combustion was discovered at a non-hazardous waste landfill. The outbreak affected the south-eastern embankment of cell No. 1, where white smoke and no flames were observed. The hot spot was located 10 m deep. The waste excavated from the fire risk zone was wetted and then spread and covered with fine sand.

The source of this fire may have been flawed compaction on the embankment slope, thus favouring the flow of oxygen to the waste, combined with the presence of mechanical or electrical sparks upon waste compaction.

Subsequent to this fire, the site operator adopted the following measures: restoration of the embankment with the addition of fine sand; and improved compaction and installation of a piezo-gas lighter to monitor CO trends over several months in the affected zone.

Other examples: 34639, 42875, 37851, 39951, 40347, 43413

Causal analysis:



As regards the "weather conditions" type of exacerbating factors mentioned in the causal analysis, we note the example of rainfall: humidity accelerates the degradation of waste (methanisation) and makes it more flammable.

Recommendations:

- Modification of operating procedures: more frequent compaction, waste acceptance solely during the morning hours, spreading prior to burial in order to detect any hot spots, covering as burial is progressing;
- Special procedure for heat waves;
- Enhanced thermographic controls, infrared camera equipment;
- Additional monitoring resources, especially during periods of closure;
- Reminder of fundamental rules to all upstream actors;
- More robust controls upon acceptance, associated with appropriate technician training.

Treatment of animal by-products

This section pertains to warehousing and treatment activities specialised in animal by-products. Several accident scenarios presented in the sections "Generic accidents" and "Waste collection / consolidation" also apply to waste of the "animal by-product" type. This section will focus solely on a typology of accident that remains in large part specific to this segment.

Storage of animal by-products (DR)

Intoxication from hydrogen sulphide

The release of hydrogen sulphide (H_2S) is inherent in the degradation of animal by-products. The accidents considered in this section pertain to cases of human intoxication by H_2S due to insufficient precautions taken during operations at the warehouse and treatment facilities devoted to this type of product. The accidents recorded are classified as workplace accidents.

Example:

ARIA 38390 - 10 September 2008 - 01 - VIRIAT

At a rendering plant, a metal plate became stuck inside a pit where animal carcasses were handled. The operation was being monitored by 2 employees, who decided to remove the plate. While one of them was looking for a sling, the other one tried to remove it manually. With 18 years of experience at the site, he was wearing a filter mask (but not an insulation mask) but was not equipped with a gas detector nor was he attached; he fell into the pit. Fire-fighters were unable to rescue him, noting the technician's death by hydrogen sulphide (H_2S) intoxication. The autopsy revealed an H_2S concentration in his blood of more than 20 times the lethal dose.

In its verdict issued on 10 December 2009, the Bourg-en-Bresse Criminal Court found the company's 2 managers guilty of manslaughter and sentenced them jointly and severally to a €30,000 fine, two-thirds of which was suspended. Over the course of the trial, it became apparent that the company had not drawn up any safety documentation.

Other examples: ARIA 17761, 28408, 31000

Causal analysis:

Human factor: overconfidence (case of technicians with experience in the field)

Workplace organisation and supervision: Insufficient supervision of employee behaviour

Choice of equipment and processes: Malfunction or inappropriate design of safety features:

- Malfunction of the waste pit cover closing system
- Absence of a fall protection installation
- Poor performance of the stale air extraction system

Risk identification: Limited awareness of risks, capable of leading to inappropriate structural layout, insufficient safety documents and individual protective gear

Inappropriate human response: unsafe behaviour, placing a technician in contact with H_2S

Release of hydrogen sulphide, followed by intoxication

Recommendations:

- Employee training in toxic risks;
- Structural modifications (fall protection barriers)
- Improved safety equipment made available to technicians: portable detector, better adapted individual protective gear (e.g. mask);
- More robust response procedures (obligation to be attached when working in the vicinity of storage tanks, etc.).

Recurrent exacerbating factors:[9] Circumstances leading to increased magnitude or consequences of events

An analysis of accidents occurring during various waste management activities has allowed us to identify recurrent exacerbating factors, particularly pertaining to fire phenomena. These factors contribute to the spread fire, hence worsening its consequences which would have been easier to control in the absence of such factors.

Such factors may exist:

- **when weather conditions are unfavourable**
    - intense heat rekindling fire embers;
    - strong swirling wind facilitating the spread of fire.

- **when the operating conditions implemented on-site are suboptimal in terms of safety. This may be the case on either a permanent or temporary basis** (e.g. degraded operating conditions due to a saturated downstream outlet, extended equipment down time, etc.):
    - unauthorised warehousing of waste, storage in excessive quantities perhaps even above authorised quantities;
    - time spent in the warehouse exceeds the norm;
    - layouts favourable for fire to spread, e.g. short isolation distance between the various storage sites;
    - modifications relative to the characteristics of waste typically stored;
    - lack of vegetation removal at the site periphery, thus raising the risk of propagation.

- **on a site not adequately monitored**, especially during periods of reduced activity (evening, night-time, weekends, period of closure, employee break times, etc.):
    - absent or insufficient guard duty;
    - monitoring system unsuitable or deficient;

  This exacerbating factor affects all hazardous phenomena, e.g. self-heating on waste pile storage (centre for waste consolidation, composting, storage, etc.), i.e. those hazardous phenomena whose primary cause is not faulty human intervention.

- **on a site located in a forested setting**
    - risk of fire spreading to the natural environment;
    - exposure to external fires.

- **on a site with inappropriate fire-fighting resources or conditions available to first responders**
    - insufficient water reserves, lack of extinction equipment, fire hoses;
    - absence of extinction agents adapted to the type of on-site waste;
    - cluttering of the site, thereby complicating response efforts;
    - log of hazardous products stored on-site not available at the time of the accident (e.g. due to an electrical outage preventing access to the computer network).

  For the exacerbating factors that the site operator might be able to control (which by definition exclude weather phenomena or adverse impacts of the natural environment, etc.), a set of recommendations are provided along with the data sheets specific to each activity as well as in the summary table, all of which are listed in the Appendix.

[9] An exacerbating factor is a causality chain that worsens the consequences of an event without modifying its underlying nature. Even without the exacerbating factor, the event would still have taken place.

A common set of deep-rooted causes

Regardless of the particular activity, the origin of these accidents may be explained by basically similar deficiencies and causes.

PRIMARY CAUSES
As regards the primary causes, **nearly all accidents can be explained by one of the following events:**

- **loss of process control (self-ignition reaction, incompatibility reaction);**
- **equipment defect (malfunction, short-circuit, wear, etc.).**

Generally speaking, the operational failures listed above **can be traced, at the primary level, to inappropriate human intervention;**

- whether such intervention is conducted contrary to safety guidelines:
  - **mandatory action poorly executed** (insufficient verification of incoming waste, incomplete sorting, loss of control over hot spot works, etc.);
- or whether such intervention was not carried according to schedule, or whether maintaining a sufficient safety level was required:
  - **mandatory action not executed** (deficient maintenance and lack of identification and/or repair of a physical flaw, equipment cleaning not performed, etc.);
- or whether it should not have been conducted, including by a subcontracted third party outside the installation.
  - **Non-required action executed** (routing of an unauthorised hazardous waste to a dumpsite, etc., malicious act).

DEEP-ROOTED CAUSES
As a backdrop to these human failings lies a series of deep-rooted causes. **The same factors are** almost systematically **found to be at fault in all the standard accident scenarios associated with the various waste management activities.**

Accident situations often reveal problems at the organisational scale (**organisational factors**) involving:

- **training:** employees with inadequate skills or who have failed to assimilate the incoming sorting/verification procedures, lacking sufficient knowledge of the risks associated with the waste handled (chemical risk, combustion potential, etc.), rules relative to labelling, etc.

- **procedures and instructions:** incomplete or inappropriate procedures mainly regarding the protocol for approving/accepting, sorting and warehousing waste; insufficient maintenance procedures revealed by accidents due to an equipment deficiency; procedures lacking compensatory measures under degraded situations (e.g. time spent in the warehouse longer than usual), etc.

- **organisation of controls:** faulty controls, notably at the end of a shift or before closing the site, leading to operational breakdowns during periods without monitoring; incomplete verifications when waste arrives at the site or before and during operations with a high level of risk; insufficient monitoring of installations and equipment incapable of identifying deficiencies before they degenerate, etc.

- **workplace organisation and supervision:** insufficient oversight of facility technicians or subcontractors, especially when performing high-risk operations

- **the choice of equipment and processes:** installation configurations not offering optimal safety level; warehousing or management procedures incompatible with the type of waste (separation distance, type of containers, etc.); technical or design choices not suited to mitigating risks; operations equipment not servo-controlled by technical safety barriers; devices unable to perform monitoring with respect to the type and configuration of waste warehousing (e.g. overly short temperature probes); transfer methods incompatible with the type of waste, inappropriate equipment design giving rise to a latent hazard (material accumulation in an elbow), absence of a physical human protection structure (railing to prevent falls near waste pits), etc.

- **risk identification:** insufficient attention paid to the hazard potential of waste handled or warehoused; an incomplete risk analysis revealed by insufficient oversight, notably during degraded operating situations (extensive warehousing, extended transit, etc.); the absence of detection at critical spots; a safety review failing to account for all scenarios (incompatibility between products and products/materials), etc.

- **incorporation of experience feedback (REX):** failure to act on lessons learnt from past events, with accident recurrence being relatively frequent at certain types of installations.

In addition – whether or not efforts are made by the organisation – purely **human factors** may play a role: overconfidence (experience in the profession), negligence, illness/fainting, etc.
Lastly, **random factors** cannot be ignored: errors stemming from the waste supplier, hazard characteristics of the substrata sent for treatment not communicated by the supplier, malicious acts, etc.

Conclusion

The diversity of waste management activities leads to diversity in foreseeable accident scenarios. For each accident configuration, both technical and organisational measures adapted to the risks must be implemented to ensure prevention and protection. Targeted efforts concerning operational practices should make it possible to avoid a large share of the accidents and incidents which are still too frequent in waste sector activities.

The identification of a few recurrent scenarios does not eliminate the need to conduct a complete risk analysis of each special case in order to allocate the appropriate resources to counter any potential operational failures, including unexpected ones. In a fast-changing sector like waste treatment, where innovations are continually emerging to improve treatment and recycling efficiency, special vigilance must be focused on the risk of accidents associated with newly-developed activities and processes.

TECHNOLOGICAL ACCIDENTS ONLINE

Safety and transparency are two legitimate demands being imposed by our society. As such, since June 2001, the website www.aria.developpement-durable.gouv.fr hosted by the Ministry of the Environment, Energy and the See has been proposing to both professionals and the general public many lessons drawn from analyses of technological accidents. The main headings of this site are presented in both French and English.
Under the general headings, site visitors have the opportunity to: consult a plethora of information, e.g. on governmental action; access extensive extracts from the ARIA base; and discover the presentation of the European scale of industrial accidents; learn about the index relative to hazardous substances released in order to complement "on-the-spot reporting" in the event of an accident or incident. The description of accidents, as the raw material of any feedback-driven approach, makes up a significant portion of the site's resources: event sequencing, consequences, sources, circumstances, identified or assumed causes, actions taken, and lessons learned. Some 100 detailed and illustrated technical datasheets present the accidents selected to benefit from their lessons. Many analyses by theme or industrial sector are also available. The heading dedicated to technical recommendations is broken down by various topics, e.g.: fine chemistry, pyrotechnics, surface treatment, silos, tyre warehouses, hot work permitting, waste processing, and material handling.
A multicriteria search pulls up information on accidents that occurred in France or abroad. The site www.aria.developpement-durable.gouv.fr is continually being expanded. For now, some 47,000 accident entries appear online, while new thematic analyses are regularly uploaded.

To submit a comment or suggestion, to notify of an accident or to obtain permission to use this data for publication purposes:
barpi@developpement-durable.gouv.fr

The summaries of all events presented are available on the following website:
www.aria.developpement-durable.gouv.fr

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