Striking a balance between prevention, mitigation and intervention

Break in an underground storage pipeline

ARIA 38242 - 01/05/2010 - 04 - Manosque

52.10 - Warehousing and storage

Around 7:20 pm, at the time of injecting naphtha originating from a refinery, a steel pipeline (DN 500-62 bar: 7 mm thick) burst open at a site dedicated to underground hydrocarbon storage using saline cavities in the heart of the Luberon Natural Park. A deafening sound combined with a sudden drop in pressure caught the attention of employees. Some 400 m^3 of naphtha flowed through the opening towards a 5,000-m^3 capacity retention basin located several hundred metres downstream; from this basin, a total of 200 m^3 of product spilled out via 2 sluice gates that had remained open and that would only be closed 27 minutes later.
The internal emergency plan was activated around 7:30 pm. Site personnel were evacuated, and the attendant fell ill and had to be hospitalised.
Faced with the risk of igniting a flammable cloud that had formed along the naphtha path, the local prefecture convened the emergency response unit and initiated the external emergency plan at 10 pm; 75 fire-fighters, a chemical emergency squad, another specialised pollution cleanup team and some 20 gendarme were all deployed. A 1,000-metre safety perimeter was implemented, traffic in the vicinity was closed on two thoroughfares, and 282 residents from two localities were evacuated. Rescue workers spread a foam blanket over the surface of the liquid contained in the retention basin and installed water curtains to dissipate the cloud. Two fire-fighters feel unwell and placed under oxygen assistance.
Four containment booms were installed on the AUSSELET and LARGUE streams, both of which were heavily impacted over a 5-km length. By 4 am the following morning, the majority of residents had returned to their homes, though water pumping was suspended in three nearby municipalities.
A specialised subcontractor pumped 150 m^3 of the naphtha. Once the cloud had been dispersed, the external emergency plan was lifted at 6 pm the same day, and the last few evacuees were allowed to return home.
The land area surrounding the defective pipeline buried 2 m deep was excavated; a 3-m long opening was identified on the lower generatrix between 2 girth welds. The facility connecting the pumping station with the storage well, retested and certified in 2003 at 73 bar, was equipped with cathodic protection.
Impacts on flora and fauna were observed in pristine and protected natural sites (death of mammals, amphibians and invertebrates); an assessment was subsequently conducted (fauna, flora, water, sediments, soil/subsoil, ecotoxicity and genotoxicity), accompanied by enhanced monitoring of both surface water and groundwater resources.
An appraisal of the defective pipe segment revealed a "cavernous" type of corrosion (i.e. by differential aeration) that had become widespread over a 50-mm strip, with a loss of thickness (1 mm on average and in excess of 3.5 mm locally).
The operator devised an initial series of remedial measures to treat the recorded malfunctions, involving: remote automation of the sluice gates slaved to pressure drop detectors ,with relays to the control room and hydrocarbon detector servo systems; modification of pipe section shutoff equipment in the event of a leak; additional hydrocarbon detectors; inspection of sluice gate condition and seals.

Striking a balance between prevention, mitigation and intervention

The focus of actors is naturally drawn to identifying and mitigating potential hazards, as well as to technical and organisational measures aimed at reducing accident probability. Regardless of the efficiency of such measures, the risk management strategy cannot be confined to the previous approach only, and overlook residual risks and their undeniable eventual consequences.

Furthermore, accident records have already shown that actors can sustain major setbacks and be relatively unprepared should the methods adopted to cope with residual risks, given the nature of exposed vulnerabilities, not be properly vetted in advance with sufficient knowledge of the potential and limitations of all resources available.

The low probability of the most feared event, coupled with approved prevention efforts, are not justifiable grounds for neglecting a strategy for such events. Several accidents have occurred more or less recently in France and abroad indicating shortcomings in this area. In the Hungarian city of Ajka (ARIA 39047), with no emergency plan, the operator of an aluminium plant was faced with a 700,000-m³ spill of mining effluent following the failure of a basin levee. In Toulouse (ARIA 21329), planned protection measures proved inappropriate since the scenario of an ammonium nitrate detonation had not been addressed. In Nantes (ARIA 5009), a strategy for extinguishing a fertiliser depot was only developed several hours after the incident had been detected; in the meantime, confinement steps followed by the evacuation of tens of thousands of residents were approved and carried out.

A lack of knowledge of both the effects and their eventual consequences can complicate the work of fire-fighters and compromise the safety of rescuers and third parties. In Salindres (ARIA 5993), inside a packaging plant for agro-pharmaceutical products, no members of the management team had any knowledge of the risks associated with a facility recently placed into service. In Rosteig (ARIA 168), the monitoring and intervention plan for an oil pipeline had not addressed scenarios like a massive leak of liquids or the presence of an explosive cloud. In Saint Romain-en-Jarez (ARIA 25669), an orchard farmer, who likely was unaware of the hazards inherent in ammonium nitrate use, only informed emergency responders of the presence of 3 to 5 tonnes of fertiliser with this ingredient 4 hours after the farm's storage hangar caught on fire; during this lapse of time, an explosion injured 18 fire-fighters, who apparently had not received the safety guidelines for dealing with this type of fertiliser. Similarly, the level of environmental awareness of exposed vulnerabilities (Natura 2000, Natural Park) must be known and taken into consideration when adapting measures to fit a given situation (ARIA 36654, 38242).

Early detection of the most feared event is a critical step to limiting its potential magnitude. For example, a fuel oil leak on a refinery pipeline detected 5 hours after the fact caused the spill of 478 tonnes of hydrocarbon, 180 tonnes of which emptied into the Loire River Estuary (ARIA 34351); 90 km of riverbanks had to be cleaned over a 3-month period. At a chemical plant not equipped with detection devices, 2.4 tonnes of ammonia were released into the atmosphere 1 hour and 40 minutes before employees became aware of the incident (ARIA 733). In an underground facility used to store supposedly non-combustible waste, which accounts for the galleries being devoid of fire detection devices, 3 hours were needed to locate a fire source; hotspots remained for 2 full months (ARIA 23030). The lack of confinement basins for fire extinction water and retention basins for hazardous overflows or their less than 100% efficiency can exert significant influence on both aquatic and terrestrial flora and fauna (ARIA 38242), in addition to adversely affecting the drinking water supply for local populations (ARIA 161).

Intervention resources available for implementation must be well defined, "easily" deployed and clearly listed in all emergency plans. At an oil depot, following the explosion of an unleaded gasoline cloud, an event that went unaddressed in the site's hazard study, the gathering of the mitigation devices (foam compound, pumping equipment) required to put the fire out took over 6 hours, by which time the area engulfed in flames had extended 6,560 m² (ARIA 2914). These intervention plans must take into account all possible accidents and undergo periodic updates and testing to ensure verification of plan relevance and effectiveness. As an illustration, trained personnel working in a power plant where drills had been conducted on a regular basis were able to bring a fire on a diesel generating set under control within 20 minutes of ignition (ARIA 33899).

During the event handling sequence, information of various actors (particularly public rescue teams) is necessary to ensure responder protection as well as adequacy of the set of measures adopted to assist or protect local populations. When a fire was burning inside a refinery's HDS unit (ARIA 27459) and in the lack of information distributed by the operator, the police temporarily halted traffic on a motorway. In Belgium (ARIA 35905), an H_2S cloud caused a nuisance to several hundreds of peoples, who fell victim to nausea and breathing problems, with 57 among them requiring medical attention; no alarm was sounded due to a lack of sufficient information circulating onsite and no communication between local responders and authorities in the neighbouring country; up to 100,000 people were potentially exposed.

As a prerequisite to posting communication during an accident, it is critical to inform the public in order that population likely to be exposed can learn first hand of the type and magnitude of risks, as well as the protection measures taken, in an effort to avoid inappropriate behaviour to the greatest extent possible.

Accident records regularly and relentlessly recall the limitations of preventive measures and debunk the myth of "zero risk". While unable to eliminate all risks of major accidents arising relative to hazardous materials and processes, it is still essential to strike a reasonable balance between prevention, mitigation and intervention. Civil society would find it incomprehensible that such processes can be implemented without planning the appropriate measures to enact in the case, even highly unlikely, where an accident might occur.

Accidents whose ARIA number has not been underlined are described on the Website :

www.aria.developpement-durable.gouv.fr

ARIA 161 – 08/06/1988 - 37 - AUZOUER-EN-TOURAINE

20.14 - Manufacture of other basic organic chemicals

An explosion and a fire occurred during the night in a chemical plant during the manufacture of a silicon oil- and additive-based waterproofing agent.

A junior technician (hired 6 months back), recently assigned to this post, was left without supervision around 1.00 am to manage a process modified in June and implemented for the second time. Since the order of addition of reactants was not specified in the operating procedure, he loaded 800 kg of oil into the tank 1702 on level 1, started heating the reactor, went back to level 0 to pump the reagent. While going up to level 2 to fill a tank with water, he observed a kind of fog escaping from the tank 1702. The explosion that occurred around 3.00 am resulted in the formation of hydrogen generated by the decomposition of the silicon oil after the abrupt and uncontrolled addition of an extremely basic alcoholate. The fire that ensued consumed 500 tonnes of chemicals (mainly alcohols), spread to significant part of the site (7,000 m²) and resulted in a huge cloud of smoke.

The technician was thrown 10m away, suffered a concussion and sustained serious burns and injuries. During the rescue operations, 2 fire-fighters were injured and 15 other poisoned. Despite the difficulties encountered, the rescue workers brought the situation under control in 4 hours. Analysis of the air revealed low levels of CO and NOx. The absence of retention devices, unused pipes and malfunctioning of the internal waste water treatment plant led to the disposal of the fire water (cyanide compounds, pentachlorophenols, etc.) in the Brenne river, a tributary of the Cisse river. Both the Cisse and Brenne rivers were polluted over 23 and 5 km respectively wiping out all traces of plant and animal life: 20 tonnes of fishes, aquatic and terrestrial mammals were destroyed. A high phenol index was measured in the Loire river: catchments were shutdown on 9/06 depriving 200,000 inhabitants of Tours and the adjoining area of drinking water. The water supply was restored in 3 days with a ban however on human consumption for 8 days. Drinking water supply was arranged for 10 days. Material damage and operating losses of the company stood at 45 MF and 8 MF respectively.

The chairman of the company was given a 1-year suspended sentence and fined 120,000 F while the plant manager received a 6-month suspended sentence and was fined 60,000 F. The damages to be paid to the civil party stood at 800,000 F.

The accident resulted from a major organisational failure (absence of safety policy, incomplete procedures, etc.).

ARIA 168 – 28/07/1989 - 67 - ROSTEIG

49.50 - Pipeline transport

While conducting earthworks, a loader punctured an oil pipeline (Ø = 400 mm), buried 1.2 m deep and carrying naphtha at a pressure of 8-10 bar. Emanating from a 30 cm² opening, a jet spray 5 to 10 m high created a yellowish smelly aerosol that was spread by gravity over several hectares, encompassing an entire football field and a recreation centre.

The subsequent explosion shattered window panes and blasted tiles from roofs on nearby dwellings. The wood panelling on a building was burned. Gendarme officers had previously overseen the evacuation of children playing on the sports pitch, which along with several hectares of fields also burned. In all, some 100 residents had to be evacuated. The pipeline opening was clogged 2 days later. The death toll due to burns stood at 2 gendarmes and 1 civilian.

The administrative department responsible for pipeline monitoring held a number of technical meetings to analyse the consequences of this accident on the oil transport facility and laid out a pipeline repair programme. Renovation works took place from April 14th to 19th, 1989. Following a satisfactory radiographic inspection of the welds, the pipe lining was successfully repaired on August 18th and 19th.

Being updated at the time of the accident, the monitoring and intervention plan had not foreseen the scenario of a massive leak of liquid product combined with the formation of an explosive cloud and therefore did not provide a suitable intervention protocol. The administrative team responsible for monitoring undertook, in collaboration with the pipeline operator, the design of a new plan in compliance with regulatory prescriptions.

ARIA 733 – 21/02/1989 - 59 - LA MADELEINE

20.14 - Manufacturing of other basic organic chemical products

During a transfer operation involving a cistern located in the acid production plant and nitrated by-products from a chemical plant, a rupture disc broke around 6:45 am on a line connecting a cryogenic ammonia (NH_3) storage facility containing a 340-tonne theoretical capacity (-33℃ at 1,013 mb, 310 payable tonnes) with a gas holder. Within a span of 105 min, between the presumed onset of the leak and its discovery by site personnel, 2.4 tonnes of NH_3 were released into the atmosphere. A passer-by notified the fire department 25 minutes later.

A toxic cloud wafted over 4 km at an average speed of 0.3 m/s. 20 min and 3 attempts were required by the team of technicians, alerted around 7:15 am, when arriving on duty to close the chain valve that isolates the ruptured disc. The first attempt failed when the chain slipped and the pulley got stuck. Bothered by the NH_3 gas entering his protective gear worn for the occasion but not properly adjusted, the technician decided to abandon the second attempt. This older-generation storage facility was not equipped with any internal pressure measurement recording system. The neighbouring population was asked to remain indoors and no injuries were reported, aside from odour nuisances and ocular discomfort from time to time until 9:30 am.

Several installation malfunctions downstream of the release preceded the accident. The operator drew a number of lessons, namely: a degraded operating regime not fully acknowledged by the technician when the cistern was being prepared for transfer; inadequate maintenance and control of both the measurement instruments (poorly calibrated flow meter) and protection systems (poorly installed rupture disc, a safety valve difficult to manipulate, etc.); design flaws (manual pressure setting, lack of visibility between the transfer station and the tank being filled); absence of leak detection device (notification relayed by neighbours); use constraints specific to the protective gear (choice of equipment, user instructions, practice); sharing of recommendations and information between line staff; intervention protocol (installation safeguards, isolation of storage compartments, etc.); staff training (under normal or degraded conditions, relevance to intervention techniques).

This accident, which generated a strong psychological impact, received heavy media coverage. Both the installation and operating guidelines were revised: installation of 2 pressure sensors, one connected to an alarm the other to a recorder; a relief valve on the tank; an NH_3 detector alarm; an automatic transfer shutoff device; and the scheduling of frequent

inspection rounds at the time of transfer operations.

ARIA 2914 – 07/10/1991 - 44 - SAINT-HERBLAIN

46.71 – Wholesale of fuel and related products

A leak occurred at the level of a fitting on a 12" racking pipe located downstream of the foot valve on a 4,525 m³ tank containing unleaded gasoline with a 98 octane rating (SP98). The retention basin of this tank also served as the basin for a 4,500-m³ tank of domestic fuel. The accident took place during remote-controlled valve opening: an aerosol formed, then spilled over the top of the basin wall (H = 2 m) and flowed by gravity onto the parking lot. After about 20 min, the cloud of some 25,000 m³ in volume ignited. The vapour cloud explosion (VCE) fatally injured a driver, seriously hurt 2 employees and caused slight injuries to 3 other drivers. The POI response plan was activated. The fire spread to two compartments of the retention basin, to 2 tanks and to the tanker trucks parked on the lot, in addition to threatening storage areas. The 200 firefighters called to the site cooled a 1.5-m³ LPG cistern located 30 m from the basin and proceeded to protect two 15,000-m³ tanks of leaded gasoline and fuel oil (using a water curtain). It would take a long time to gather the necessary firefighting resources: 80,600 litres of emulsifier were assembled (17,000 litres borrowed from neighbouring industries), a tugboat equipped with a 12,000 l/min pumping station provided sufficient pumping capacity (an 8-m high tidal range on the LOIRE prevented the pumps from operating properly). The ensuing fire, propagating over a 6,560 m² area, was extinguished in 72 min.

The explosion caused serious damage to structures as far away as 100 m and broken windows up to a distance of 1 km; it was exacerbated by ignition of the aerosol within an enclosed room at the washing station, which had the effect of both raising the inflammation energy (with the lorries parked at an angle helping accelerate the path of the flame) and increasing the pressure surge generated by the deflagration. The site's wastewater network was overcome by hydrocarbons and became the site of subsequent explosions. Total material damage was estimated at 16 million euros: 2 tanks, 4 vehicles, 15 tanker trucks and their washing station were all destroyed; 3 other reservoirs and facility offices incurred damage, and system pipes were deformed. Approximately 500 m³ of hydrocarbons polluted the ground over a 2-ha surface area to a depth of 7 m and seeped into the groundwater.

A pressurised gasoline leak at the level of a rubber seal for a pipe fitting would have been the cause of the accident; moreover, the lack of wind served to limit dissipation of the vapour cloud that formed. A prefectural order was issued on October 30, 1991 suspending operations, with resumption of site activity requiring completion of a full authorisation request submission. The fuel depot was reopened for business at the end of 1993.

ARIA 5009 – 29/10/1987 - 44 - NANTES

46.75 - Wholesale of chemical products

At a warehouse storing unknown contents, the self-sustaining decomposition of a stockpile of 850 tonnes of fertiliser NPK 15-8-22 delivered five days earlier caused the formation of a cloud 10 km long heading westward; in this cloud, the presence of nitric acid and chlorine were detected.

The ORSEC plan for dealing with crises was activated; 200 fire-fighters, 627 police officers , 489 gendarme officers, 356 soldiers, 200 emergency responders and over 1,000 municipal employees were mobilised. An extensive evacuation plan spanning 7 municipalities located downwind of the warehouse was implemented. The incident was eventually controlled after 7 hours of emergency intervention.

The human toll amounted to 3 intoxicated employees, one of whom was placed in 24-hour observation at the hospital. Even though the overall evacuation measure applied to a population of 70,000, the actual number of individuals moved for a period of 9 hours during the crisis was evaluated at 38,000. The LOIRE River was only minimally polluted considering the widespread dilution of fire-fighting water.

As a result of both their transport conditions (in the hold of a ship that had previously stored wheat) and storage conditions (on a bed of sawdust), the fertilisers responsible for this accident were placed in close contact with organic matter, whose concentration at certain spots could have been quite high. Moreover, the site's obsolete electrical installation was partially to blame.

The combustion zone began at a point directly aligned with the electrical cables that were dangling underneath the aboveground system for handling stored substances; the cut ends of these cables were probably buried in the mass of fertiliser. Under these conditions, ignition was likely initiated in the depths of the fertiliser pile, immediately adjacent to both the mass contaminated by sawdust and the buried electrical conductors. The fire then spread by means of self-sustaining decomposition of the fertilisers.

This accident still would not have reached such proportions had an efficient response been organised as of the initial detection of heat accumulation.

ARIA 5993 – 02/11/1994 - 30 - SALINDRES

20.15 - Fabrication of nitrogen products and fertilisers

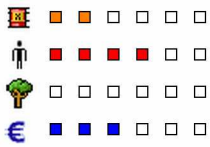
In a factory packaging agro-pharmaceutical products, an insecticide (LANNATE) fell from a hopper on a packaging line while employees were changing the valve at the base of the machine. The building was evacuated owing to the presence of toxic dust. A slight explosion occurred slightly thereafter (electrical incident -> sparks). A fire broke out and spread to neighbouring packaging (fertilizer…) and to the building (2 levels- 1,600 m²); 130 firemen intervened (3 were effected), 40 employees and local residents were evacuated. A neighbouring site and a childcare centre were instructed to confine themselves. The community was isolated. The firefighting water was collected in a 8,500 m³ catchpit. Certain difficulties were encountered during the intervention: the plant had been commissioned recently and the firefighting network was not yet operational, building inaccessible, fire doors closed, no executive personnel was had knowledge regarding the hazards at the site, slightly swirling wind, light rain and low ceiling, no map and products poorly known… Property damage was evaluated at 20 MF.

ARIA 23030 – 10/09/2002 - 68 - WITTELSHEIM

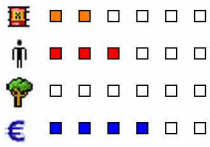
38.22 - Hazardous waste processing and elimination

A fire broke out at a potash mine about 4:15 am within an underground storage site devoted to toxic industrial waste (50,000 tonnes/year), which had been operating since February 1999 in galleries specifically excavated for this purpose at a depth of 535 m below the ground surface.

The waste authorised for storage, identified as not flammable, explosive, gaseous, liquid, volatile, radioactive, biologically toxic, unstable at the mine bottom temperature (35℃) or reactive with salt or water, was placed in "big bags" (capacity: 1 m^3), with a double pocket or in metal containers stored in 220-litre metal barrels. The fire spread over a 1,700-m² area and involved 1,800 tonnes of household/industrial waste incineration ash and residue from asbestos removal operations; according to the site operator, it was the residue packing material (big bags, pallets) that caught fire. Miners were first disturbed by smoke entering the rock salt galleries around 5 am, then the storage site personnel sounded the alarm about 7 am. The fire was located at 7:15 am; 4 teams of miners, all wearing self-breathing apparatuses, relayed one another at the mine bottom assisted by 25 fire-fighters at the surface. A water pipe was installed inside the gallery. Blocked air intakes helped limit spreading of the flames. A press release delivered during that afternoon suggested that the situation would soon be under control. High sulphur dioxide concentrations were measured at the manhole outlet; the population was not asked to remain indoors, yet 3 schools close by were closed out of precaution. The slow combustion of these wastes would last for several days, with hotspots persisting for another 2 months. A court case was brought against unknown persons for deliberate endangerment of others. Conformance of the waste being stored relative to operational specifications was examined, and 4 independent experts were called to verify compliance with safety rules. The impact of smoke released into the environment was also investigated.
Site activity was suspended, 27 employees at the storage facility and 350 miners were made redundant. Since such an occurrence had been deemed unimaginable, the galleries were never equipped with fire detection sensors; 3 hours were required to locate the source of this fire. Since the storage centre was not independent of the mining activity, some of the galleries were connected to salt mining galleries. The operator revised the entire centre's safety plan. Expert analyses pointed to self-ignition of the wastes (through biological degradation, chemical decomposition, chemical reaction between isolated substances). The centre's definitive closure, announced for September 2003, led to conducting additional studies, this time focusing on: onsite waste storage safety through building confinement, partial or total waste recovery, long-term mechanical behaviour of the underground facility, environmental and health-related impacts for neighbouring residents and businesses.



ARIA 25669 – 02/10/2003 - 42 - SAINT-ROMAIN-EN-JAREZ
01.24 - Cultivation of fruits with seeds and stones
Fire-fighters battled for 45 min to contain the blaze at a 1,000-m² hangar belonging to a fruit farmer when a very powerful explosion rocked the building around 5 pm. The explosive mass involved was estimated at 300-500 kg of TNT. The building housed: between 3 and 5 tonnes of ammonium nitrate stored in big bags, 2 gas bottles, and cold storage units filled with fruit. The emergency response plan was activated.
A total of 23 injured, including 18 fire-fighters, were reported, 9 of whom in serious condition. Roofs and cars were damaged over a radius extending 800 m by shockwave and projectiles, but no significant thermal effect was observed. The fire that spread after the explosion released a large quantity of black smoke. Emergency responders experienced difficulties: no mobile phone network coverage, fire hydrants plugged or lacking pressure. This accident was contained around 8 pm; 94 residents had to be housed elsewhere, after setting up a 300 to 400-m safety perimeter, and safety measures remained in effect throughout the night. The psychological team dispatched to the site as of 3 October logged over 100 consultations. Some 60 residents had to wait 4 days before returning home. The monitoring programme was stopped by local gendarmes 11 day after the explosion.
This explosion corresponded to the detonation of a portion of the 3 to 5 tonnes of ammonium nitrates present in the hangar. During the year 2003, local farmers' fertiliser inventory levels were especially high since they went unused following a frost event in April. According to experts, the melted plastic from crates likely spread and got mixed with the ammonium nitrate, which in turn melted when exposed to heat. This mix might have been a factor leading to the instability that caused the explosion. Several ignition sources could have triggered the fire: an electrical overload on the installation (modified just prior in order to transform the cold storage rooms), or fermentation of the hay in storage or a simple smouldering cigarette, all of which have been hypothesised. Yet the most credible thesis would be that a light bulb apparently left lit exploded (the switch was found in the "on" position). The abundance of combustibles in the hangar led to a fast and extensive spreading of this fire.
Likely unaware of the hazards related to ammonium nitrate, the operator only notified the rescue crew of its presence at 8 pm. According to fire-fighter accounts however, no national memorandum had been circulated warning of the dangers associated with these fertilisers. Following this accident, verifications of storage conditions for ammonium nitrate-based fertilisers on farms and agricultural supply cooperatives were strengthened at the national level.



ARIA 27459 – 26/06/2004 - 69 - FEYZIN
19.20 - Oil refining
Fire broke out on the furnace of a hydrodesulphurisation (HDS) unit for refinery diesel. Flames and thick black smoke, containing CO_2 and SO_2, were visible at the smokestack. The site was locked down 5 min after detection of the accident. The internal emergency plan was not activated. Notified by neighbours, 60 fire-fighters and 15 emergency vehicles were dispatched to the site without having to respond. The fire was contained within a half hour by internal teams, once incoming loads and H_2 were

shut down, as the strategy called for the fire to burn itself out: reactor decompression downstream fed the fire inside the furnace for several hours.
Out of precaution and lacking precise information from the operator, the A7 motorway was closed for an hour. City police evacuated 600 residents. During the evening, the site director issued a press release: 2 members of the in-house fire crew were slightly injured. The quantity of burnt hydrocarbon was estimated at 45 tonnes, while 1 tonne of SO_2 was released. According to atmospheric pollution records, the SO_2 concentration never exceeded the threshold required to issue a public statement.
At the suggestion of the DRIRE (Regional Directorate for Industry, Research and the Environment), the Prefect ordered that any resumption of HDS unit operations be conditional upon submission of a report on: the smokestack condition, state of continued unit safety, and evacuation/elimination of all waste and effluent stemming from the fire. The furnace (T = 420℃, P = 40 bar), fitted with austenitic stainl ess steel tubes (diam.: 6''), contained a convection zone in the upper part (not accessible to inspection) and a radiation zone (tubes in contact with the flame, accessible and considered as the most heavily exposed) below. During the accident, the upper part underwent the greatest heat flux: in some spots, metal exposed to red heat, melted tubes, fired refractory material. An appraisal of the responsible tube (not melted) revealed a lack of thickness due to a former attack exacerbated by oxidation/sulphuration and slight creep due to the presence of coke on the walls. An analysis of operating parameters showed no evidence of a drift. The operator replaced the furnace along with other equipment, depending on the temperatures actually reached. The smokestack, shared by the HDS and atmospheric distillation (AD) units, was thoroughly inspected (for thermography and verticality), yielding no noteworthy anomaly. The furnace flue and connection were renovated (with new refractory bricks). AD unit operations, shut down during the accident, were allowed to resume. The HDS unit was down for a total of 3 months. The cost of property damage was estimated at €6 million, while operating losses amounted to €22 million.

ARIA 34351 – 16/03/2008 - 44 - DONGES
19.20 - Oil refining
While loading 31,000 m3 of bunker fuel in a ship, a leak in a refinery transfer hose resulted in a major oil spill in the Loire estuary.
At 4.10 pm, a person on a barge observed the presence of hydrocarbons on the water surface and sounded the alert. At around 4.45 pm, a roundsman identified and isolated the leak at 500 m upstream to where the hydrocarbons were detected.
The internal contingency plan was triggered at 5.00 pm and the inspection authorities of classified facilities were informed. A recovery ship was stationed at the mouth of the river while two trawlers recovered hydrocarbon pellets from the river.
The public ban on access to several beaches and fishing in the river that was in place subsequent to the spill was gradually lifted between the 4 and 18 of April. Over 750 people were involved for three and a half months in cleaning up the 90 km of polluted banks (6,170 tonnes of waste recovered and stored onsite before disposal). The operator bore the cost of 50 M euros to cover for the damage incurred, clean up and compensate effected businesses.
Investigations revealed that the leak was detected only after 5 hours leading to 478 tonnes of fuel being spilled of which 180 tonnes flowed into the Loire estuary.
A 16 cm² longitudinal breach caused by corrosion localised under the insulator was observed upon examination of the hose. The corrosion resulted from a water leak in the vertical pipe. Water seeped beneath the insulator, caused corrosion and subsequently caused the fuel pipe to rupture. Despite several defects detected the previous month on the same rack, the operator failed to revise this inspection programme to take into account the specific risks presented by this line given its proximity with the river banks. The effected fuel line was completely stopped and the inspections on the entire rack revealed several corrosion points on other lines that required repair.
The operator was required to implement several additional initiatives and measures:
- Extending inspection operations to other pipes in the site along with measurement of thickness at sensitive points (supports, spurs, etc.)
- Moving the layout of the service water mark so that it is not in a vertical position with respect to the insulated pipe
- Using a leak detection system along with a remote alarm in the control room to constantly monitor pipes located near the river
- Modifying the ground below the rack to channel any accidental spill to an adapted recovery network
- Installing a device to monitor the quantity of products leaving the tank and entering the corresponding transfer hose
It was also planned to consolidate the available emergency measures in the event of accidental pollution of the Loire river.

ARIA 35905 – 02/09/2008 - BELGIQUE - ANVERS
19.20 – Oil refining
At 11.57 AM a power failure occurred in a refinery. The supply of electrical power was cut off, as a result of the failure of the main power line during maintenance. Because of this the refinery was almost completely powerless, which led to an emergency shut down of the whole plant. The automatically operated safety systems started working : large quantities of products were dumped in the emergency torch and were burnt off. Safety valves opened and released gasses to the atmosphere. Personnel and people working at the refinery were evacuated and only an emergency staff remained at the plant.
Information at the central operating desk about what was going on in all the components of the plant was sparse. In the first hour after the incident it was not known which safety valves were opened and which products were ventilated into the atmosphere. That information became available bit by bit during the cause of the afternoon.
One of the safety valves that opened released an amount of ca. 70 kg H2S into the atmosphere. The release point is situated at about 40 m above ground level. After 5 min, the cloud of H2S formed reaches a downwind distance of about 3 km with a concentration valued at nearly 10 ppm 3 m above ground level. After 20 min the cloud has traveled 14 km and has reached the Netherlands. Concentration levels in the cloud vary between 0.64 ppm at ground level and 0.06 ppm at the top of the cloud at an altitude of about 850 m.
Driven by a wind from the south-south-west at 45 km/hr, the cloud proceeds over the western part of the province of Brabant and after about 70 min has reached the city of Dordrecht, 50 km from the refinery. Concentrations of H2S in the cloud are about 0.06 ppm, still well above the smell detection level.
No warning of the H2S spill was issued, partly due to a lack of information at the plant, partly due to a lack of

communication between Belgium emergency services en the Dutch authorities.
A population of about 100.000 people was in the path of the cloud and potentially affected by it. An estimated several hundred people were affected by the H2S and experienced nauseous ness, and respiratory problems. 57 people needed medical care.
However the Dutch emergency services were not prepared to deal with the situation, due to lack of information about the event and its possible consequences. This in turn led to insecurity and a loss of confidence in the capacity of the government to deal with incidents like these.

ARIA 36654 – 07/08/2009 - 13 - SAINT-MARTIN-DE-CRAU
49.50 - Pipeline transport
A leak was discovered on a crude oil pipeline (diam.: 40'', maximum service pressure: 40 bar, built in 1972) composed of welded rolled tubes. The accident occurred on a Natura 2000 site in the Crau Natural Reserve, home to several protected species. A park warden sounded the alarm and the operator activated the pipeline's emergency plan.
Rescue crews and various administrative departments were onsite by 8:30 am. Aerial reconnaissance was performed and a safety perimeter set up. A "geyser" 3 to 4 m high gushed from a "buttonhole" rupture 15 cm wide and 1.8 m long on the longitudinal weld.
The Prefecture convened a crisis monitoring cell at 11:15 am. The Secretary of State for Ecology arrived on the scene at 4:30 pm, and the court was seized.
The Prefecture requested a precise evaluation of environmental impacts. According to the operator, the pipe break was due to a fatigue crack caused by the "roof effect" at the level of a longitudinal weld bead. The damaged tube was replaced by a new one; others were inspected and reinforced as a preventive measure.
5,4000 m3 of crude oil were discharged over a 5-ha land area.
Surveys, coring and analysis of land are made to thoroughly assess the impact of pollution on the area. The water table is situated between 9 and 12 m depth, 72 piezometers were gradually installed in the following months to monitor the impact of pollution on groundwater together with a hydraulic barrier to contain the possible migration of the pollution. Analyses carried out regularly by the operator of the pipeline at the request of the authorities showed that no hydraulic capture downstream, either for irrigation, animal feed or human consumption, has been affected. Many studies were conducted to assess the impact of the accident on the local fauna and flora of the reserve. However, the consequences are difficult to assess beyond the polluted area due to a lack of accurate baseline even within a nature reserve. The Coussoul (flora) is yet destroyed over 5 acres.
A year after the accident, the operator claimed having spent 50 million euros to "treat" the consequences of the leak, including a dozen for environmental restoration. On the whole, at the end of 2010, more than 73 000 tons of contaminated soil have been disbursed, then transported to a processing centre of a neighbouring department. These lands came from the stripping of polluted soils over a 40 cm depth. In the 5 ha area, a depositing was carried out with local materials transferred from a nearby quarry, respecting the original structure of the soil. The surface layer was reconstructed by directly transferring the Coussoul taken from areas not yet exploited of the quarry. Scientific monitoring is planned to observe the recovery of this Coussoul. The work is completed April 15, 2011.
Given the succession of accidents that occurred during 2009 in the chemical and petroleum industries, as well as in the pipeline transport of hazardous materials sector, a meeting on industrial safety and environmental protection was organised in September 2009 between the Secretary of State for Ecology and key leaders in these sectors.
Participants submitted proposals for improving safety at their installations, by means of strengthening controls and maintenance on ageing facility, while paying greater attention to ecologically-sensitive zones with the aim of better caring for protected species / zones.
Further to this accident and as an experiment, the Secretary of State launched in August 2010a project to build a natural reserve near the affected area to “cultivate assets” that could offset negative impacts on biodiversity. For that purpose, a specialized company will restore rare and endangered species habitat by transforming an industrial orchard in a pasture zone.