Meeting – Bordeaux, June, the 11th and 12th, 2002

LESSONS LEARNT FROM INDUSTRIAL ACCIDENTS

Classified installations / IMPEL inspectors

Photo DRIRE Midi Pyrénées

Thanks

The conference organizers do thank the participants to the meeting for their presentation and their contribution in the achievement of the following synthesis.

The speakers' names are listed below in alphabetic order (but grouped for each presentation).

- *Monsieur Gérard AUTRAN (DRIRE Provence – Alpes - Côte d'azur – France))*
- *Messieurs Alain BARAFORT, Prosper CATS et Patrick COUTURIER (DRIRE Midi – Pyrénées - France)*
- *Messieurs Guy BONNET et Michel ISLIC (DRIRE Languedoc – Roussillon - France)*
- *Madame Anouk COURAGE (Bureau de l'environnement de la province de Limburg – Pays-Bas)*
- *Monsieur Jacques DAUBLANC (DRIRE Ile-de-France – France)*
- *Monsieur Sébastien DELHOMELLE (DRIRE Nord-Pas-de-Calais – France)*
- *Madame Inge DELVAUX (Ministère de l'environnement - Belgique)*
- *Monsieur Philippe DUMORA (DRIRE Poitou-Charentes - France)*
- *Monsieur François FONTAINE (DRIRE Corse – France)*
- *Monsieur Philippe FRICOU et Madame Anne-Laure JORSIN-CHAZEAU (DRIRE Rhône-Alpes - France)*
- *Monsieur Jean-François GAILLAUD (DRIRE Picardie –France)*
- *Madame Corinne HELFER (DRIRE Picardie – France)*
- *Monsieur Andrew HITCHINGS (Agence de l'environnement – Royaume-Uni)*
- *Monsieur Loïc MALGORN (STIIIC - France)*
- *Monsieur Laurent MOCHE (DPPR/SEI/BRTICP - France)*
- *Monsieur Antoine PINASSEAU (DRIRE Basse-Normandie - France)*

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Introduction

Welcoming of participants

Opening speech

Meeting of June, 11th and 12th, 2002

Welcome

François Goulet
Regional Director of Industry, Research and the Environment
for the Aquitaine Region

DRIRE Aquitaine is particularly pleased and interested to welcome in Bordeaux the 4th IMPEL meeting dedicated, as the previous ones, to the experience feedback in connection to technological accidents.

Aquitaine region had to face up in the last previous years such events whose last one was the explosion of the silo located in Blaye, on the 20th of August, 1997.

I will not forget the effects of the storm that occurred on December 1999 and lead the electronuclear plant of Braud Saint-Louis on Gironde estuary to see that its basement was flooded and that several emergency circuits failed.

This shows as well that risks and hazards lie outside the framework of "Seveso".

During the year 2001, the main schedules of the Seveso II directive were implemented.

In Aquitaine region, 80 industrial establishments are concerned, among which 50 are submitted to the requirements of the regulations. DRIRE Aquitaine has resolutely committed itself to check the good implementation of these arrangements.

I attach a great value to this stake towards our fellow-citizens.

Of course, the pressing necessity concerning the best way to protect people and goods, requiring if necessary in this aim the use of the best available technologies, was not obvious for all.

The accident of AZF plant in Toulouse on the 21st of September, 2001 has overcome the resistances that still existed. Our vigilance must not be relaxed: time does its work, except in the memory of victims' relatives. Knowledges are never definitive, this is a sentence that our inspectors must never forget, whatever the interests at stake.

These two days of meeting in Bordeaux must contribute to feed the reflections that we need to reinforce the preventive action of the Inspectorate in order to check and curb risks.

I wish the presentations and exchanges on the lessons learnt from the past to enrich even more our experiences.

Now, Marie-Claude Dupuis, Head of Industrial Environment Service inside the Ministry of ecology and sustainable development, is going to introduce this meeting.

In this awaiting, I welcome all the inspectors and particularly those who come from other countries of the European Union and hope that their stay in Bordeaux will be in the best conditions.

Let me thank as well the agents of DRIRE Aquitaine who dedicated themselves to prepare this 2 day-conference, particularly Sylvie Buisseret.

Seminar introductory speech

Marie-Claude Dupuis
Head of the SEI ("Service de l'environnement industriel", Industrial Environment Department).

It is my pleasure to open this 8th seminar on industrial accidentology, which has been organized for the 4th time within the scope of the European IMPEL network.

Firstly, I would like to thank François Goulet, Regional Director for Industry, Research and the Environment of the Aquitaine Region for his participation and the DRIRE Aquitaine's contribution in organising this event. I would like to welcome all of the industrial installation inspectors from various member states of the European Union (France, Great-Britain, The Netherlands, Belgium, Portugal, Italy, Germany, Denmark, Sweden), and the representatives from Lithuania and Cyprus. I would also like to acknowledge the presence of several experts from the INERIS, the IRSN, the INRS and a few representatives from the labour regulations service.

This seminar opens within a very special context following the terrible accident in Toulouse last September 21st, which resulted in the death of 30 people and several thousand injured. Much like the Enschede catastrophe in May 2000 in the Netherlands, this dramatic event has lead to extensive reflection regarding risk prevention procedures in France, and beyond, notably in the European Union.

Significant progress has been made since September 21st, 2001. To cite just a few essential steps, I would simply like to mention the organization of regional and national level debates on the cohabitation of plants at risk and other activities, the parliamentary inquiry and its 90 proposals, the preparation of a bill relative to the reinforcement of technological risk prevention, the attribution of reinforcement for the inspection of registered installations (150 in 2002) and additional means for the INERIS.

The launch of a series of inspections in fertilizer plants and warehouses was the first immediate decision following the Toulouse catastrophe, although the feedback doesn't stop there. A lot remains to be done. The new government has not yet voted on the bill introduced to the Senate. The judicial inquiry is far from being completed; the experts' battle has only just begun. This, however, must not make us wait to change our system.

Laws are not the answer for us to think about and structure our (enhanced expert evaluation, implementation of skills bases within the DRIRE), to reinforce the links with the working world (labour inspectorate, CHSCT (the committee for hygiene, safety and working conditions) and labour unions), in order to develop joint action primarily within SPPPI ("Secrétariat Permanent pour les Problèmes de Pollution Industrielle", permanent secretariat on industrial pollution problems) and the CLIRT ("Comités locaux d'information sur les risques technologiques", local information committees on technological hazards) and to develop the use of compensated public servitudes.

Clearly, our objective consists in anticipating other potential accidents which human consequences which may reach dramatic dimensions such as that of Toulouse.

Of course, feedback from the analysis of previous accidents holds major place a place in this entire system. The operators should be strongly urged to gather accident and incident related data, to develop corrective measures and to follow up their actual implementation. This method is essential for the rigorous correction of failures which occur in the operation of installations. In addition, it ensures progressive improvement of the safety level of installations as soon as it is applied to the incidents without waiting for the accident to occur.

Feedback must also be pooled in order to benefit all risk prevention players. This is why I would like the BARPI to built ties with the GESIP ("Groupe d'Etude de Sécurité des Industries Pétrolières", petroleum industry safety task force) and the UIC ("Union des Industries Chimiques", chemical industries union). Feedback is based on the elaboration of new national and European legislation (SEVESO II amendment), and must also feeds local regulatory action. Obtaining a very high level of security, demanded by our fellow citizens, requires that a collective safety culture be developed and that this "wealth of knowledge" gained though both success and failure be shared openly.

Openness must also be ensured when conducting our actions by providing the media and the public with information so that they can make their own opinion. This point is of utmost importance in the field of risk prevention insofar as our topics are relatively complex and liable to become a cause for great concern among the general population when accidents occur. In this framework, I asked the BARPI to propose a new industrial accident severity scale in order to facilitate its use by the media. The proposal will be presented this afternoon.

Before starting our presentations, I would like to remind everyone that the organisation of this seminar would not have been possible without the efficient assistance of the DRIRE Aquitane, and without the contribution of the inspectors, both foreign and French, who have prepared the presentations, and without the participation of the BARPI.

Our seminar will be broken down into four half-day phases. This morning, we will be studying several accidents caused by maintenance failures. Our afternoon will consist of an examination of accidents which involve flammable materials. Tomorrow, we will address toxic substances, warehouses and finally the AZF factory in Toulouse.

Thank you for your attention.

Sheets of the accidents presented

Silo
Explosion
Dust particles
Works

Explosion of dust particles in a silo

May 14th, 2001

Albert (80) - France

THE INSTALLATIONS IN QUESTION

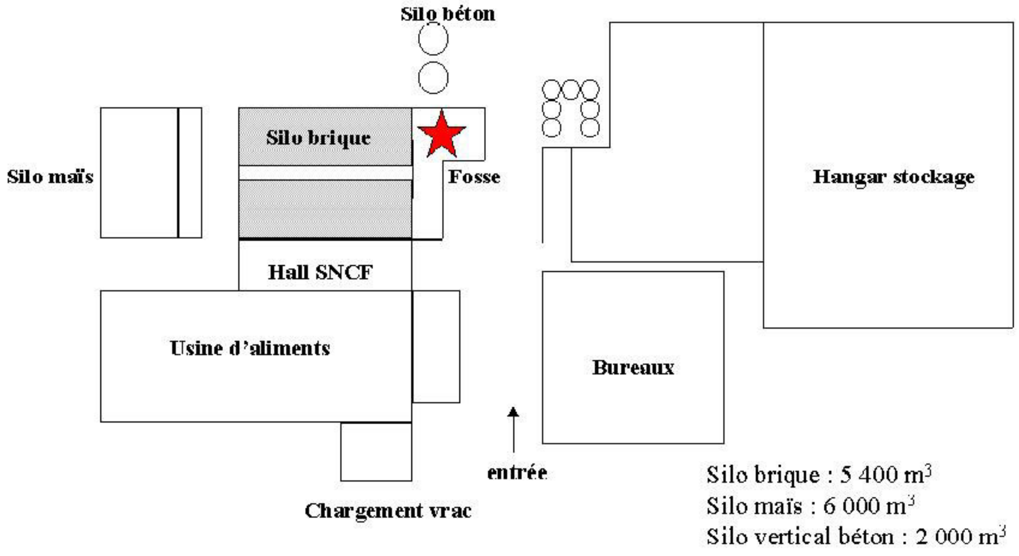
The company specialises in the production of animal feed: cereals, meal, etc. It has been established since 1989. The raw materials are stored in silos before being ground and mixed. They are then dispatched in bulk or in bags.

The site is a registered installation authorised by an order of the Prefect dated June 19th, 1989 mainly for the activity of grinding vegetal substances. The site does not come under the terms of the Seveso directive.

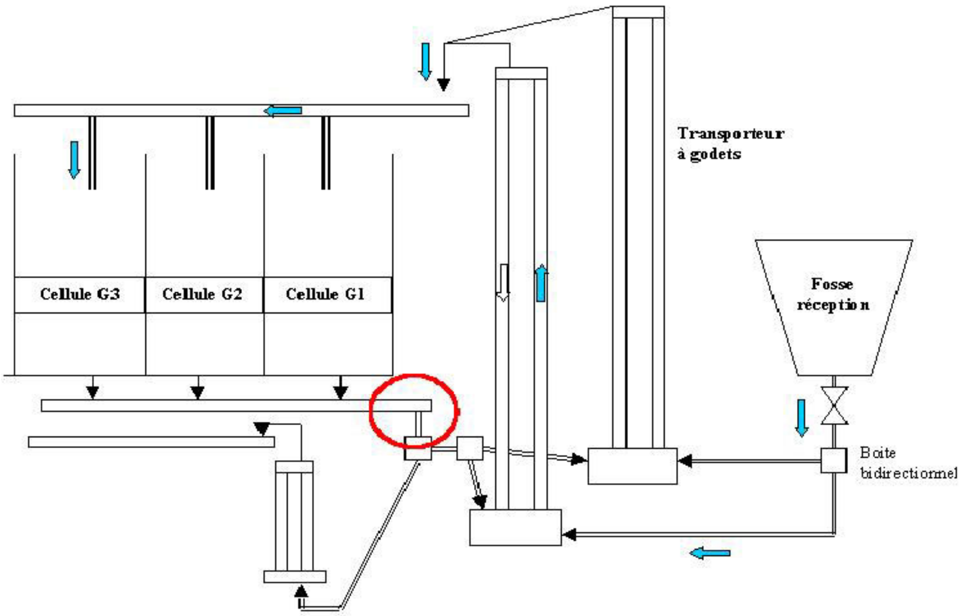
The installations comprise the following:

- a horizontal brick silo with a capacity of 5,460 m^3
- a vertical concrete "raw materials" silo with a capacity of 2,000 m^3
- a horizontal metal "corn" silo with a capacity of 6,000 m^3
- a disused metal silo with a capacity of 730 m^3
- a feed mill with a bulk loading tower, which constitutes a capacity of 308 m^3.

Diagram of the installation – site where explosion occurred is shown



The damaged brick silo consists of a reception/shipping station, a handling tower, the warehouse, roof space and two underground galleries.



The receiving/shipping station is located side by side with the silo gable, but there is no communication between them. The roofing and walls are made of steel siding on a metal frame. It is completely open on one side. The receiving hopper is built into the ground. It communicates by force of gravity with the bucket elevator located in the handling tower.

The 20 m handling tower has two elevators. It comprises, at its base, a pit composed of a reinforced concrete casing, and, in its upper part, a light structure made of galvanised corrugated sheeting mounted on a metal frame. Its covering consists of corrugated fibre-cement roofing panels on a metal frame.

The storage space consists of two rows of 6 and 9 cells, which are completely open and separated by a corridor approximately 2 m wide from top to bottom. The cells are a composite structure, consisting of a reinforced concrete frame filled with hollow bricks. They are located in a metal-framed building with walls and covering of metal sheeting and fibre-cement roofing panels.

The materials processed in the unit are cereals and meal. Handling of these systematically causes dust to fly or be deposited. These clouds can be explosive where there is a hot point.

THE ACCIDENT, ITS BEHAVIOUR AND CONSEQUENCES

A violent explosion occurred at the level of the handling tower during the unloading of a lorry.

The accident was classed level 2 on the severity scale, due to the decease of an employee as a result of his injuries.

The accident:

On May 14th, 2001, around 10 a.m., a lorry arrived at the plant to deliver 29 tonnes of rapeseed meal. The driver began the unloading operation in the reception pit of the brick silo.

At the same time, two operators arrived to carry out work on the brick silo's unloading conveyor, in order to repair the drive chain of the scrapers. To do this, they took off the cap located at the end of the conveyor, on the pit side, and cut and soldered the links of the chain.

A violent explosion occurred at approximately 11.15 a.m..

The driver of the lorry situated in front of the unloading platform was slightly burned. The two operators who were in the pit were seriously injured (3rd degree burns). One of the operators managed to get out of the pit by himself. He activated the emergency stop button of the handling installation. His co-workers sat him on a chair while waiting for the emergency services, who arrived approximately 10 minutes after they had been called. The other operator remained unconscious at the bottom of the pit. He was removed from the pit by the firemen 30 minutes later.

The explosion, which was heard in the surrounding area, was followed by fires in the pit, the hopper and the tower and cell gallery areas.

The hot gases and/or incandescent particles caused the combustion of dust deposits in the respiration system of the cylindrical silos located a few metres away, but at a height greater than that of the horizontal silos. The firemen, alerted by wisps of smoke, rapidly intervened and stopped the fire in these depots, thus preventing the fire from spreading to the vertical cylindrical cells.

Consequences:

The two workmen carrying out the maintenance operation in the pit of the handling tower were seriously injured, and one of them died several weeks later; the driver of the lorry delivering the rapeseed was slightly injured.

Property damage was extensive. The explosion blew out half of the surface area of the silo and ripped open the walls of the handling tower. Chunks of the fibre-cement roofing panels were found 30 m away, and metal bars from the access stairway to the vertical silos were cut into pieces.

The descending duct of the bucket conveyor that was being used was blown open over a length of nearly 4 m under the ground, as well as over 2/3 of the height of the tower.

ORIGIN, CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

The origin of this accident is linked to the non-respect of the elementary rules of prevention for cereal storage installations.

The premises had not been cleaned. Large quantities of cereals and dust had accumulated in the pits, on all of the surfaces, with a thickness that exceeded several tens of centimetres.

A maintenance operation involving soldering and grinding was carried out in a confined space. A fire permit was signed as a matter of form, but no cleaning took place. The operators carried out work on the return conveyor while the bucket elevator was in operation. Inside it, the atmosphere was thick with dust particles.

The lorry's unloading operation was practically finished and the soldering and grinding operations had been terminated when the explosion took place.

Investigations carried out on-site included, in particular, checking of the electrical continuity of the metal structures. Analyses and laboratory measurements made it possible to discount any particular reactivity in the meal during unloading and handling, as well as the presence of any significant amounts of residual hexane. Mechanical tests were also carried out on the parts of the sheaths that had been blown out.

Following analyses of the elements collected on the site and various tests, the most likely accident scenario, as far as the administration is concerned, is the following:

× Initially, flying metal particles caused by the grinding operations fell:

✓ either into the pit, causing one or several centres of combustion,

✓ or into the chutes of the redler conveyor, before entering into contact with the dust-filled atmosphere of the descending arm of the elevator.

Holes that would have made this pathway possible were discovered in the junction and switching boxes of the various handling installations,

× Then,

✓ a primary explosion occurred in the descending sheath of the elevator at the level of the handling tower pit,

✓ the explosion of the elevator spread throughout the volume of the pit, due to the suspension of the dust particles present in the pit,

✓ the rupture, due to the pressure of the explosion, of the descending sheath of the elevator at level 2 of the handling tower, spread the explosion throughout the whole tower,

✓ at the same time, the explosion in the pit affected the upper part of the tower via the openings,

✓ the explosion in the tower spread towards the entire storage building and the roof space.

The pit in which the accident took place is a strategic handling node, where the power and extraction circuits for all of the company's silos are grouped together and interlinked.

The operator claims that a rotating part of the damaged elevator had blocked and could have become hot, thus causing the explosion.

ACTION TAKEN

An emergency order of the Prefect dated June 16th, 2001 prescribed, for the resumption of activities:

✓ the delivery of a prior updated study of the dangers of the site, in accordance with the dispositions of article 3 of the decree dated September 21st, 1977,

✓ justification by the operator of the strict conformity with the regulatory provisions in force of the entire animal cereal and feed reception, handling, storage and processing installations,

✓ delivery to the Prefect of the report specified in article 38 of the decree dated September 21st, 1977, for the damaged transfer chamber, with details of the conditions under which measures have been taken to ensure that such an accident does not occur again.

On June 28th, 2001, the company delivered a study of the dangers and then justified, one stage at a time, the strict conformity of its installations. Restarting of operations in the "corn" and "brick" silos was progressively authorised.

LESSONS LEARNED

On site, preventive measures have been taken at the level of the damaged pit:

✓ simplification of the means of communication between the silos,

✓ installation, at the head of the new elevator, of a vent over its entire surface linked to the exterior; the elevator supports are equipped with blast panels,

✓ the concrete floor on the ground floor of the brick silo, which corresponds to the ceiling of the elevator pit, has been replaced with an expanded metal floor,

✓ installation of a door separating the reception pit and the sub-cell gallery,

✓ installation of a separating "profiled steel" sheeting between the handling tower and the upper part of the cells, in order to limit, on the one hand, dust collecting in the tower and, on the other hand, the spreading of a second explosion, should another accident occur.

In addition, a safety manager's post has been created in the installation.

Flooding
Waste
Fire
BSE

Fire Followed by Flooding of a Hazardous Waste Treatment & Transfer Facility

October 30th, 2000

Sandhurst - United Kingdom

THE INSTALLATIONS IN QUESTION

The Sandhurst site is located on the banks of the River Severn to the north of Gloucester, approximately 1.2km from the outskirts of the City and 1.4km west of the village of Sandhurst. The nearest dwellings on the outskirts of Maisemore are about 500m away.

The site was originally a brick works and then a tar works from 1860. The operator purchased the site in 1972 and developed it into a waste treatment facility. Land adjacent to the site was purchased by the operator in 1994. Local land use is mainly agricultural with some light commercial and residential uses.

The western boundary of the site is adjacent to the River Severn flood embankment whilst the area surrounding the site forms part of the river floodplain. The site is subject to flooding from the river and is also affected by tidal action.

The treatment processes on site include:

- ✓ The mixing of aqueous waste streams in the large mixing well to neutralise the materials added,
- ✓ Receipt and treatment of waste oil to produce a fuel for use on site and for sale,
- ✓ Mixing of wastes with absorbent materials such as sawdust or other shredded waste,
- ✓ Storage and bulking up of other wastes which cannot be treated on site before transfer to other facilities.

In general terms, wastes that may be received at the site for treatment under the waste licence are:

- ✓ Acids and alkalis,
- ✓ Industrial effluent treatment sludges,
- ✓ Metal compounds and inorganic compounds/materials,
- ✓ Organic compounds including hydrocarbons, solvents, polymers, adhesives, resins, fuels, oils, greases, soap/detergent, sewage sludge and pharmaceutical/cosmetic products,
- ✓ Contaminated packaging waste and rubbish,
- ✓ Filter materials and tank cleaning/interceptor wastes,
- ✓ Waste from specific industries (printing, paint manufacture, tanneries, food processing).

The wastes that may be received at the site for transfer activities include all the general categories given above and additionally the following waste types:

- ✓ Asbestos,
- ✓ Metals,
- ✓ Inorganic compounds which liberate toxic gases on acidification,
- ✓ Oxidising compounds,
- ✓ Chlorinated solvents,
- ✓ Pesticides.

Wastes may be received in a variety of packages varying in size from small aerosol containers to road tankers.

At the time of the accident the site was subject to regulation as a lower tier site under the Seveso II Directive (96/82/EC) and licensing under the Waste Framework Directive (75/442/EEC as amended).

THE ACCIDENT, ITS DEVELOPMENT AND CONSEQUENCES

The accident :

30 October 2000

02.00 - fire occurred in compound 1. The site was unoccupied at the time.
02.25 – arrival of Fire and Rescue Services. Fire and Rescue Services unable to access site for several hours because of the fire intensity and small aerosol cans exploding.Police evacuated 60 local people. 13 people sought medical attention although none required admission to hospital.
18.00 – fire extinguished after burning for approximately 16 hours.

2 November 2000

Because of imminent flooding the operator guided by Environment Agency and Health and Safety Executive (HSE) moved waste to compound 3; highest area on the site.

5 November 2000

Access by boat because of concern over one fire damaged 205 litre-drum that had appeared to have reacted. It was found to contain selenium, cadmium and arsenical compounds.

6 November 2000

Access by boat again to audit site and discovery of seven 25 litre-drums labelled “solvent contaminated with BSE”.

3-13 November 2000

Site flooded. Site monitored by Environment Agency and HSE using helicopter and boat. Various additional movement of “at risk” materials.

8-28 December 2000

Further flooding of the site hampering clearance.

January 2001

2 drums of radioactive waste are dicovered.

Consequences :

The seat of the fire was located in the southwest corner of compound 1. Compound 1 is used for storage and bulking of substances prior to transfer to other facilities. The following substances were involved (either destroyed or heat damaged) in the fire in compound 1:

- ✓ 12 x 1 tonne containers of isopropyl alcohol in a double stacked row,
- ✓ Approximately 60 x 205 litre drums packed with “lab smalls” in 2 double stacked rows,

- ✓ Approximately 125 x 205 litre drums, 4 x 1 tonne containers and smaller drums of mixed waste, mostly flammable solvents, adhesives, resins etc,
- ✓ 24 x 205 litre drums of acetone in a double stacked row,
- ✓ 6 pallets of waste batteries, mostly lead acid plus some nickel/cadmium, lithium, mercury and zinc,
- ✓ Approximately 180 tonnes of mixed chemical wastes including some pesticides.

Damage by flooding and necessary work to make the site safe has made identification of the cause of the fire more difficult.

Investigations by a HSE electrical specialist has concluded that ignition from electrical origin can be ruled out and with the site being unoccupied at the time of the incident a number of other possible sources (mechanical sparks, hot surfaces, naked flames, etc) can also be discounted.

ORIGINS, CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

There are a number of possible chemical scenarios for initiating the fire:

- ✓ Small laboratory samples could have lost their containment e.g. as a result of being blown over in storm force winds. They could then have reacted together, generated heat, and eventually ignited a sensitive material amongst them. A number of small laboratory sample drums were found close to the remains of IBCs which had contained flammable materials in large quantities,
- ✓ If pyrophoric or reactive materials are exposed to air or moisture, they will react building up heat until they ignite or ignite materials stored close by,
- ✓ Leakage of flammable material from a container can form a flammable atmosphere and this may ignite due to sources of ignition.

Arson has also to be considered as a possible cause.

ACTIONS TAKEN

Investigation and Site Clearance

The Environment Agency and HSE are conducting a joint investigation of the incident.

These investigations discovered the unforeseen presence of un-authorised wastes including 7 25 litre-drums labelled “solvent contaminated with BSE” and 2 drums of radioactive waste.

The site was substantially cleared of waste by 30 April 2001. This clearance has been under the direction of the Environment Agency and HSE.

Monitoring the Environment and Health

Substantial and prolonged monitoring and modelling has been undertaken. This includes:

- ✓ 17,500 tests on 500 environmental samples (air, water and land), none of which indicated any significant levels of contaminants off-site,
- ✓ At the time modelling of the accident by the HSE indicated that a “dangerous dose” of toxic materials would not have occurred at the site boundary,

- ✓ Blood tests on those exposed on the day of the fire were found to be negative for solvents and heavy metals,
- ✓ Radiological monitoring off-site concluded that there was no evidence for the presence of radioactive materials in the areas surveyed,
- ✓ The local Health Authority have undertaken multiple health surveys. These surveys offer evidence that the physical and/or physchological health of a significant number of Sandhurst residents involved in the surveys were affected following the fire, although these symptoms are generally though to be self-limiting. Health monitoring work continues.

Communication

The Environment Agency opened an incident room on the day of the fire which was maintained until 1 December 2000. Daily surgeries were held in Sandhurst village from 6 November 2000 and the Environment Agency produced a daily question and answer bulletin. The Sandhurst Parish Council held a public meeting on 7 November 2000.

The HSE and Environment Agency have both published reports considering their prior regulation of the site.

The HSE and Environment Agency have made 2 public reports on the incidents to the Deputy Prime Minister.

Enforcement

The Agency and HSE are progressing investigations into possible offences in a number of areas. It is not appropriate to provide any further details at this time.

LESSONS LEARNT

Lessons learnt by the Environment Agency can be split into 2 areas, the impact of the flooding and lessons for the regulation of similar waste facilities.

The impact of flooding

The impact of the flooding on the incident and its aftermath was significant for a number of reasons:

- ✓ It placed restrictions on the Fire and Rescue Services' ability to fight the fire initially because of the adjacent flooded fields,
- ✓ The potential for materials escaping from the site was increased because of the encroaching floodwater,
- ✓ The flooding of the only access road to the site prevented rapid removal of the "at-risk" materials when the floodwaters continued to rise,
- ✓ The ability of Fire and Rescue Services, site operators and regulatory bodies to carry out investigations was limited because of the access problems,
- ✓ Observation of the site had to be carried out from boats and helicopters.

These lessons have been widely disseminated and have been used by the Agency to:

- ✓ Revise policies on future developments in the floodplain,
- ✓ Inform inspection and licensing of existing activities,

- ✓ Review the Agency's emergency response arrangements.

Regulation of waste facilities

The Agency has a National Action Plan based around 7 issues so that lessons learned are implemented across the country.

Issue 1: Licensing arrangements at Sandhurst site

Issue 2: Licensing arrangements for all chemical waste treatment and transfer facilities

- ✓ The need to revise waste management licences to include inventories of special wastes,
- ✓ Auditing of similar sites to establish unauthorised storage of low level radioactive wastes,
- ✓ Working with industry and others to consolidate "best practice" guidance for this industry sector.

Issue 3: Emergency response arrangements

- ✓ Review arrangements to cope with long running incidents,
- ✓ Review sampling and monitoring arrangements.

Issue 4: The balance of maintaining customer confidence in the licensing process and taking enforcement action

- ✓ Application of the Agency Enforcement and Prosecution Policy.

Issue 5: Officer awareness of Agency policy, procedures and practice on inspection and prosecution

Issue 6: The Agency's environmental policies and procedures

- ✓ Review inspection policy and procedures,
- ✓ Review Special Waste Classification Guidance to include BSE contaminated materials and "lab smalls",
- ✓ Review standards and frequencies for licence reviews,
- ✓ Consider changes to criteria for determining suitability of sites in light of future public interest in locating such sites.

Issue 7: The Agency's Health and Safety Policy issues

Hydrogen sulfide

Methane

Composting

Sump

Asphyxia

Deaths

Fatal accident due to asphyxia by H_2S

February 15th , 2001

France

THE INSTALLATIONS IN QUESTION

The company

The establishment at Baupte employs approximately 350 people. It is specialized in the production of natural food additives such as gelling agents pr stabilisers, algae-based products through extraction (carraghenane) or by bio-fermentation (xanthane).

It is governed by a Prefectoral order of September 22, 1997 completed February 20, 2000.

The operator employs a peat bog of approximately 600 ha on this site, authorised by a Prefectoral order of July 4, 1974 for a period of 30 years. The peat extracted is used in the production of soil amendments.

The installations concerned

In the algae-based extraction process, the insoluble fractions, not used in the finished product, are recovered by filtration on a filtering soil (perlite) then through pressing. Approximately 15,000 m^3 of filter cake per year is collected in this manner, which represents approximately 4,500 t/year of dry extract (≈ 30%).

The filter cakes derived from this operation are sent by trailer to a hermetic storage area to undergo lixiviation (removal of the sat) then composting.

After several turning operations (aeration of the storage heap) and after 18 to 24 months, the composted product used completely used for soil amendment purposes (with the peat) or to make horse riding trails.

Until 1999, the filter cakes were stored on a non-hermetic storage area. In order to reduce the environmental impact of this storage facility, since 1999 the area consists of a central paved portion of 3,000 m² and a peripheral portion made of compacted earth measuring 2 x 1,825 m². It is now possible to recover the drainage runoff.

The entire area is isolated from the subgrade by a geotextile membrane then by a geomembrane and is equipped with a drainage network and a degassing vent system. The latter system consists of a honeycomb structure placed underneath the lower geomembrane.

The drainage water is recovered in two sumps, one of which is equipped with a "cellar drainage pump" which conveys the leachates to the site's effluent processing station. This pump is controlled by a level floater.

THE ACCIDENT, ITS BEHAVIOUR AND CONSEQUENCES

The accident:

On February 15, 2001, two company employees performed maintenance on a sump pump used to recover drainage runoff from the filter cake: according to the site Director, owing to the design of the drainage system, the hose connecting the pump discharge to the line going to the treatment plant comes disconnected relatively frequently.

In this case, the following operation is performed:

- ✓ the sump is drained using a motor-driven pump,
- ✓ the pump is removed from the sump using a chain,
- ✓ the hose is reconnected,
- ✓ the pump is placed back in the bottom of the sump and the flange is replaced.

This is the type of intervention, which had already been performed 5 to 8 times since the storage facility was reworked in 1999, that the two companies perform.

At around 3.15 pm, the sump drainage operation was completed and the first operator entered the sump. At 3.35 pm, a witness noticed the second operator on the outside.

At 5.15, when it was noted that the employees were not back yet, the alarm was given.

Consequences:

At 6.30 pm, the two employees were found dead in the bottom of the sump.

ORIGIN, CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

The filter cakes consist of sulphur-containing organic materials which, through anaerobic fermentation, release hydrogen sulphide and methane. This release is inescapable and cannot be avoided.

According to the operator, the very rainy climatic conditions in the weeks prior to the accident did not allow the heaps to be manipulated. The anaerobic fermentation was thus promoted. These conditions of strong humidity significantly increased the production of H_2S.

The hermetic character of the storage zone, built to recover the drainage runoff, actually confined the gases in the drainage network located underneath the geomembrane.

The INERIS, an organisation requisitioned by the District Attorney, conducted atmospheric measurements by chromatography in a mobile laboratory, just a few days after the accident.

The results of the measurements taken in the sump are as follows:

- ✓ sump totally full: NTR,
- ✓ sump drained to the level of the pipe bringing the drainage runoff: 222 ppm of H_2S. (Note: when the pump was stopped, the concentration of hydrogen sulphide in the sump went from 222 to 6 ppm in approximately 20 minutes).
- ✓ Sump completely drained: 550 ppm of H_2S. (In the bottom of the sump, the concentration of hydrogen sulphide reached 2,270 ppm).
- ✓ Average methane content: 300 ppm (0.03%).
- ✓ Oxygen concentration: approximately 20%.
- ✓ Carbon dioxide concentration: 0.1 to 0.2%.

Results of the measurements in a degassing vent:

- ✓ H_2S: 6,570 ppm,
- ✓ O_2: 1.1%,
- ✓ CO_2: 28%;
- ✓ CH_4: between 40 and 80%.

According to the material safety data sheet, the hydrogen sulphide is, at ambient temperature and atmospheric pressure, "a colourless gas, heavier than air *(d = 1.19), having a characteristic fetid smell (rotten egg)… "*. This odour, detectable at very low concentrations (0.02 to 0.1 ppm) can be attenuated and even disappear at strong concentrations (the sense of smell is lost at concentrations above 100 ppm).

This gas is deadly in just a few minutes at concentrations above 1,000 ppm and causes a rapid loss of consciousness, then death without immediate medical assistance above 500 ppm.

Hydrogen sulphide is thus the cause of the death of the two operators. The operator had not identified this toxic hazard. As a result, the design of the installation and the maintenance procedure were inappropriate.

ACTION TAKEN

Given the concentrations of H_2S and CH_4 measured and the considering the hazards that they represent (toxicity, explosiveness), on February 26, 2001 the DRIRE proposed a draft order indicating emergency measures (signed March 5, 2001 by the Prefect *département*) aimed at considering the storage facility as a controlled zone and the area surrounding the sumps and the degassing vent as dangerous zones, and by laying out provisions to be taken in case of intervention (limited access, prior atmospheric measurements, …).

The operator has foreseen to modify the pump's discharge line to avoid having to enter the sump. This modification, however, cannot be made until the judicial authorities in charge of the inquiry have granted authorisation.

Beyond these measures, the longer term technological changes must be considered to minimise the risks due to the inevitable formation of these gases, against the probable causes identified.

In this respect, the operator was asked to study and submit to the inspectorate possible provisions to optimise the management of the filter cake stock (quantity produced, storage time, heap aeration frequency, …) and to avoid possible zones of gas accumulation.

In addition, it was requested that a danger study be updated bearing on all of the company's activities.

Release of hydrochloric acid by the manhole of a benzoyl chloride tank

February 5th , 2002

Persan (95) - France

Hydrochloric acid

Discontinuance of business

Benzoyl chloride

Tank drainage

THE INSTALLATIONS IN QUESTION

The company and the administrative context:

The company mainly produces additives for oils, antioxidation and anti-UV agents and sucroglycerides.

For reasons associated with industrial competitiveness and production optimisation, the company, despite restructuring of its activities at Persan over several years, decided to shut down this site in the summer of 2001 and layoff its personnel.

This establishment had two activities associated with the use and storage of toxic and very toxic liquid substances exceeding the "AS" levels according to the nomenclature of the Classified Installations Inspectorate. It is governed by a Prefectoral order of April 2, 1997. Several Prefectoral orders complete the operating provisions, namely concerning the processing of soil and water table pollution discovered at the site.

As the establishment is governed by the Ministerial order of May 10, 2000 relative to the prevention of major accidents, the operator was required to submit a danger study prior to February 3, 2001 and set up a safety management system within the same deadline. As the deadline was not respected, official notification was issued for the company to comply with this obligation before July 2001.

In early summer 2001, after having announced the closure of the site and the complete shutdown of manufacturing operations, the operator reviewed its position and showed its desire to maintain an industrial potential at the site in order to facilitate its possible restart or, in the medium term, contemplate different production activities in its installations. In a difficult situation in terms of laying off its personnel, the operator was also securing the site and removing the stocked products and raw materials.

In October 2001, the Prefect of the Val d'Oise *département* requested that the company officially confirm that it was either discontinuing its business activity or continuing an industrial activity in Persan. Faced with uncertainly and the lack of clarity in the company's decision-making, the Classified Installations Inspectorate proposed an additional draft order to the Prefect of the Val d'Oise on January 30, 2002, designed to regulate the installations of the Company during the manufacturing shut-down period.

The prescribed measures foresaw provisions relative to the following points:

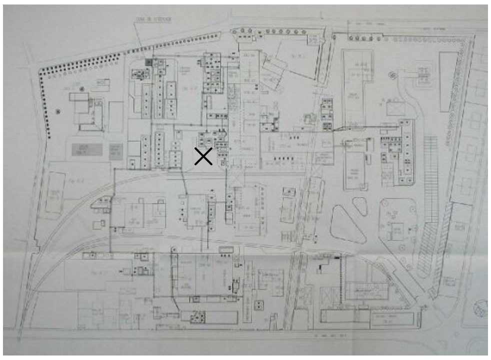
- ✓ The clean-up and securing of the installations including the organisational aspect;
- ✓ The dismantling of structures, equipment or buildings;
- ✓ The precautions relative to special risks (asbestos or radioactive sources);
- ✓ The management of a site rehabilitation program in relation with the soil and water table pollution;
- ✓ The operation of the utilities, the management of emergency response means and site guarding.

Finally, several incidents occurred in early 2001, the first caused by the untimely shut-down of a gas scrubber which resulted in the release of HCl into the atmosphere, the second resulting from maintenance/servicing on the computer management system of an industrial process which resulted in the release of xylene into the natural environment.

The installations concerned:

The benzoyl chloride was used in the manufacture of an anti-UV and benzophenone. Due to a process change, this product had not been used for several years. It was stocked in a 30 m^3 tank (C-95) located along the organic synthesis workshop. At the time of the incident, the tank contained 11.7 tonnes of benzoyl chloride, that had been delivered May 21, 1999.

Benzoyl chloride is a corrosive product to which risk phrase R34 is applicable (causes burns). It is a colourless liquid and has a pungent odour. Its density is 1.2 and its flashpoint is 72°C. It is unstable in the air under the action of humidity. It reacts violently with water and numerous components such as alcohol.

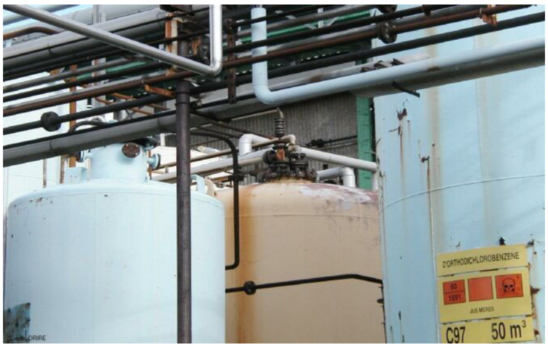


x *: Location of tank C95 containing Benzoyl Chloride*

THE ACCIDENT, ITS BEHAVIOUR AND CONSEQUENCES

Following the shut-down of production at the Persan site, GLCF began draining and cleaning the storage tanks. A few days earlier, the operator was unable to drain tank C95 due to solid benzoic acid deposits which most likely formed due to the slow decomposition of the product. The operator decided to disintegrate the deposits by adding solvent. Laboratory tests were conducted with methanol without detecting any abnormal reactions.

Following tests, tank draining operations were begun on February 5, 2002 at around 9.30 am. The operation, conducted by a technician from the company, and assisted by a fireman from an external company, consists of pumping 2 m3 of methanol into the tank then, circulating the product designed to homogenise the mixture, and then finally transferring the mixture into a tanker truck for subsequent destruction.



Having noted that the transfer pump was malfunctioning, the GLCF technician stopped the operation and began spraying down the tank with the sprinkler system. The personnel noted a small explosion, probably due to excess pressure in the tank, and a cloud of acid gas was released through the faulty flange seal on the upper dome of the tank.

The personnel attempted to bring down the cloud by setting up a water curtain and spraying down the tank.

Consequences:

According to the testimonies gathered, an opaque cloud in the form of a "fluffy mist" was observed on the site and was moving towards the homes located approximately 150 m from the tank concerned. Residents complained of a prickly sensation in their eyes. An elderly person was effected and transported to the hospital for an examination and stayed a day under observation.

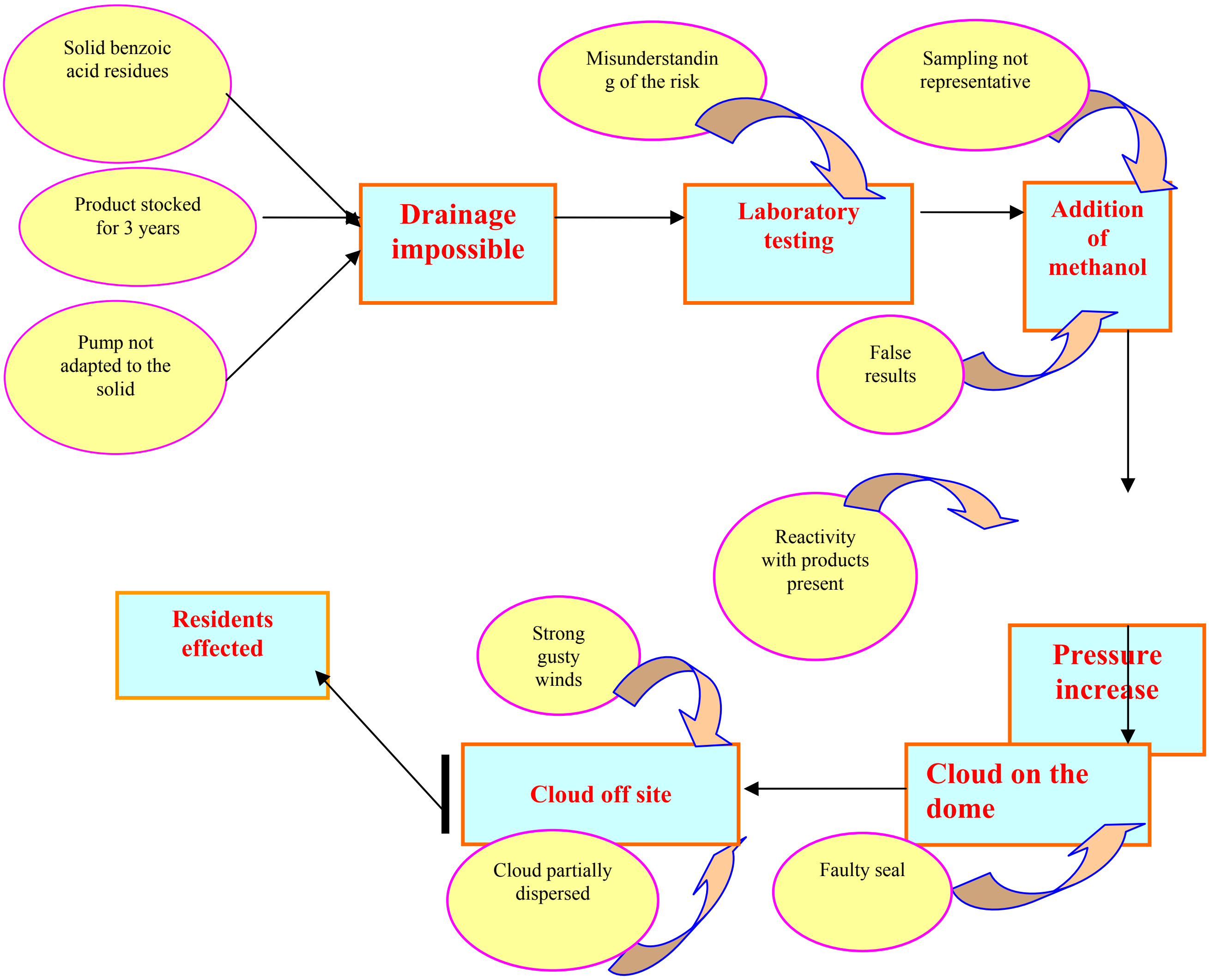
The phenomena lasted a few minutes. The cloud of acid gas coming from the tank moved by bursts in the direction of the wind although its dispersion was hindered by the presence of buildings next to the storage facility. There were no harmful consequences to the river which flows through the plant.

ORIGIN, CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

Benzoyl chloride (C_6H_5-COCl) is a highly reactive acyl halide. Its hydrolysis is very exothermic and leads to benzoic acid (C_6H_5-COOH) with the formation of hydrochloric acid (HCl). A reaction also occurs with alcohols and leads to an ester and the release of HCl.

New tests conducted after the accident showed reactivity of the benzoic acid/methanol mix at temperatures above 30°C. The laboratory tests conducted by the company were thus not representative.

At the time of the accident, adding methanol (CH_3-OH) to tank C95 thus caused a significant release of HCl (estimated at 90 kg, or 55 m^3 of hydrochloric acid for 100 litres of methanol introduced into the tank and supposing that a complete reaction occurred). The reaction was accompanied by a heating up of the mixture.



 Sheet preparation date: June 2002

ACTION TAKEN

Technical actions:

After plugging the leak on the seal, no release was visible on the tank the evening following the accident. The reaction was completed and the system returned to a stable state. At the request of the Registered Installations Inspectorate, the installations were monitored and a senior executive was placed on standby for the night and following days. A tarp was installed on top of the tank to protect it from the rain.

The Registered Installations Inspectorate requested that the operator prepare a technical file (upheld by an emergency prefectoral order) describing the security measures and precautions to be taken relative to the safety of the operations and the maintenance and back-up means needed to perform them. Prior to all further work, a new tank drainage procedure was compiled; this procedure was to be examined by a third-party expert.

The total drainage of the tank took place from the 22nd to the 30th of April, 2002, after the procedure used was approved by INERIS. The solvent used was xylene.

Administrative and penal actions:

Following this event, on February 13, 2002, the Prefect of the Val d'Oise established an order implementing article L 512-7 of the Environmental Code in order to prescribe the operator provisions concerning the installation clean-up and securing, their dismantling and the organisation of safety measures to prevent similar events from reoccurring given the existence of dangerous material storage facilities at the site. This order notably required the company to prepare and submit procedures prior to draining the benzoyl chloride tank and a second tank containing aluminium chloride; a critical examination of these procedures was to be undertaken by a third-party expert.

The classified Installations Inspectorate requested that the operator also submit an accident report. Event analysis and the on site investigations showed the presence of the following anomalies:

DESIGNATION	*ANOMALIES REPORTED*
Accident declaration	• The accident was not declared to the Classified Installations Inspectorate
Safety organisation	• No senior executive at the site and failure in the management of the organisational and decision-making chain in terms of safety, • The internal contingency plan initiated too late • Lack of operator organisation in the management of events immediately following the accident
Management of benzoyl chloride storage	• Long term storage of the product – Unchecked and unused since 1999 • Corrosion on the outside wall of the tank • Tank high level disconnected in the control room • Poor condition of the seal on the manhole flange

Misunderstanding of the dangers associated with drainage	• Implementation of a drainage procedure resulting in risks of the personnel and the environment owing to insufficient prior analysis bearing mainly on the incompatibility of the substances used and an evaluation of the consequences of such action. • No danger labels on the methanol container.
Condition of firefighting means	• Poor condition of the site's firefighting hoses • Certain Dräger lines for searching for HCl were expired since July 1998.

Non-conformities were noted relative to the technical provisions required of the operator. An inquiry was conducted by the judiciary police at the request of the public prosecutor's office of Pontoise.

LESSONS LEARNED

Unused products must be removed in a reasonable time in order to avoid new risks (product deterioration, equipment condition, loss of information).

Special vigilance must be maintained during work performed following the shutdown of manufacturing operations or the dismantling of installations, notably in facilities at risk in which dangerous materials are used. In a similar context, the operator must provide an unambiguous statement relative to its intention to discontinue its business activities or continue operations.

This accident illustrates the importance of the internal contingency plan and the need to implement an operational organisation should an accident occur. The operator must have thorough knowledge of this document and the previously assigned roles of the persons concerned.

Explosion of a hydrocarbon storage tank

February 20th , 2001

Lespinasse (31) - France

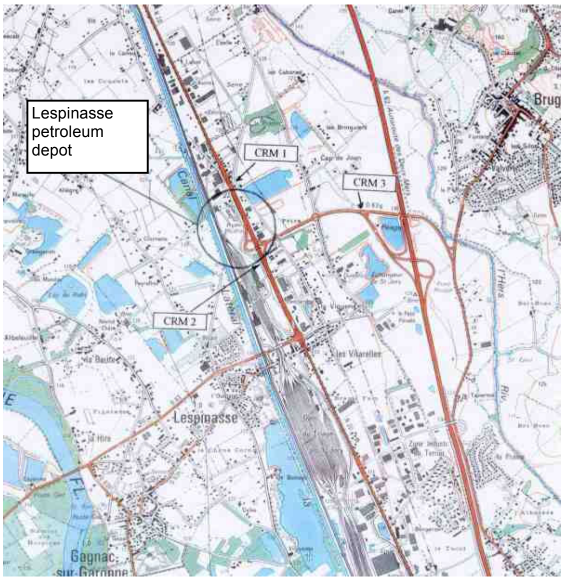
Explosion
Hydrocarbons
WorksFloating screen tanks
Flammable liquids, Gasoline
Injured;
Property damage
Internal Contingency Plan
Prevention organisation

THE INSTALLATIONS IN QUESTION

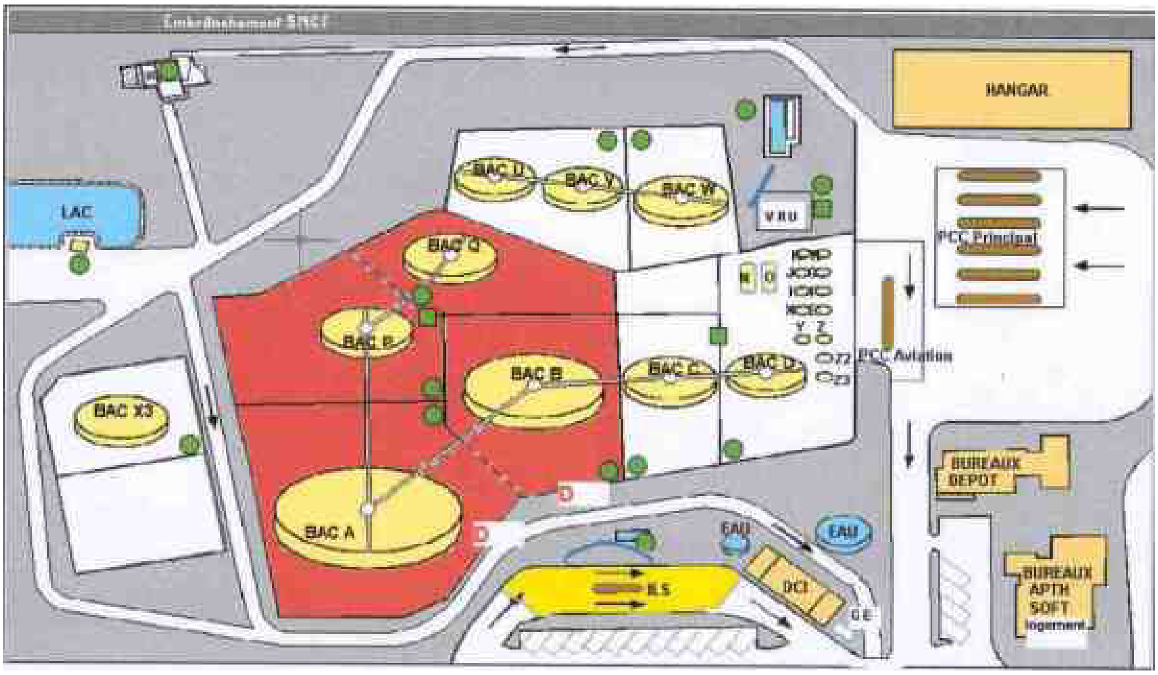
The site:

The site operates a liquid hydrocarbon storage tank, created in 1972. The company employs 9 people. The site is located to the north of the city of Lespinasse, between the channel lateral to the Garonne, the railway line to the west and the RN 20 national highway to the east.

It is subject to the "Seveso" directive and exceeds the high level threshold in terms of storage capacity.



The depot includes 9 main tanks with either a roof or floating screen. The products are supplied by train and then shipped by truck. The site's authorised capacity is approximately 57,000 m³.



THE ACCIDENT, ITS BEHAVIOUR AND CONSEQUENCES

The accident:

The tank involved in the accident was commissioned in 1991 and had a capacity of 5,090 m³. The tank was of fixed roof type with a floating screen. Cleaning operations were taking place on the tank at the time of the accident.

On the day of the accident, the tank was empty although normally contained premium type gasoline.

The operations, conducted by employees from an external company, consisted in scraping the floor to remove residual deposits. The tank's screen was at a height of approximately 1.2 m. In this case, the working space was limited.

At roughly 4 pm, an explosion occurred while the 2 contractors were inside the tank.

Consequences:

The 2 contractors were seriously injured: they were able to exit the tank by themselves and were subsequently hospitalised when the emergency rescue team arrived. Both were burned, one of which being seriously burned.

The tank was totally destroyed. Activity at the depot was stopped for approximately 2 months.

The costs of the accident:

- Property damage: 1 M Euros
- Operating losses: 0.6 M Euros
- Securing and dismantling operations: 0.2 M Euros

The accident did not initiate the domino effect.

ORIGIN, CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

The tank involved by the accident was equipped with only one manhole. Configuration during the cleanup operations:

- all of the vents were not open,

- the ventilation used to remove fuel fumes was stopped for the intervention,

- operations were started before reaching a gas concentration lower than 10% of the LEL (lower explosive limit).

The employees had limited space to move around: this also constitutes an unfavourable element.

The hypothesis of a spark created by one of the worker's tools is the most plausible. Within an explosive atmosphere, this could have caused an explosion.

ACTION TAKEN

The operator engaged the internal contingency plan. The firemen arrived at the site and brought the accident under control within 45 minutes. Traffic on the national highway nearby was stopped for a few minutes.

On the proposal of the Registered Installations Inspectorate which visited the site on the day of the accident, the *Prefect* drafted an order requesting that emergency measures be undertaken before operations resumed:

- a study on the precise causes and circumstances of the accident,

- determination of the measures to be taken to prevent such an event from happening again,

- verification of the safety of the installation concerned, as well as the neighbouring installations,

The accident was classified as 2 as per the severity scale, which became official in February 1994 by the Committee of Competent Authorities of the member States which oversees the application of the 'SEVESO' Directive 82/501/CEE. This level is associated with the number of injured (2 seriously injured), the amount of property damage at the site (1M Euros) and the operating losses (0.6 M Euros).

Although slightly below the Seveso 2 Directive criteria, the accident formed the subject of a report submitted to the European Union for its interest relative to the type of intervention involved.

LESSONS LEARNED

Locally, the operator took the following measures to prevent such an accident from reoccurring:

⌅ Modification of the procedure for maintenance/servicing inside a hydrocarbon tank:

- compilation of procedures adapted to the site and to the tanks (all tanks are not identical in terms of equipment, which changes the precautions to be taken prior to the operation)

- cleaning/degassing operations are to be performed only after validation by the depot manager or an assistant.
- vapour concentrations (explosive atmosphere) specified in the procedures are to be reached before the start of any maintenance/servicing in the tanks (no anticipation).
- improvement of the ventilation by opening branch connections, removing valves, or opening manholes, ...
- maintain forced ventilation throughout the entire operation

⌧ Reminder of intervention principles for external companies performing tank maintenance/servicing operations

Notably after this accident, the GESIP, the French petrochemical industry association, created a think tank to fine tune certain rules. A few of these rules, derived from the document entitled "Guide de sécurité pour l'exploitation des dépôts d'hydrocarbures liquides" (Safety guide for operation petroleum products marketing terminals) and dealing with the degassing of fixed roof tanks with screen, are outlined below:

- low level extraction of vapours and possibly forced ventilation,

- the need for at least 2 renewed atmospheres/hour and an injection speed greater than 20 m/sec.

- compressed air-powered equipment, with conduits and equipped with a shunt/ground bond with the tank structure.

- opening of the roof and the screen.

- work authorised using PBA and cold if % LEL is less than 10.

- explosimetre measurements to be taken in carefully selected zones (30 cm above slurries, far from the manhole,...)

In summary, it is obvious that the intervention of individuals in a confined space must be preceded by the appropriate verification of the atmospheric conditions of the work area. This must also be monitored and controlled through the entire operation.

leak

flammable liquids

surface water pollution

pump

equipment failure

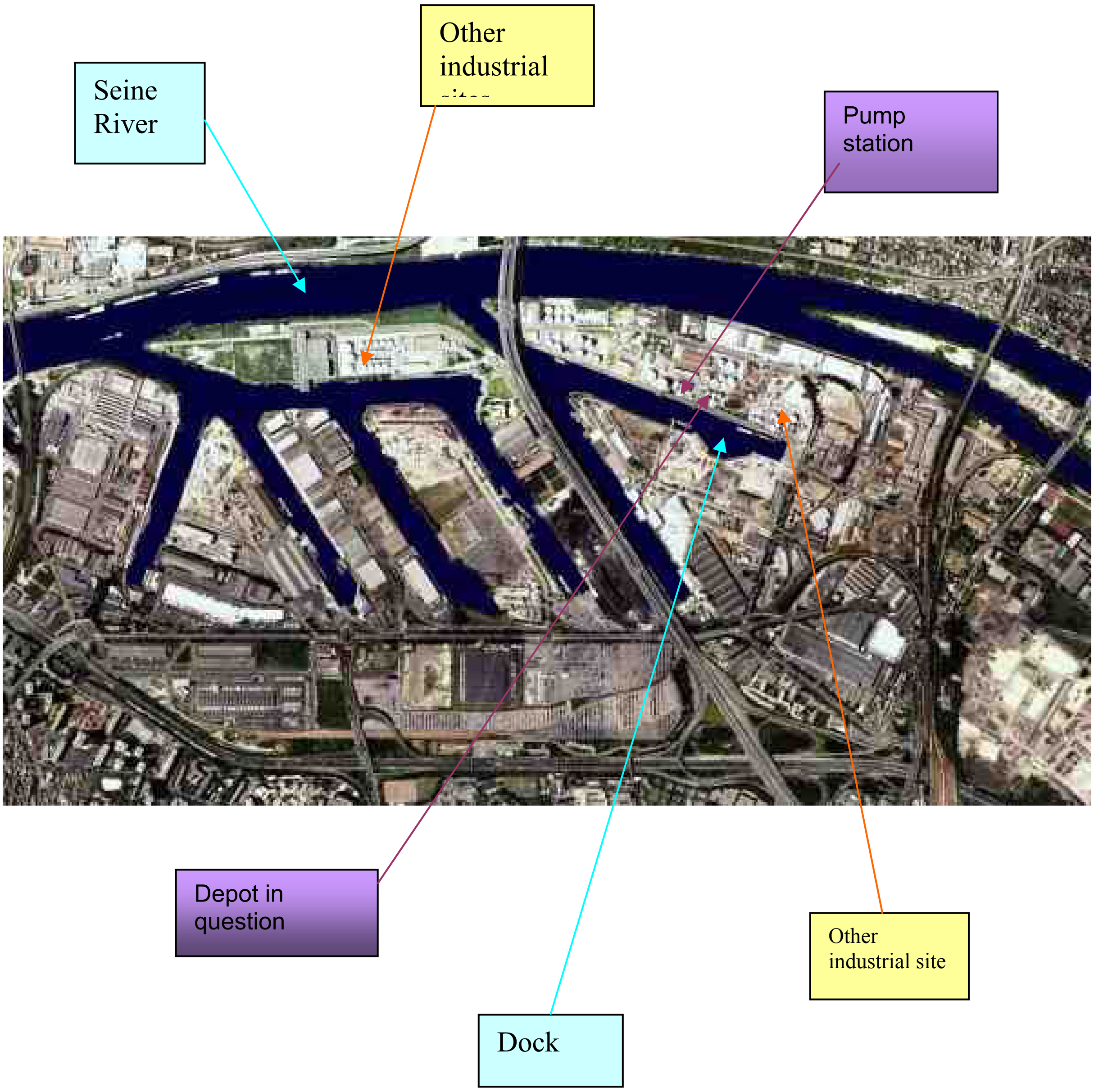
Organisation

Heating oil FFO leak in a petrol storage

October 12th , 2001

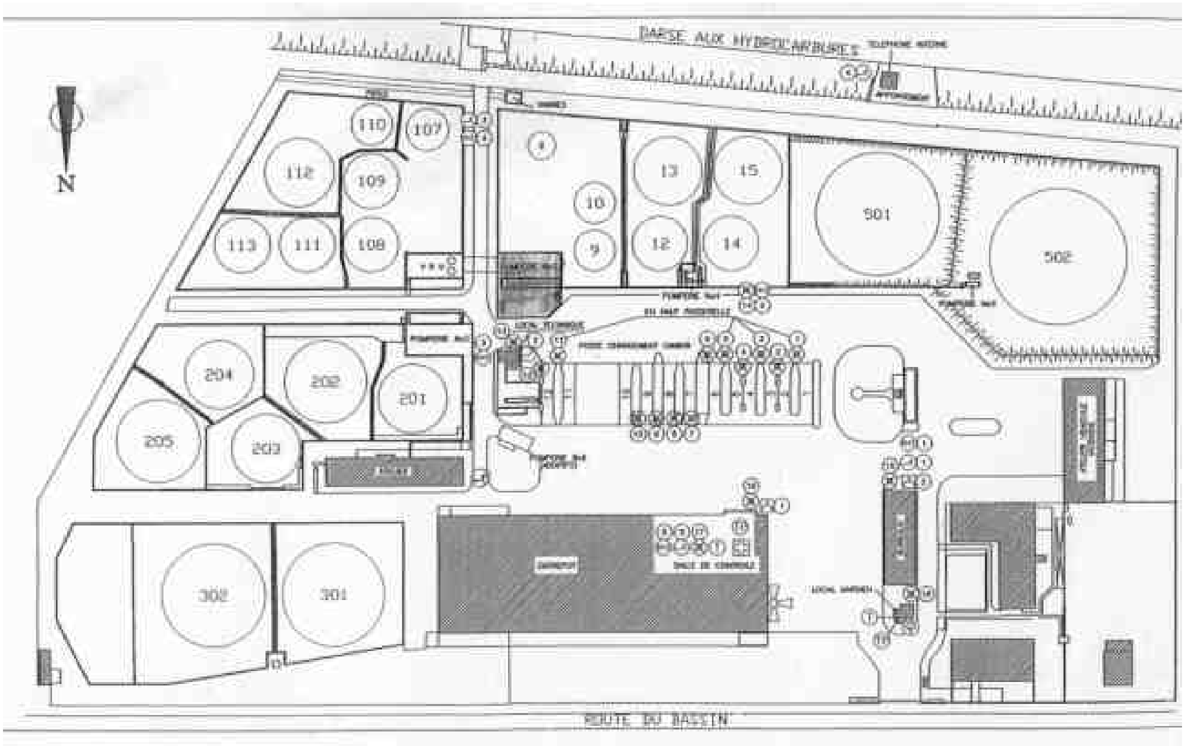
Gennevilliers (92) - France

THE INSTALLATIONS IN QUESTION



The depot is located next to the docks. It consists of 23 tanks, having a nominal capacity of between 537 m³ and 19,193 m³, for a total nominal capacity of approximately 107,000 m³. The establishment is subject to authorisation and easements (AS). It is also classified under the Seveso directive.

The site includes 12 tuck loading stations and 3 pump stations.



THE ACCIDENT, ITS BEHAVIOUR AND CONSEQUENCES

The accident:

October 12, 2001, at **5.20 am**, an operator of the depot was alerted by a driver and heard an unusual noise in pump station No. 1. He discovered a leak of furnace fuel oil FFO (heating oil): the pump station's retaining pit contained approximately 80 cm of FFO.

The operator took the following measures:

- Manual closure of the valve in question, stopping the leak,
- Closure of the "polluted" rain water release valve into the Seine,
- Disconnection of the electrical power supply to pump station No. 1,

- Securing of the site by closing all tank valves by activating the emergency stop,
- Checking to see if the devices located at the separator outlet operated correctly and closed the pipe which releases into the Seine,
- The depot manager and his assistant were contacted by telephone,
- Firefighting system triggered,
- Evacuation of all trucks present.

The assistant and the depot manager arrived at **5.50 am and 6.05 am**, respectively. The following measures were undertaken:

- Evaluation of the situation, namely by performing an estimate of the quantity of FFO lost: 239 m^3 of FFO were released in the pump station and in the network,
- Implementation of pumping means,
- Checking of surface water in the dock area,
- Control of the Seine: this latter operation was apparently difficult; there were problems related to access and visibility.

7.25 am: The Paris fire brigade was called in case of possible pollution of the Seine, the PAP, other operators located nearby.

7.35 am, the firemen arrived.

The following operations were conducted **throughout the morning**:

- Information released by the *Prefecture* of the Hauts-de-Seine *département*,
- Recovery of product (185 m^3) and elimination of 100 tons of hydrocarbons containing water,
- Report and shutdown of downstream water pumping stations along the Seine.

12.00 pm, arrival of the Registered Installations Inspectorate

12.30 pm, the operator decides not to engage specific measures following the observation of irisations on the Seine.

Shortly thereafter, the DRIRE arrived on site to access the accident. Its report is based notably on the disregard of a condition of the Prefectoral order requiring that "all provisions be taken so that there cannot be, in case of an accident, a recipient rupture of this type, the direct spillage of dangerous or polluted materials into the sewers or the natural environment".

10/16/01, i.e. 4 days later, the depot (excluding pump station No. 1) is returned to service.

10/19/01, pump station No. 1 is returned to service.

Consequences:

Release into the Seine was limited: an estimated 500 litres of FFO. Irisations, however, were observed on the Seine.

The costs, an overall amount of approximately 200 k€, can be broken down in the following manner:

- Property damage:	112 k€
- Decontamination/clean-up costs:	23 k€
- Operating losses:	61 k€

ORIGIN, CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

The leak occurred on one of the pumps of pump station No. 1. The pump body ruptured. This rupture was due to the accumulation of excessive stresses linked to:

- incorrect supporting of the lines and line accessories
- incorrect attachment of the lines to the pump

The phenomena was aggravated by the nature of the pump's casing (cast iron).

In addition, spillage of product was possible as the resulting of various malfunctions:

- A liquid hydrocarbon detector was present 2 m from the pump in question but it was not operating: at this time, the operator had undertaken work enabling the closure of the tank bottom valves to be slaved with signals from the detectors. This slaving was supposed to be operational at the end of October.

- The petrol intercepting trap was equipped with a densimetric plug (floaters) which prevented release into the Seine, but as the closure was not immediate, several hundreds of litres of FFO entered the Seine.
- The pump concerned was a back-up pump which was not in operation at the time of the incident. However, the overall management of the site was such that the valves were maintained open on a permanent bases.

ACTION TAKEN

The operator took the following immediate actions following the accident:

- The depot was secured.
- Disassembly and verification of all the pumps of pump station No. 1.
- Expert evaluation of the pump. (it should be noted that an attack alert occurred the day before).
- Closure of the Seine discharge valve.

Other measures were taken in a second phase:

- Slaving of Seine discharge valve closure to the detection of liquid hydrocarbons located in the last compartment of the intercepting trap.
- Monitoring of pump stations 1 and 3 by the personnel during depot business hours pending the refurbishing of the hydrocarbon detection system.
- Monitoring during off hours of the pump stations and participation of the surveillance staff in "industrial protection" tasks".
- Installation of a "one-fourth turn" valve on the retaining area of pumping station No. 1.
- Drainage and cleanup of the petrol intercepting trap and the sewer network.
- Forwarding of the corresponding documentary evidence relative to the elimination of the products resulting from the cleanup and drainage of the wastewater network
- Piezometric monitoring of the water table.

LESSONS LEARNED

Other more general measures were also adopted:

- Integration of this type of scenario in the danger study.
- Systematic closure of manual intake and discharge valves of the back-up pumps.
- Expert evaluation of pumps and piping: an action plan based on the elimination of stresses and on the verification that the material used is adequate for the job. Priority actions were to be undertaken prior to 12/31/02. The plan can also include the replacement of pumps which, after examination, would need to be replaced.

In addition, the administration requested that the implementation of other modifications also be foreseen. The main modifications are as follows:

- Slaving of the Seine discharge valve closure also to the detection of hydrocarbons within the pump station: this would thus lead to the immediate closure of the Seine discharge valve on all detection signal, either liquid or gas.
- The study of the closure of this valve according to a detection noted at the Control Centre: this would lead to an emergency shut-down situation at the Control Centre, closing the valve.
- Verification of the correct positioning of the hydrocarbon detection device located at the outlet of the separator: it must be located sufficiently upline from the shut-off valve to avoid any discharge into the Seine. In case of detection, the valve's reaction and closing time must be taken into consideration.
- Possibility to have a floating barrier operational on a permanent basis: this phase still poses certain problems for the docks.
- A study concerning the installation of a fixed floating barrier at the Seine release point: The barrier was purchased, although a study is currently underway regarding its fixed installation.
- A study concerning the closure of all of the pump stations' mechanical valves when the depot is not open: the solution retained by the operator is to maintain the tank bottom valves closed during "off business" hours.
- Rework of the seal of pump station No. 1.
- Improvement of signalling systems throughout the entire depot is underway.

A series of explosions on alcohol tanks at a distillery

September 3rd , 2001

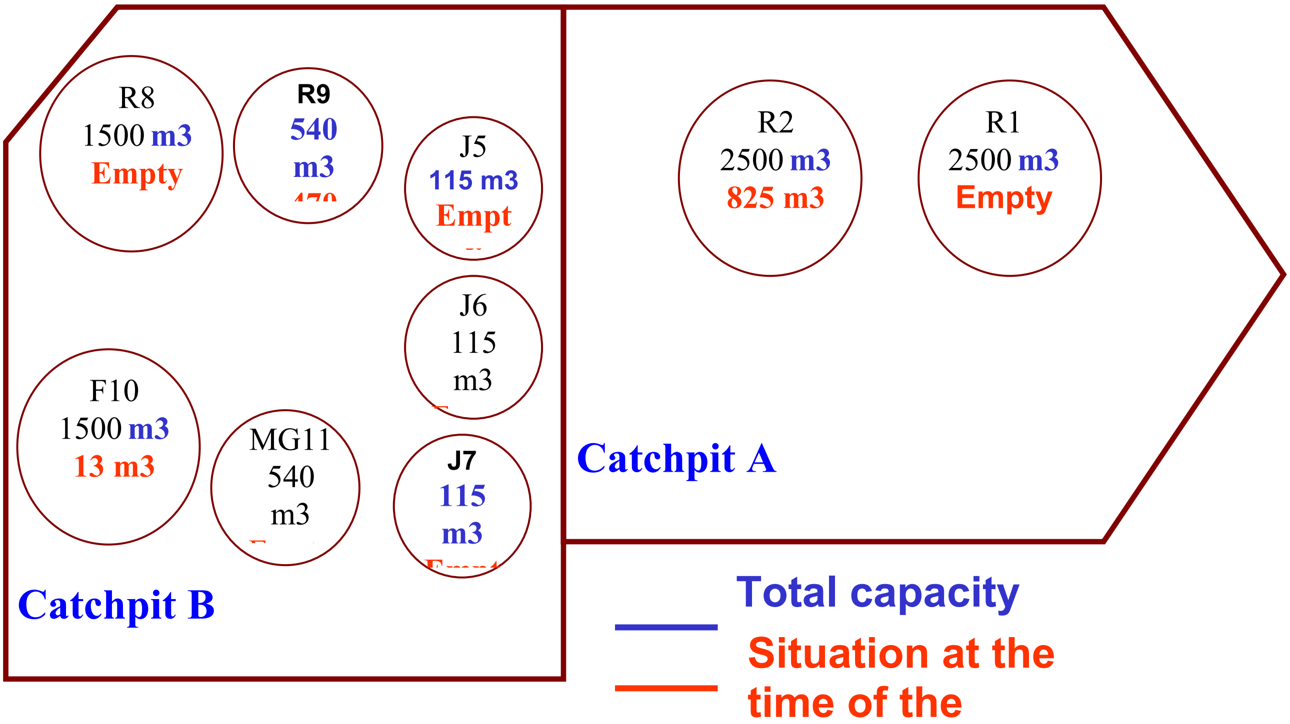
Lillers (62)- France

Sugar refinery
Distillery
Explosion
Tank
Alcohols
Permanganate

THE INSTALLATIONS IN QUESTION

Since 1925, the company has been located on approximately 65 ha of property situated between a primarily rural and the urbanized zone of the city of Lillers. The company processes approximately 1,000,000 tons of beets per year and operates an associated distillery with a processing capacity of 2,500 hl/day of alcohol.

The alcohol storage area, an installation attached to the distillery, consists of 9 tanks having the following characteristics:



As regards the regulations, on the day of the accident the establishment was operating under the authority of a prefectoral order dated January 6, 1999 relating to the global update of the regulations imposed on the site. It comes under the Ministerial Order of May 10, 2000 (SEVESO 2) for the storage of flammable liquids (quantity stocked > 5,000 tons).

The installation in question was in-status and had formed the subject of a prefectoral order, dated June 8, 1993, concerning additional requirements relative to the application of the ministerial technical order, dated November 9, 1989, relative to the existing old stocks of flammable liquids and specifically on the reinforcement of fire prevention and fire fighting facilities.

THE ACCIDENT, ITS BEHAVIOUR AND CONSEQUENCES

The accident:

On September 3, 2001 at roughly **4 pm**, the distillery personnel were performing a cleaning and alcohol transfer test operation into tank F10 (1,500 m^3) which was empty and degassed for this purpose. 50 kg of potassium permanganate in powder form was dispersed into the bottom of the tank and approximately 15 m^3 of alcohol was gravity fed into the tank. Once this operation was completed, the personnel left the storage facility at roughly **4.35 pm**.

At 4.42 pm (t = 0), tank F10 exploded projecting its roof more than 10 m into the air. The roof fell onto the roof of tank F8. Catchpit B and tank F10 caught fire.

Roof of tank F10

At 4.52 pm (t = + 10 min.) – explosion of tank MG11. The roof was blown off and landed roughly thirty meters on a nearby stock of limestone.

The distillery's security staff, alerted by the initial explosions, went to the fire pumping station to engage the fixed extinguishing means:

- ✓ Foam monitor of the alcohol storage facility in open position,
- ✓ Water spraying rings on the neighbouring silos opened,
- ✓ The spray rings on the alcohol storage tanks were opened as required with foam or water from the distribution stations located near the catchpits.

At 4.55 pm (t = + 13 min.), while the fixed extinguishing installations started to be implemented, tanks BJ6 and BJ7 exploded ripping off at roof level.

The last explosion occurred while the fixed installations were being started; fortunately no one was injured.

From 4.49 to 4.58 pm (t = + 16 min.), calls from the company and eye witnesses arrived at the CODIS 62 (Centre Opérationnel Départemental d'Incendie et de Secours, departmental fire and rescue centre) reporting " an explosion followed by flame at the Lillers distillery".

At 5.01 pm (t = + 19 min.), the plant manager put the internal contingency plan into action. The rescue services on site (firemen) reinforced the fixed extinguishing means to prevent the fire from spreading to catchpit A.

At 5.10 pm (t = + 28 min.), the operator's command centre was set up and began to seek foam concentrate assistance (from neighbouring manufacturers and suppliers).

The company personnel was counted: No-one was missing.

The action of the fixed extinguishing means on catchpit B began to take effect. The flames started to recede.

At 5.15 pm (t = + 33 min.): arrival of the fire chief and contact made with the plant manager at the internal contingency plan centre (POI). While the fire had been surrounded, the layer of foam is pierced by numerous outbreaks of flame.

At 5.35 pm (t = + 53 min.), the CODIS 62 engages the 2nd echelon.

The fixed extinguishing means and firemen were adjusted to reserve the foam concentrate for catchpit B and to switch to water to protect the other installations. The amount of water being pumped at this time is approximately 800 m^3/h, not counting the storage cooling rings of the storage facility and neighbouring installations.

At 5.40 pm (t = + 58 min.), four 1,000-liter containers of foam concentrate are transferred into the 30 m^3 fire storage tank which is dropping rapidly.

At 5.54 pm (t = + 1 h 12 min.), the situation is assessed in the operator's command centre, then on site.

The layer of foam is stable; there is no more visible fire re-ignition, and it can be considered that at **5.55 pm (t = + 1 h 13 min.),** the fire was brought under control.

The monitors are readjusted to cool down the collapsed tanks and the full tank R9. Foaming operations are reduced. Catchpit B is 50% full.

At 6.30 pm (t = + 1 h 48 min.) – spraying down of the neighbouring installations is stopped.

At 6.40 pm (t = + 1 h 58 min.)– the fire is out – the tanks are cooled intermittently to avoid prevent the catchpit from overflowing.

A thermal imaging camera is used to monitor the cool down of the structures.

At 6.55 pm (t = + 2 h 13 min.), the foam concentrate tank is empty. Two 1,000-liter containers from neighbouring manufacturers are pumped over.

At 7.15 pm (t = + 2 h 33 min.), a situation report is conducted between the plant manager, the CODIS and the DRIRE concerning further actions:

- immediate replenishing of the foam concentrate tank and the company's water reserve,
- monitoring of the cooldown throughout the night,
- a meeting the next day to plan the unloading operations.

At 7.30 pm (t = + 2 h 48 min.), the operator's command centre is shut down.

A detachment of firemen and plant personnel will monitor the site until **8 am** the next day.

Consequences:

Operating losses are evaluated at 2.13 M Euros and property damage at 2 M Euros: 1,500 m³ tanks (structure collapsed) and 540 m³ tanks (roof blown off) destroyed, and the roofs of three 115 m³ tanks ripped open.

The 2,000 m³ of firefighting water were recovered in the storage tanks' catchpits and processed in the plant's treatment facilities (lagoon system).

ORIGIN, CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

At the request of the Classified Installations Inspectorate, the company called upon the INERIS ("Institut National de l'Environnement industriel et des Risques", the National Institute for Industrial Environment and Risks) to determine the causes of the accident.

According to the subsequent expert evaluation, it appears that the explosion of tank F10 was to due to the ignition of an explosive atmosphere (ATEX) made up of alcohol vapours and air, present in the void of tank F10. The ignition was caused by a strongly exothermic reaction between a surplus of oxidizing agent, the potassium permanganate ($KMnO4$), and the aqueous ethanol solution at 96%. Owing to the domino effect, the consequences of the accident were worsened by the damage caused to the other tanks.

The expert assessment was based primarily on the results of a laboratory test showing the exothermic character of the heterogeneous mixture ($KMnO4$ + ethanol) in the proportions used causing the explosive air/ethanol atmosphere above the mixture of products to ignite. This permanganate mixture, which had been made since the storage facility was created (1980) without any incident, is designed to reduce the trace of sulphur-containing components present in the alcohol.

LESSONS LEARNED

The foam concentrate made available by other manufacturers located near the plant were incompatible, not enabling them to be used in the refinery's installations for flammable polar liquids (alcohols).

The firemen's means of communications malfunctioned as during the internal contingency plan exercise of June 28, 2001.

The solid permanganate was replaced by diluted liquid permanganate liquid after the process was validated.

Transport pipe
Flammable liquids
Soil water table pollution
Monitoring
Intervention

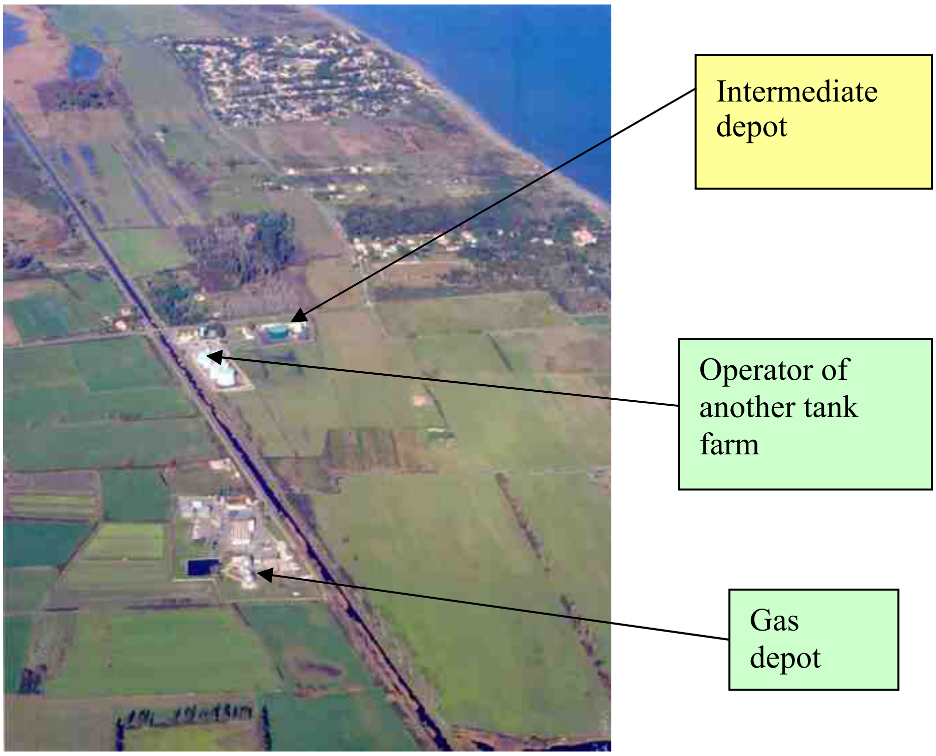
Hydrocarbon leak on a pipeline

September 18th , 2001 and February 9th , 2002

Lucciana (20) - France

THE INSTALLATIONS IN QUESTION

The industrial facilities are located on the territory of the *commune* of Lucciana. The operation of these facilities requires the use of pipelines transporting liquid and liquified hydrocarbons. This is normally the case of the electrical power plant located inland to which a 8,000 m³ intermediate depot is associated, located in a littoral zone, which is used as a buffer during fuel deliveries.



THE ACCIDENTS, THEIR BEHAVIOUR AND CONSEQUENCES

The installation:

The fossil-fuel power plant was commissioned in 1973, and the hydrocarbon pipeline used to supply the littoral depot with fuel was commissioned in 1975.

After delivery by sea, the hydrocarbon pipeline allows the heavy fuel oil (FO2) and the light fuel oil (FOL) to be transferred from the plant operator's intermediate depot located 1 km from the littoral boundary to the power plant depot located 7.5 km inland; the pipeline is buried at an average depth of one meter. As a general rule, it remains continually filled with light fuel oil (FOL) between two transfer phases.

The pipeline is made of 5.56 mm-thick steel and has a useful diameter of 100 mm. With a total length of 7,430 meters, the pipeline consists of 12-meter linear sections welded end to end. It is coated in a casing of 3 mm-thick synthetic resin which is bonded to the metal, then by 5 cm-thick polyurethane foam and finally by a casing similar to the first.

These service pressures are 40 bar under normal operation and 90 bar during forced operation, notably when cooling the heavy fuel oil during unloading operations. The pipeline was tested at 102 bar when commissioned and during the ten year inspection operations.

The product transfer procedure from the intermediate depot to the plant is as follows:

- light fuel oil (FOL) is transferred at 70°C at 10 bar for 4 hours in order to heat up the walls of the pipeline to prevent freezing points,

- transfer of the product heated (FO2) to 85°C at an initial pressure of 40 bar; the pressure is lowered to 36 bar during the transfer operation when the temperature of the pipeline walls stabilises,

- pumping of "cold" light fuel oil (FOL) in the pipeline for cooling purposes at 20 bar

- FOL "filling" of the pipeline at zero pressure between two transfer operations. In reality, the pressure of the pipeline on the littoral side (at the location of the accident) is approximately 2 bar. This static pressure is due to the difference in elevation between the plant and the littoral (column of fluid).

The transfer operations are performed by site personnel near the intermediate depot and operate it under contract. When its depot is filled, the Plant has approximately 20 to 45 days of production autonomy depending on the energy demand.

Two incidents of the same type are presented here: that of September 18, 2001 and that of February 9, 2002. A brief description is provided separately in the majority of the descriptive paragraphs. Subsequently, insofar as a certain number of feedback actions and organisational elements are common, the 2 cases are handled jointly.

The accident of September 18, 2001:

This incident involves a leak of heavy fuel (FO2) and heating fuel which occurred on the connecting pipeline between the seaside petrol station and the power plant, during one of the power plant supply operations.

The pipeline was transporting heavy fuel at the time of the accident.

The objective of the product transfer operation on that day, resulting in the incident of September 18, 2001, was to replenish the power plant's on-site stock.

Consequences:

On September 18, 2001, heavy fuel was noticed approximately 600 meters from the hydrocarbon depot, in a corn field along the departmental highway, along the pipeline route.

The results of the investigations conducted by the operators revealed the following points:

- soil pollution by heavy fuel in superficial layers,
- soil pollution by light fuel (FOL) limited to underground sandy areas; this pollution was contained in the sandy layers by the massive presence of compact peat,
- occasional pollution of the underground water table in a restricted sector but whose migration is potentially moving at "an unknown speed".

The operator estimated the volume of infiltrated FOL at approximately 400 m³, in addition to the volume already extracted (250 m³). Nevertheless, it appears somewhat difficult to make this estimation without precise knowledge of the leak's age. The leak may have occurred before September 18.

The accident of February 9, 2002:

The second incident, which occurred on February 9, 2002, confirmed the extent of the defects discovered during the first accident. At around 3.15 pm, a farmer informed the shift personnel that there was heavy fuel in his field approximately 2 kilometres from the plant.

The PSI ("Plan de Surveillance et d'Intervention", intervention and monitoring plan) was put into action and the following measures were taken:

- ✓ The pipeline was filled with water at zero pressure,
- ✓ The polluted area (approximately 10 m^3) was stripped and the heavy fuel from the intermediate depot was stocked in an oiltight 8,000 m^3 retaining pit,
- ✓ Search for the leak.

The first visual inspection of the pipeline did not allow it to be determined if cause of the leak was due to corrosion problem or external aggression. It was noted, however, that the farmland located near the pipeline was inside the zone supposedly covered by easements. In addition, the pipeline markers had been moved.

ORIGIN, CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

The accident of September 18, 2001:

The pollution resulted from a leak that was located in the days following the spill. Temporary repair was undertaken, with the heavy fuel oil transfer operations then being performed while being closely monitored.

The following study program was implemented:

- visual inspection,
- chemical analysis,
- micrographic examination
- microanalysis examination with an electronic probe.

Chemical analysis was used to confirm that the steel analysed corresponded to the grade of the material used in the construction of the pipeline.

The micrographic examination conducted near the leak in the pipeline showed a significant loss in thickness as well as several corrosion spots. Ripped material was noted at the location of the perforation. The presence of numerous corrosion craters in a zone outside the penetration was also observed.

In addition, the presence of oxides on the external wall and on the edges of the rip possibly indicate that the leak was not recent.

Finally, the micro-analyser/electric probe examination of the oxides on the external wall of the pipeline near the perforation highlighted the presence of chlorines.

These investigations enabled the operator to conclude that the breakthrough on the pipe occurred after a significant loss of thickness located in the zone having widespread corrosion caused by chlorines on the external wall due to the presence of brackish water. The brackish water comes from water table variations, particularly under the influence of the "salt wedge" (the rise of salt water into the water table). A localised defect in the pipeline's protection is most certainly allowed the salt water to come into contact with the pipe and cause the corrosion.

The "salt wedge" hypothesis was confirmed by the board of hydrogeologists approved by the *département* of Haute Corse; the variation in the height of the water table is also important, several metres in a few days, until it becomes level with the level of the soil.

The accident of February 9, 2002:

The first visual inspection of the pipeline did not allow it to be determined if cause of the leak was due to corrosion problem or external aggression. Upon completion of investigations described in the paragraph below, it appears that the hypothesis proposed for the deterioration observed on the pipeline was use of heavy equipment used to clean the canal where it is located.

However, the farmland located near the pipeline inside the zone supposedly covered by easements was noted. In addition, the pipeline markers had been moved.

ACTION TAKEN

The accident of September 18, 2002:

The intervention and monitoring plan (PSI) was set into action and the following measures were taken:

- the pipeline was filled with water at zero pressure,
- pumping of the liquid part of the product at the surface,
- search for the leak,
- surface stripping of the polluted zone (approximately 250 m^3) and temporary storage in an oiltight reservoir.

Besides these measures, the power plant operator undertook operations to control the polluted zone, with eight core samples and the installation of three piezometres.

The 7,430 metres of pipeline was inspected. The method retained, searching for faults using leakage currents, revealed 17 faults on the "upline" sector between the littoral and the intermediate depot, and 9 faults on the "downline " sector, between the intermediate depot and the power plant.

It was then decided that the pipeline was to be checked (involving trenches, thickness measurements, metallurgical exams, etc.) as a priority based on the extent of the fault.

Monitoring of the soil and underground water pollution was performed by the Direction Départementale de l'Agriculture et de la Forêt (DDAF) in charge of the policing the area.

In addition, the power plant operator hired an engineering firm to conduct the following operations:

- soil clean-up operations while maintaining the pipeline in operation,
- the decontamination of materials stocked and their disposal after treatment,
- clean-up of the water table.

The accident of February 9,2002:

Temporary repair was carried out, identical to that performed following the incident of September 18, 2001.

The investigations conducted as of February 10, 2002 revealed limited surface pollution of approximately 2m². The first piezometre was installed to check the presence of a water table and any possible pollution. Furthermore, the Inspectorate requested that the operator accelerate the pipeline investigations.

As far as this point was concerned, the examination of the defects detected between the littoral boundary and the depot were stopped due to the upswelling of the brackish water due to the spring tides.

The operator thus began its search inland on February 22, 2002 by digging trenches at the fault nearest the power plant located in the bed of channel designed to drain away water in the case of a flood.

The following points were developed during the manual digging operations:

- degradation of the pipeline's position markers,
- mechanical deterioration of the covering,
- decreased tube wall thickness (two series of ultrasound measurements)

The Inspectorate thus wanted to engage overall reflective thinking along two axes:

- in the short term:
  - ✓ Continue the in-depth expert evaluation of the faults observed over the entire pipeline,
  - ✓ Implementation of an awareness campaign among operators concerning the problems of pipelines encountered in the sector,
  - ✓ Examine the respect of easements associated with the operation of the pipelines.
- in the medium term and within the scope of a PSI review:
  - ✓ Review the fault search procedures and frequencies,
  - ✓ Ensure that easements associated with the operation of the pipelines are respected.
  - ✓ Ensure that these easements are publicised by the commune.

LESSONS LEARNED

Concerning the repairs, the operator integrated the elements available to mitigate new leaks into the framework of its spare parts management system.

From the equipment point of view, the method used to search for faults (leakage currents) proved its efficiency and is its use has been considered for checking the other pipelines in the zone concerned by the upswelling of brackish water; depending on the results, this type of verification as well as their frequency will be established within the framework of a modification of PSIs (Plan de Surveillance et d'Intervention, intervention and monitoring plan) which will also take the regular verification of easements into account.

Depending on the results, discussions will also take place concerning the possible replace of the pipelines, in whole or in part.

The mutual disclosure of information prepared by the operators and the commune took place in the presence of the Government Entities concerned; DDAF, DDASS, DRIRE.

Finally, within the scope of better information relative to underground structures at risk, an interdepartmental SIG ("Système d'Informations Géographiques", geographic information system) is currently being created. It should enable civil engineering firms to be informed of underground pipelines and electrical lines via the communes.

Butadiene leak in a petrochemical unit

December 14th , 2000

Lavéra (13) - France

Leak

Polymerisation

Butadiene

Internal Contingency Plan

Equipment defect

Design

Abandoned channel

THE INSTALLATIONS IN QUESTION

The establishment in question is located within the *commune* of Martigues in the Lavéra petrochemical complex which includes 9 operators, 7 of which carry high-level SEVESO classifications. The Naphtachimie company is authorised by Prefectoral Order to operate a steam cracker and a butadiene production unit. It is classed as high-level SEVESO.

The installation concerned by the accident is the Butadiene unit which handles the C4 fraction from the steam cracker or imported.

It manufactures two finished products:

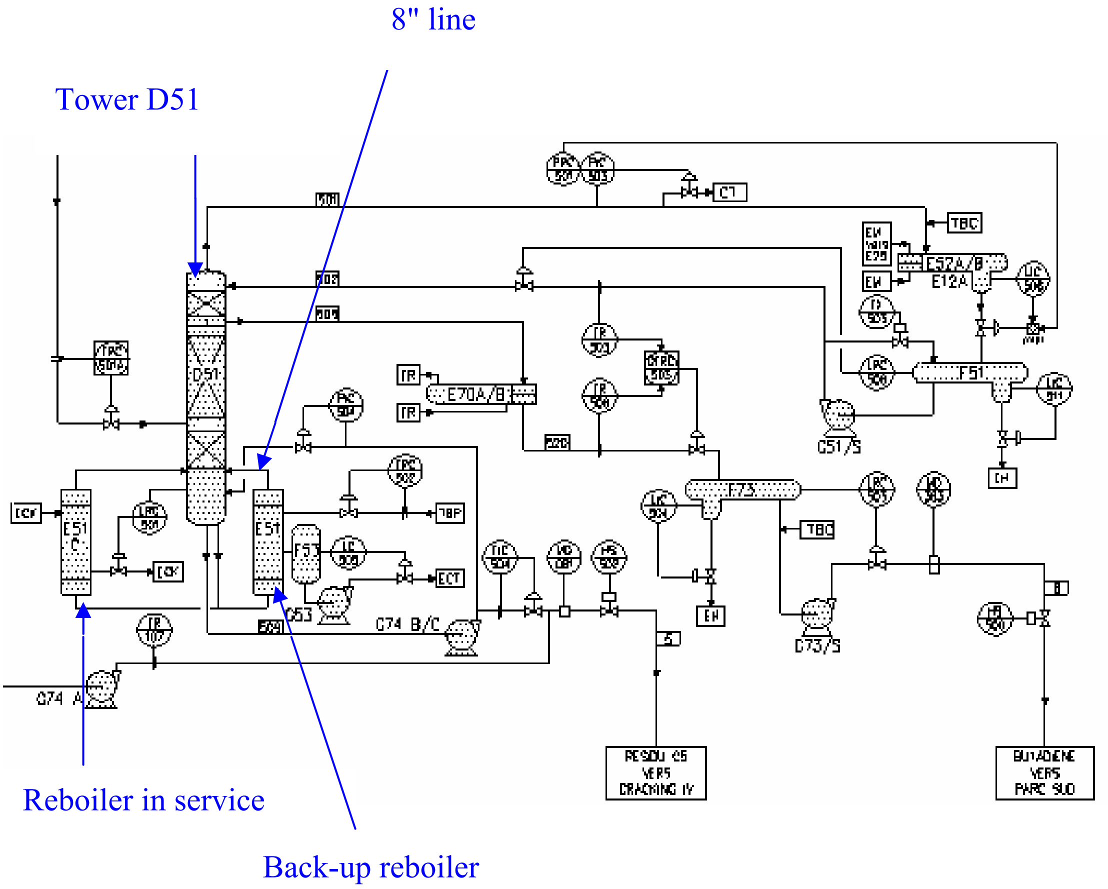
- raffinate 1 which is used by the neighbouring BP polyisobutene production unit,
- butadiene 1-3 which is stored, then shipped in its totality.

The facility can be broken down into 6 sections:

- elimination of hydrocarbons into C3 by distillation,
- principal scrubbing and secondary scrubbing,
- predegassing and degassing of the solvent,
- compression of the recycled gas,
- regeneration of the solvent,
- distillation of the butadiene.

The accident occurred in this section.

The butadiene distillation section consists mainly of a tower D51, a reflux vessel F51 and two reboilers E51 and E51C, only one of which functions in normal operation. The back-up reboiler (E51) is connected to tower D51 via a line which includes a branch connection leading to this reboiler's safety valve via an 8" pipe.


8" line
Tower D51
Reboiler in service
Back-up reboiler
D51
E51
F51
F73
E70A/B
E52A/B
E12A
C51/S
C73/S
C74 A
C74 B/C
C53
RESIDU C5
VERS
CRACKING IV
BUTADIENE
VERS
PARC SUD

THE ACCIDENT, ITS BEHAVIOUR AND CONSEQUENCES

The accident:

On December 14, at 8.10 pm, a butadiene leak triggered the gas alarm. The leak was caused by the rupture of an 8" supply line running toward the protection valve of one of the 2 reboilers of the butadiene purification tower. A cloud of gaseous butadiene was formed and spread into the unit and outside its boundaries, causing the emergency shut-down of the installation. The internal contingency plan was put into action, water curtains installed and traffic at the site was stopped. The personnel of the facility and the neighbouring units downwind were confined.

At 8.35 pm, the unit's personnel were able to isolate the leaking line by closing the manual valves. The rate of the steam cracker and the PIB unit was reduced.

At 8.50 pm, the public was informed (a taped message for the opinion leaders of Lavéra). The authorities were informed at 9 pm.

At 9.40 pm, the internal contingency plan was called off and at 10 pm, the public was informed that the alert was cancelled by a taped message.

Consequences:

The consequences were limited owing to the rapid intervention of the emergency response teams, the immediate implementation of water curtains and the use of explosion-proof equipment eliminating all ignition source.

Approximately 7 tonnes of butadiene were released into the atmosphere. Property damage was minor.

ORIGIN, CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

The origin of the accident is attributed to the design of the supply line of the reboiler's valve which formed a dead branch in which the gaseous butadiene accumulated, polymerising in an anarchic manner without being able to exit due to the inverse slope.

At the time of the accident, tower D51 was operating at 3.6 bar and was processing 17 tons of raw butadiene per hour. The reboiler in question (E51) was not in service. It was isolated on the steam side by a control valve, although remained under gas in order to act as a back-up for the other reboiler.

The pipe ruptured under the pressure generated by the formation of polymer in the dead branch (referred to as "popcorn"). The pipe was opened like a tulip over approximately 1 meter along the lower generatrix.

ACTION TAKEN

The manufacturer modified the installations as follows:

The dead branch which caused the accident was removed. The slope of this line was modified in order to prevent "popcorn" from accumulating in the future. This line is now vertical. The same is true for the pipe of the same type on the other reboiler and the reflux vessel. For this reason, the valves of the devices were brought closer together.

All the manholes on the fractionating tower were equipped with a internal solid plug and an external solid plug. To prevent the formation of popcorn, the space between these two plugs must be purged every 2 weeks.

The inlet lines of main valves on the fractionating tower (D51) and scrubber (D24) were modified with a branch connection separated by a valve.

An inhibitor injection branch connection was created on the intake side of the pumps.

Certain procedures were indicated in addition to the modifications made on the installation:

The plated reboiler E51 must be maintained in normal operation.

Tower D51, as well as the condensers, reboilers and the reflux vessel, must be passivated prior to start-up.

The operator compiled a specific procedure relative to the formation of popcorn and the monitoring of the line. The following rules are established by this procedure:

- ✓ Limit the influx of oxygen into the installation.
- ✓ Prevent the formation of rust in the equipment during restart by means of prior passivation.
- ✓ Do not process the C4 fraction containing peroxides.
- ✓ Ensure the injection of inhibitor into the flows containing more than 75% butadiene.
- ✓ Limit the volume and the existence of butadiene-rich dead zones.
- ✓ It is imperative that the horizontal dead zones be done away with.

A monitoring plan was established:

- ✓ Monitoring of manholes, elbows and the horizontal sections of lines by radiography every 3 months to detect the possible formation of popcorn.
- ✓ The updating of inspection plans with this monitoring procedure.

LESSONS LEARNED

The accident shows that the risk of "popcorn" formation must be taken into consideration in this type of installation.

The formation of "popcorn" can be attributed to the influx of oxygen into the tower via the manholes.

The popcorn is a rigid polymer which can form in the butadiene1-3 in concentrations above 75%, in the presence of a polymerisation initiator such as oxygen, peroxides, rust or when two metals are in contact under mechanical stress.

The product resembles that of popcorn or a granular mass resembling meringue. Translucent or white in colour, it yellows in the presence of oxygen and can, over time, spontaneously ignite releasing very dense brown smoke. To avoid this fire hazard, the popcorn must always be handled wet.

The dead zones where the butadiene stagnates promote the development of popcorn.

Popcorn growth is stimulated by the temperature. A temperature increase of 2°C reduces the time necessary to double its mass by 50%.

Popcorn is insoluble in butadiene. It develops in both the liquid and gaseous phase.

When polymerisation takes place, it releases a considerable amount of heat and exerts pressure on the outer envelop until it ruptures. Polymerisation growth then stops and the butadiene is released.

The solution thus consists in avoiding dead volumes, the influx of oxygen and to establish a strict installation monitoring plan. The measures taken by the manufacturer are oriented in this direction.

Atmospheric pollution after a fire on transformers containing PCBs

June 18th , 2001

Vénizel (02) - France

Fire

Pollution

PCB

Dioxin

Furan

Epidemiological study

THE INSTALLATIONS IN QUESTION

The industrial site is occupied by two plants:

The first company manufactures corrugated paper to be used in the manufacture of corrugated cardboard boxes from regional hardwood (160,000 t/year) and recycled paper (80,000 t/year), as well as lignin suffonate coproducts from regional hardwood.

The second one manufactures corrugated cardboard.

The plant's workforce is 241 people.

THE ACCIDENT, ITS BEHAVIOUR AND CONSEQUENCES

The accident:

On June 18, at roughly 2.50 am, a "fire alarm" is indicated in the Energy shop's control room. The duty foreman went to the location and noticed smoke in the corner of the electrical room. The amount of smoke seemed to increase and come from the cable tunnel located under the electrical room. The exact origin of the fire could not be located, as no flame could be seen.

At 2.58 am, at the request of the foreman the guard shack called the firemen. The procedures foreseen to shut down and evacuate the installations concerned where implemented (evacuation of the Cellulose shop, shut-down of boilers' gas supply, …).

At around 3.10 am, the managerial staff on duty, the people in charge and the site's security personnel as well as the site's firemen arrived.

The firemen arrived at 3.17 am and stopped approximately fifty meters from the burning facility. At that distance, they were able to already the notice abundant, thick smoke falling back down on the floor. At that time, flames were not visible, the problem being to locate the origin of the smoke.

Between 3.34 am and 3.53 am, while the firemen were looking for the fire, the room burst into flames, with fire suddenly appearing above the walls and reaching heights of 5 to 10 meters.

At 4.47 am, the firemen requested reinforcement from the CMIC ("Cellule mobile d'intervention chimique", mobile chemical response unit) following the discovery of transformers containing pyralene, whose presence in the facilities had been unknown.

Up to 5.30 am, the firemen battled the fire with spray nozzles with an estimated output of 100 m^3/h. The firemen declared that the fire was under control at around 5.30 am. The actual duration of active combustion was estimated from 1 to 2 hours. The fire was declared out at 6.20 am.

Consequences:

Engulfed in the flames, 3 transformers were totally emptied, a fourth transformer was emptied half way, releasing 1.5 tons of dielectric containing PCBs. In addition to the PCBs considered toxic to man, the products resulting from their decomposition must also be dealt with. At temperatures above 500°C and in the presence of oxygen, their decomposition can result in the release of highly toxic compounds such as dioxins and furans.

The trajectory of the smoke resulted in a cone-shaped zone of 2.5 km in length resulted in the monitoring and restrictions banning the consumption of vegetable produce. Roughly one hundred samples of soot, construction elements, soils, water and vegetables showed the presence of dioxins and furans.

The building involved in the fire was destroyed, and the amount of damages was estimated at 15.2 M euros.

ORIGIN, CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

The exact causes of the fire were not formally established by the experts or by the operator itself. Both parties however lead more toward the possibility of an electrical defect without establishing if the fire's point of departure was due to a short circuit or the poor condition of an electrical component.

ACTION TAKEN

When the fire was brought under control, the manufacturer thought that there was no more risk and was ready to resume activity. Only the part of the facility that was destroyed was secured.

The Registered Installations Inspectorate was advised of the accident at around 10 am. An inspector went to the site to assist the government representative with the initial security measures: restricting access to the site to everyone, evacuation of third parties living in homes neighbouring the site, determination of a security perimeter…

The Registered Installations Inspectorate proposed that the *Prefect* order the emergency shut-down of the site based on the risk of dioxin and furan contamination in the environment as a result of the transformer fire. This order required:

- ✓ that investigations be conducted to determine the extent of the contamination (analysis on and off site up to 2.5 km downwind from the site, a health study, and the management of waste and firefighting water).
- ✓ the suspension of plant activities, with restart taking place only following explicit authorisation by Prefectoral order with the submittal of the corresponding documentary evidence.

The result of the investigations would enable the environmental impact of the transformer fire to be evaluated:

- ✓ approximately 500 to 600 kg of PCB was lost from an initial quantity of 2,800 kg.
- ✓ the quantity of dioxins released was estimated at approximately 13 kg. The results of the analyses showed that a significant part of the dioxins and furans produced by the fire remained concentrated near the heart of the fire.
- ✓ the results of the analyses conducted in the perimeter of the investigations are near the lower reference limits recorded on French soil within a rural zone (between 0.02 and 1 ng TEQ/kg of soil) or urban zone (between 0.2 and 17 ng/kg of soil) and much below the reference values for French industrial zones (between 20 and 60 ng TEQ/kg of soil)

Work was conducted at the site:

- ✓ according to the criteria set by the Prefectoral order for the decontamination, all zones near the heart of the fire were contaminated.
- ✓ the building where the fire started was initially confined in view of being dismantled.
- ✓ the 36 transformers containing PCBs still present at the site were dismantled and disposed of.

The installations were progressively placed back into service 15 days after the accident. The restrictions affecting the land outside the site were lifted 25 days later.

A medical examination was conducted on the 96 people present at the time of the accident (firemen, employees, 2 journalists and 7 residents living next to the site). A year-long epidemiological study is foreseen on the persons concerned.

LESSONS LEARNED

The "transformer fire" scenario had not been included in the danger study conducted in 1992, mostly likely due to the fact that it was standard equipment present in many establishments. This accident shows that this scenario must not be neglected.

The personnel who discovered the accident did not know the exact location of the transformers. It is important that a precise establishment map be created, indicating the location of this type of equipment.

N°ARIA 24856 –24853 – 24854

Leaks of hydrogen cyanide in a unit producing acrylonitril.

October 1999, the 14th, December 2000, the 6th and April 2001 .

Sittard-Geleen-Born-
The Netherlands

Leaks
Material failure
Stress corrosion (acid and alkaline)
Repairs
Modifications
HCN
Management

THE INSTALLATIONS IN QUESTION

The company involved is one of the largest Dutch multi-national chemical companies. One of its production locations is situated in the city of Sittard-Geleen-Born, a town near Maastricht. This large chemical complex contains 57 plants and its surface is approximately 800 ha. The naphta crackers and the polymer plants of this large complex have been sold recently to another company. The company in question still produces fertilizer, industrial chemicals and pharmaceutical intermediates. It operates 2 acrylonitril plants, called ACN-1 and ACN-2 plants. Acrylonitril is used as a raw material for synthetic fibres in garment. It is also used in plastics like ABS and other chemicals that the company produces. In the production of acrylonitril, a number of side-products is formed. Hydrogen cyanide or HCN is one of the most important side products. It is a lethal chemical substance that is converted into other products. Both ACN plants were built in the 1970's and have been used for now 30 years.

The ACN-plants were ISO-14000 certified. The local authorities issued the environmental permits for these plants. The distance between the plants and the urban population is only 500 m.

In the last 3 years, the following incidents happened at the ACN-plants :

- On October 1999, the 14th, loss of containment and leak of HCN due to a pipe rupture,

- On December 2000, the 6th, a storage tank leaked during the investigations searching for the cause of the previous one. Fortunately, the tank was located in a liquid-tight tray.

- On April 2001, a leak occurred during the start-up of the ACN-plants.

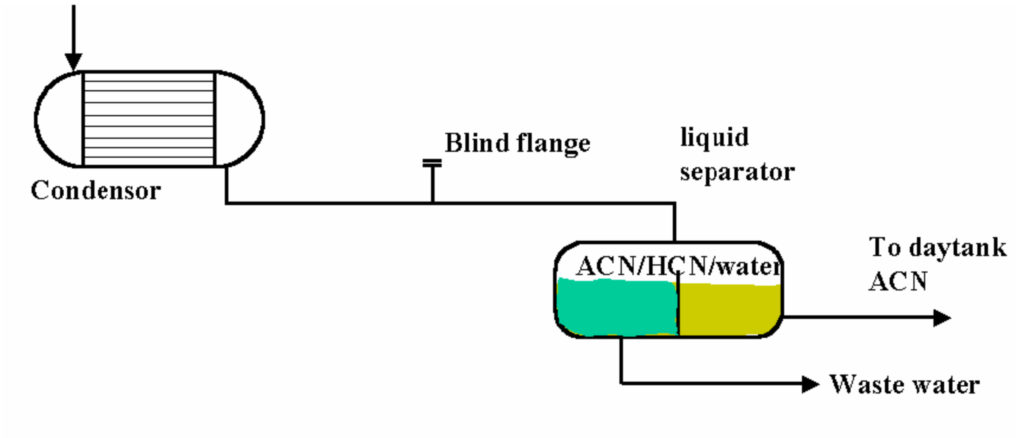
The accident which will be most developed in this sheet is the 1st one. The other ones will be described as consequences and actions taken (they occurred whereas the 1st incident was investigated and during the start-up of the units involved).

THE ACCIDENT, ITS BEHAVIOUR AND CONSEQUENCES

The accident of October 1999, the 14th :

A leak occurred in the part of the process whose normal operating conditions are 30 – 40°C and nearly atmospheric pressure. It took place in a pipe between a condensor and a liquid separator, as mentioned on the diagram here-under. About 4 000 l of liquid were emitted containing about 200 kg of hydrogen cyanide. At one point, the pipe involved contained stump, which should be closed with a blind-flange. However, it appeared that the blind-flange was not present and that the stump was ruptured.

In hindsight, it is expected that this situation was present during at least 1 week before the accident. Moreover, probably the stump was plugged due to polymerised product. However, due to a high level in the crude product storage tank and the omission of opening a proper release valve, an overpressure took place. This caused the loss of process fluid.



Immediately, the operator applied a water screen to prevent loss of the HCN outside the battery limits. Frequent monitoring of the atmospheric HCN concentration was applied, because of the short distance to the nearest urban population about 500 m. The operator immediately shut down the ACN-plant.

The ruptured pipe was replaced and the same pipe in the other ACN-plant was inspected. At that time, no deviations were detected in the other plants so the ACN-plants were restarted.

Its consequences :

Only one employee of the company was injured due to a mild cyanide intoxication.

ORIGIN, CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

Immediately after the leak, the Labor Inspection, the operator and the local authority started an inquiry to investigate the cause of this accident.

The first conclusion was that the probable cause was cyanide stress corrosion.

What stress corrosion is?

Cyanide stress corrosion frequently occurs in carbon steel. Due to welding, such material contains residual stress unless the welds are annealed to release the welding stress. Annealing of welds means slowly heating to 650°C and subsequently cooling of the welded material to environment temperature. Welds that not have been annealed are very sensitive for stress corrosion. Especially in an aqueous hydrocyanide environment. A cyanide concentration of as low as 1% is expected to be harmful. Annealing is not necessary for welded stainless steel constructions. In the early seventies, stainless steel was too expensive. That was the reason why this type of plants all over the world was made of carbon steel.

The effect of cyanide stress corrosion was studied. It was generally expected that cyanide stress corrosion leads to failure within 6 years of exposure to aqueous cyanide. The ruptured weld at the point of the missing flange was constructed in 1984.

Although, during the initial plant construction, the licensor ordered that all the welds had to be annealed when the medium contained more than 1% thus 10 000 ppm cyanide.

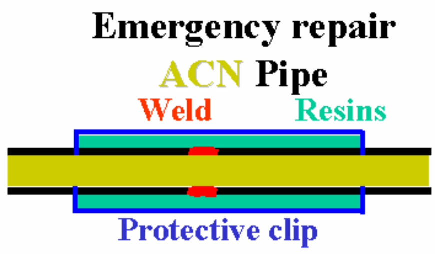
According to its experience, the company estimated that no cyanide stress corrosion occurs at a concentration of less than 200 ppm. This is a factor 50 lower than the licensor stated. It was reasonable to expect that the operator instructed its personnel that all modification welds, when the medium contains more than 200 ppm cyanide, should be annealed. However, the operator could not show the authorities the heat diagrams of the welds.

Moreover, at that moment, its personnel did not know how many modification welds were applied. Therefore, the 2 plants were completely inspected with the result that probably 15 modification welds were made.

Using an experimental method, it was proved that all these welds showed stress corrosion. The welds made during the initial period showed no stress corrosion.

For the control, an emergency repair as shown on the drawing was found. Normally, such repair is a temporary measure but this one was carried in 1994.

It was reasonable to expect that during the next maintenance stop (1996), the pipe would be properly repaired.



ACTIONS TAKEN

These findings resulted in severe doubt about the integrity of the installation. The Public Prosecutor was informed and decided that this incident should be investigated with respect to violation of the environmental and criminal law.

When the newspapers published that the Public Prosecutor started an inquiry, a lot of discussions took place in the surrounding villages. People did not feel safe anymore. Because the operator wanted to delay the maintenance stop within 3 months, the local authority hired an independent institute to investigate the integrity of the plant.

TNO reviewed the measures immediately after the incident, evaluated the number of gas detectors and concluded that there should be a back-up detector system available. TNO concluded that there was no problem to delay the maintenance stop for 3 months. So, the local authority approved the delay and ordered that all modification welds had to be replaced at the maintenance stop.

However, the Public Prosecutor still had serious doubts about the plant integrity. This was based on investigations carried out by an expert from the United States. This institute had the opinion that stress corrosion also occurs at a concentration less than 200 ppm cyanide.

In April 2001, during the maintenance stop, the results of the Public Prosecutor were challenged by TNO.

After the 1st incident, the replacement of all modification welds by stainless steel during the stop was planned. Because of the results of the Public Prosecutor, the local authority ordered additionally that not only the part were the modification welds were present had to be replaced by stainless steel pipes but that all the carbon steel pipes, containing medium with more than 200 ppm hydrogen cyanide, had to be replaced before January, the 1st, 2002.

Indeed, while the investigation following the 1st incident was still going on, a 2nd incident occurred in the ACN-units. This situation constituted a part of the file in connection with the 1st one so, as a consequence, it is shortly presented in the following paragraph.

Another aspect of the question was the outside corrosion. The operator stated that a reduction to 10% of the initial wall thickness was still acceptable due to over design in the initial construction. This was not accepted by the local authority : it ordered that in the future, all the pipes and installations need to be replaced in the case where wall thickness is reduced to less than 50%.

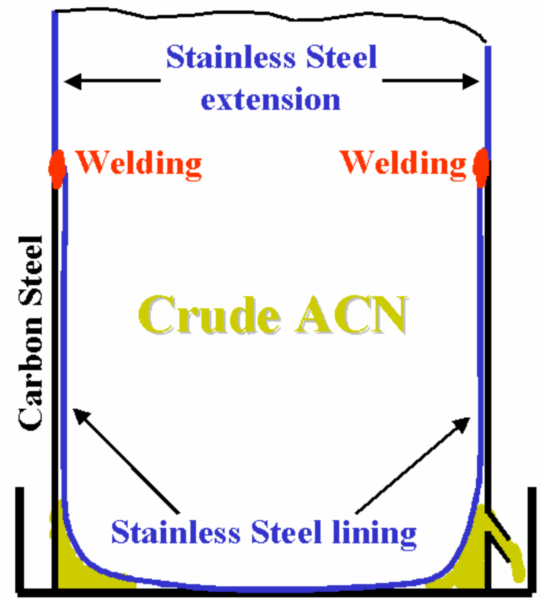
The Public Prosecutor still kept doubts about the integrity of the plants. However, the operator had already replaced the most critical spots by stainless steel constructions; After lengthy discussions between all the parties involved, it was decided that the plants were safe enough to be operated again.

Reminding of the accident dated December 2000, the 6th

From a carbon steel storage tank with a stainless steel lining, a leakage of about 600 l of crude product took place. Fortunately, the tank was located in a liquid tight tray.

The product contained 10% hydrogen cyanide. The leakage from the tank was caused by a ruptured weld in the stainless steel inner tank lining. This lining had been constructed in 1974, after a leakage due to cyanide stress corrosion. On the drawing, it is possible to see that the upper side extension of the tank was made of stainless steel.

The lining was 2 meter high.



Due to the rupture, the crude product was able to attack the carbon steel material of the tank. Because there was an opening to the environment at the bottom of the tank, the incident was immediately observed.

The direct measures were a foam layer to prevent evaporation of hydrogen cyanide. The content of the storage tank was immediately pumped into another tank and the damaged tank was blocked for normal operation. The spilled crude ACN was transported to the waste-water treatment plant of the operator.

After investigations, I seems that also in this case, stress corrosion was the probably cause. The operator explained that this lining was made as a low-cost investment.

After this incident, the operator exchanged this tank with a tank completely made of stainless steel. A comparable other storage tank will be replaced in due time..

Incident in April 2001 :

During the start-up after the maintenance stop, a regular water run was carried out for about 2 h. This means that the equipment is filled with water to test the tightness of the equipment. A stainless steel pipe showed an unwanted leakage. Since no toxic process fluid was present, this incident needed not to be reported to the authorities. Nevertheless, the company informed the local authority and the Mayors of the surrounding villages. This incident was also investigated.

Because stainless steel is susceptible for chloride stress corrosion, and chloride is present in the isolation material around the pipes, initially the occurrence of this kind of corrosion was investigated. A large number of spots in various stainless steel pipes were analysed. These results excluded chloride stress corrosion as a possible cause. Further investigations showed that the stress corrosion occurred at the place were frequently the installations are cleaned with caustic soda solution. Because of the polymerised product, the installation must be cleaned frequently. Again, the Public Prosecutor doubted the integrity. Because of the safety risks in this case, the local authority asked again a new assessment to TNO: It agreed that the most probable cause was caustic stress corrosion. Thus, the stainless pipe was replaced.

As an extra safety precaution, the operator was forced to test the equipment tightness by filling the system with water and nitrogen, applying the maximum process pressure for 24h. These tests were carried out under supervision of the local authority and TNO. Since no leakage was detected, the operator received permission to restart the production of ACN again.

As needed measures, the replacement of all carbon steel pipes was ordered before January, the 1st, 2002. Also, the enhancement of the gas detection system should be carried out in this period. Total repair of the outside corrosion should be ready before 2004.

LESSONS LEARNED

These incidents lead to the following lessons learned :

✓ **Impact of ISO 14000**

It became clear that certification of a company according to ISO 14000 does not guarantee compliance behaviour. ISO 14000 is comparable with E-mas. However, due to these incidents, this certificate was finally withdrawn.

✓ **Database system for maintenance and inspections :**

During the operator's investigations, the Public Prosecutor and TNO, it became obvious that historical data about maintenance and inspections of the ACN plant were not traceable. Plant modifications were not incorporated in the actual schemes of the ACN plant. Inspections results were often not transparent for outsiders. There was no system to monitor the execution of inspections under the authority of the plant manager.

The authorities ordered that the operator uses a database for planning and monitoring of all relevant inspections. Such system was introduced for the entire operator's production site, in this part of the Netherlands. The ACN plant was used as a pilot for this database system.

✓ **Modification of the environmental permit procedure :**

It appeared that there was a different inspection regime for installation parts constructed before and after 1984. The regime for the elder installations parts was less strict than the one for the newer parts. This was remarkable because inspection of elder installation should be stricter due to a higher risk factor.

It was decided to apply the same inspection regime for all plants, based on Seveso II. As a consequence, 42 environmental permits of the operator will be revised on this issue.

Dust

Ammonia

Dairy

Refrigeration

Organisation

Identification of circuits

Ammonia leak in a dairy

August 29th, 2001

Saint-Saviol (86) - France

THE INSTALLATIONS IN QUESTION

The company and administrative aspects:

The dairy (110 employees) specialises in the manufacture of soft cheeses (camembert, etc.).

The dairy is located roughly 37 miles (60 km) south of Poitiers, in the district of Saint-Saviol, in the Vienne department. It lies in rural surroundings: the nearest house is more than 100m away. The others are more than 200m away, including the Château de Leray (a listed 12th century castle) located to the north-east.

The dairy is a registered installation subject to authorisation, and inspections are performed by the veterinary services. Its activity is regulated by an order of the Prefect dated July 11th, 1990.

The refrigeration installations are not authorised. In July 1999, following an incident concerning the ammonia system, the inspector reminded the operator of the regulations and requested it to regularise its position if the quantities of ammonia used exceeded 150 kg. The operator took no action in that respect.

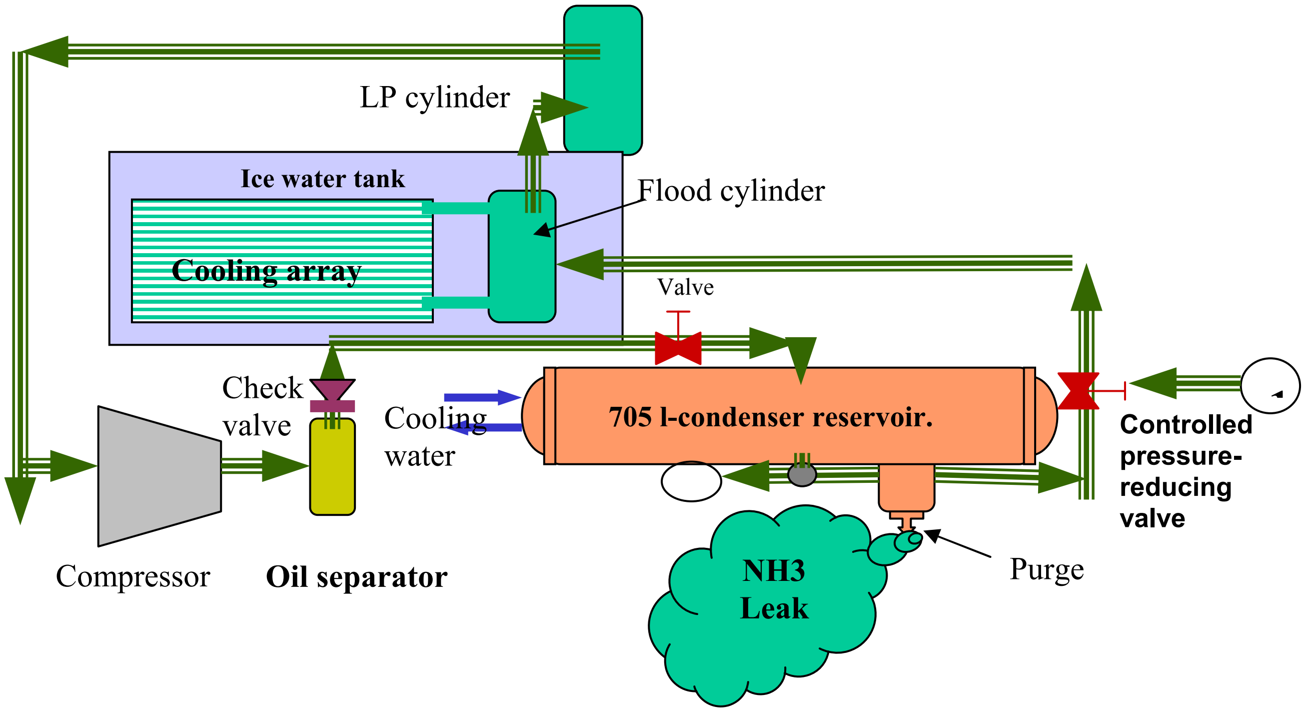
The installations concerned:

In August 2001, the dairy operated an ice-water manufacturing installation, located within the facility measuring approximately 4,000 m^2 (50x20x4). These premises were not used exclusively by the dairy.

The installation consisted of three independent ammonia circuits of 1 ton each, connected to a large ice tank in which the water was cooled, for plant requirements, in an open circuit that was in contact with pipes containing ammonia at -10° C.

Each circuit comprised a compressor, a multipipe condenser, and a system of buffer cylinders and ice tank that acts as an evaporator (known as a cooling array).

Ammonia (a toxic inflammable gas) was used in closed circuits (Carnot cycle) from a hot source, the condenser, where it changes from the gaseous phase to its liquid state at room temperature (20°C, 8.5bar) to a cold source, the ice tank, where it changes from its liquid state to the gaseous phase (-10°C, 3 bar), by way of the buffer cylinders downstream of the condenser, with the compressor upstream.



Heat exchange for each circuit takes place in a multipipe condenser, where the ammonia condenses on contact with water coils through the loss of its latent heat of evaporation. In this case, the condenser also acts as an ammonia reservoir.

A level measure, with a built-in float, controls the opening and closing of the downstream pressure-reducing valve that allows the ammonia to pass from the condenser to the buffer cylinders and the evaporator, depending on the contents of the condenser.

THE ACCIDENT, ITS BEHAVIOUR AND CONSEQUENCES

The accident:

On August 29th, 2001, at approximately 9.45 a.m., an ammonia leak occurred in the 4,000 m² ice water production building while work was being carried out on the cooling water system by a welder from an outside company.

Consequences:

A leak of approximately 100 kg of ammonia in liquid state occurred first, 65 kg of which formed a pool on the floor and 35 kg of which escaped in the form of vapour and aerosol. Controlled by a level with integrated float, the downstream pressure-reducing valve that allowed the ammonia to pass from the condenser to the buffer cylinders and the evaporator, depending on the contents of the condenser, closed normally, but upstream, on the compressor side, the circuit was not cut: 500 kg of gaseous ammonia was emitted over 4.5 hours.

The leak concerned a total of approximately 600 kg of ammonia.

A toxic cloud floated over the site and the surrounding area, with a favourable wind directing it away from the few habitations around the site. The police and fire department took rapid action, using suitable means (chemical cell, 30 people, protective suits, high-power fans).

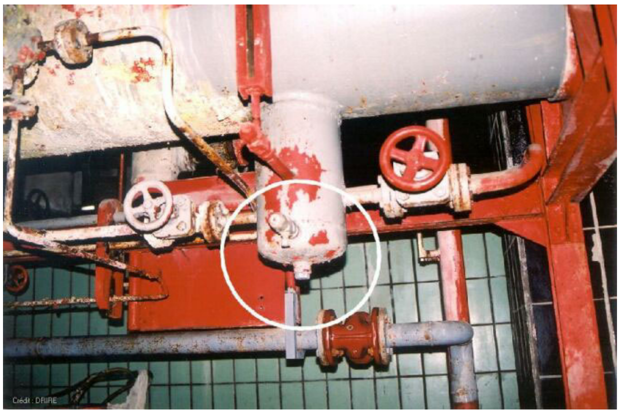
A nearby road was closed, the two people present on the ice water production premises were hospitalised as a precaution and the 50 other employees were evacuated. Fans were installed in order to extract the ammonia which was trapped in a high concentration in the building.

Activity on the plant resumed 2 hours and 45 minutes later.

ORIGIN, CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

A welder from an outside company was engaged to perform work on the cooling water circuit of one of the three condensers. The end cap of the condenser shell was, in fact, eroded at the level of its bolted mounting flange. Water had been leaking for two days and the management had decided to repair the oxidation by means of localised welding.

The day before the work took place, the installation was stopped and the condenser water coil was purged by the plant maintenance manager.



When he arrived the next day, the welder found that the part to be repaired was still humid and asked a plant mechanic to complete the purge of the water circuit. The latter, who was badly informed, thought that the purge plug under the condenser would allow him to carry out this operation. He therefore unblocked the plug and left the welder to proceed with the additional purge. In fact, it was the ammonia condenser purge.

The operator therefore had insufficient knowledge of the circuits and the works were badly prepared. The installations were not equipped in accordance with the regulations regarding the limiting of ammonia emitted.

ACTION TAKEN

Administrative and penal consequences:

The Inspectorate noted the lack of registered installation authorisation and, on its recommendation, the Prefect served notice on the operator asking him to regularise the situation of the refrigeration installations.

Technical consequences:

The damaged circuit was re-started 15 days later, after work had been carried out.

Following this loss of containment, which had no effect on the personnel or the outside environment, the dairy management engaged a specialised company, in order to drastically reduce the risk at source.

The results of the study led the dairy managers to invest in a new 1 million frigories/hour installation containing 90 kg of ammonia. It should be noted that the previous installation, with 3 circuits of 1 t of ammonia allowed a total production of less than 400,000 frigories/hour. According to the operator, the overall investment, including studies, amounts to 210,000 Euros.

Moreover, the operator has decided that all maintenance work on the new installation, which is, in fact, no longer subject to the regulations regarding registered installations for the protection of the environment, will be carried out by a specialised company and not by his own maintenance teams.

LESSONS LEARNED

These installations were not in conformity with the technical requirements specified in the ministerial order dated July 16th, 1997. In particular, the ammonia circuits were not identified (this would no doubt have prevented confusion between circuits during the operation).

The use of the barriers specified in the order would perhaps not have prevented the purge of the condenser, but would have facilitated its dilution in the roof of the premises by means of the regulatory extractor.

A succession of incidents at a chloride and sodium production facility

1995 to 2002

Pomblières (73) - France

Gas emission
Chlorine
Sodium
Succession of incidents
Inspectorate
Danger study
Critical analysis

THE INSTALLATIONS IN QUESTION

The installations are located in a mountainous region, in a valley. The mock-up photo of the site below depicts the location of the main parts of the plant.

The plant's workforce is currently 260 people. The plant manufactures sodium, with chlorine being a fatal product derived from electrolysis.

The main quantities authorized are:

- Chlorine: 1,500 tons (toxic)
- Sodium: 2,400 tons (flammable)

Brief history of the site:

The site's activity goes back a long way, as shown by the brief history outline below:

1898:	Hydraulic electricity and chlorine production
March 1899:	Sulphuric anhydride production

Up to 1907:	Buy-out of the activity
1903:	Phosphorous production
1903 / 1925:	Extension and development of the company (leading French chlorine liquefaction facility)
1931/1982:	Cobalt production / closure of the Cobalt facility
1963:	Sodium production (including High-Purity sodium for the nuclear industry) – Fused-salt electrolysis process
1972:	Extension to chlorinated derivatives of vanadium and other special metals (including lithium and indium phosphorus in '85 and '86)
1996:	End of tetraethyl lead. Drop in the sodium market
1997:	Transfer of the plant by the group and a request to extend the sodium activity

The site consists of:

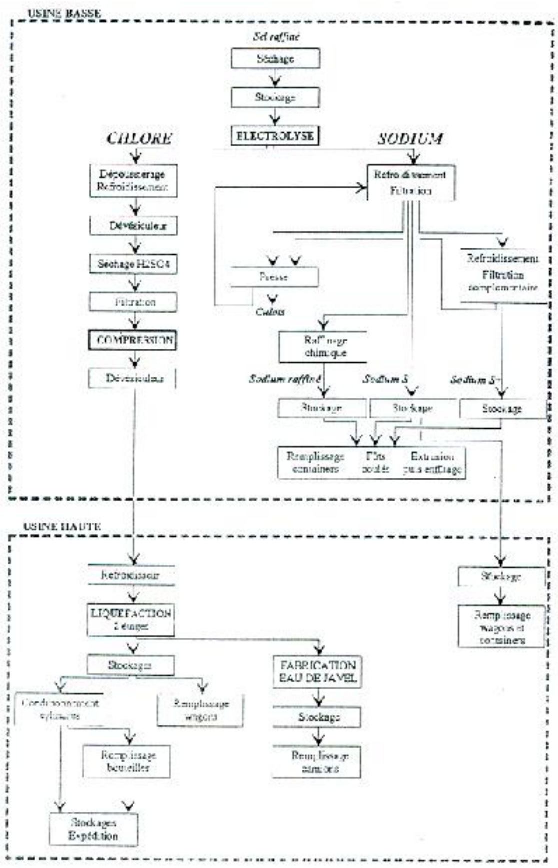
- **The "lower" plant** where NaCl electrolysis takes place (2 facilities) and which includes a chorine gas processing (scrubbing, drying, compression) and collection system

- 2 **chloroducs** (+1 backup) ensuring the transfer of the chlorine (see photo opposite)

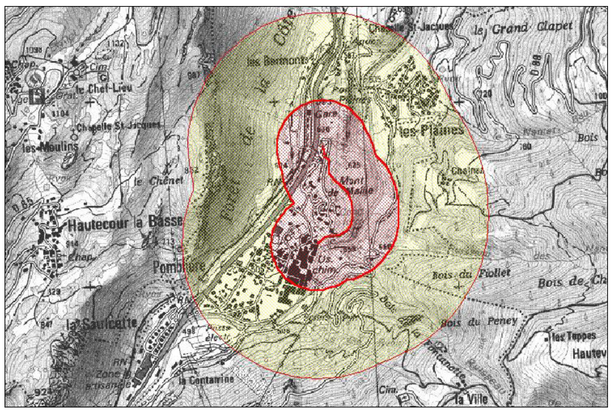
- The **"upper" plant** which conducts the liquefaction, storage, packaging and shipment of the liquefied chlorine.

Chloroducs at the site

The logic diagram of the main production phases is given below. It shows the fields of activity of parts of the site.



In terms of community planning, the distances are 250 m for deadly effects and 730 m for irreversible events. The distance corresponding to the PPI ("plan particulier d'intervention", external emergency plan) is 2,300 m, as indicated on the map opposite. The main sources of risk consist of the chloroducs and the chlorine storage facility.



A few comments on the special safety devices:

The plant is equipped with the following main safety devices (non-exhaustive list):

Lower plant:

- ✓ 1 soda neutralisation tower with a capacity of 4 t/h (Degussa)
- ✓ 1 chlorine detection network
- ✓ control interlocks enabling the electrolysis facility to be shut down

Upper plant (confined chlorine):

- ✓ 1 drainage tower (5 t/h for 5 min.): drainage of confined storage zones, of the tanker loading facility, … .

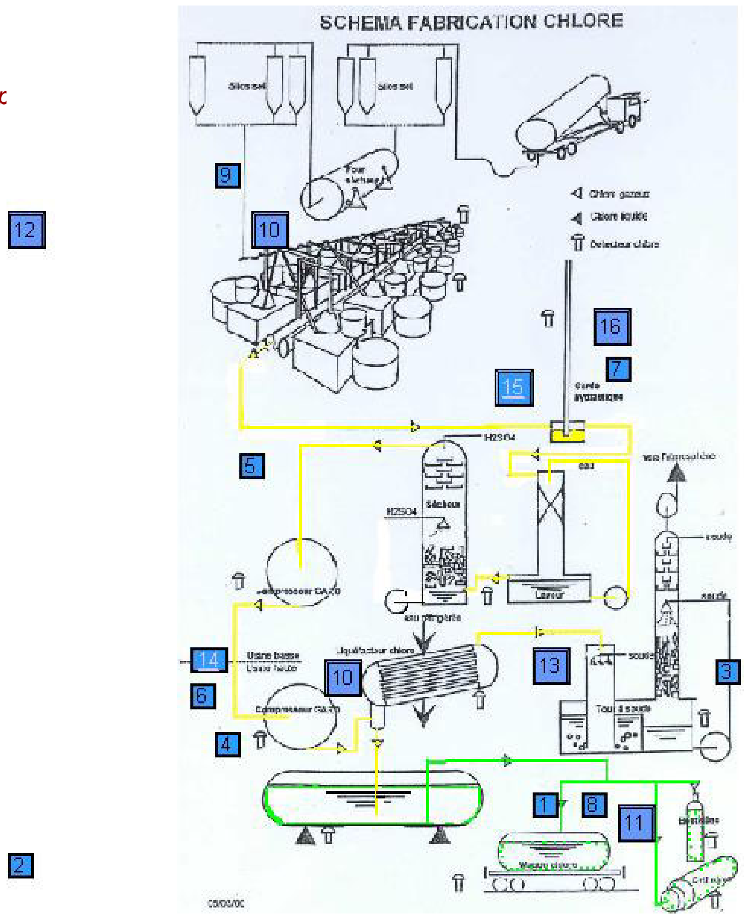
- ✓ 1 javel water production tower (4.8 t/h for 12h): used to produce javel water and neutralisation of the equivalent of the chlorine gas production of the lower plant.
- ✓ 1 confined tanker loading station
- ✓ 1 confined storage facility in the cellar
- ✓ 1 chlorine detection network
- ✓ 1 confined small recipient filling hall
- ✓ 1 confined high-pressure compressor hall (triple confinement)

THE ACCIDENTS OR INCIDENTS: MAIN CHARACTERISTICS

the accidents or incidents:

Out of the 17 accidents / incidents recorded and included in the appendix, 16 occurred between 1999 and 2002:

- × **8 at the lower plant, including**:
- ✓ 2 on the sodium facility (industrial accidents)
- ✓ 6 on the chlorine facility (including 4 on the hydraulic seal and 2 in the electrolysis facility)
- ✓ *2 of the chlorine accidents originated in the up plant*
- × **9 at the upper plant, including:**
- ✓ 1 originating from the sodium
- ✓ 3 concerning the tanker station
- ✓ 3 concerning the compressors
- ✓ 2 concerning liquefaction
- ✓ *2 accidents occurred in the lower plant*
- ✓ *Common point: neutralisation defective*



The figure opposite shows the location of the various accidents or incidents on the general diagram which presents the process and the main units.

A brief description of each of the events is presented in the appendix hereto. For the meaning of each number in the diagram, simply refer to: a brief description which indicates the nature of the accident, the causes, consequences and the measures taken.

A more detailed description of accidents 7, 8 and 15 is given.

Accident 15 – June 9, 1999

This accident was one of the first in the series of events observed. For all of the players, it formed a sort of "warning".

A summary of the main elements is given below. The chronology and a few additional elements are given below for a better understanding of the accident, with the help of diagrams and a few comments.

•Location: **Lower plant, hydraulic seal**

•Nature: Release of non-discharged chlorine

•Cause: Operator error during the chloroduc switchover operation, leading to the simultaneous shutoff of both manifolds for a few instants.

•Consequences:

6 workmen slightly effected

•Measures taken:

Reinforcement of procedures

The diagrams below are provided for a better understanding, if not in detail, at least the main stages which lead to the chlorine release observed.

Chronology:

1

Initially, the control crew was switching the chloroducs. At the same time, , electrolysis continued to operate. Following an operating error, the operators actually closed one of the 2 chloroducs.

2

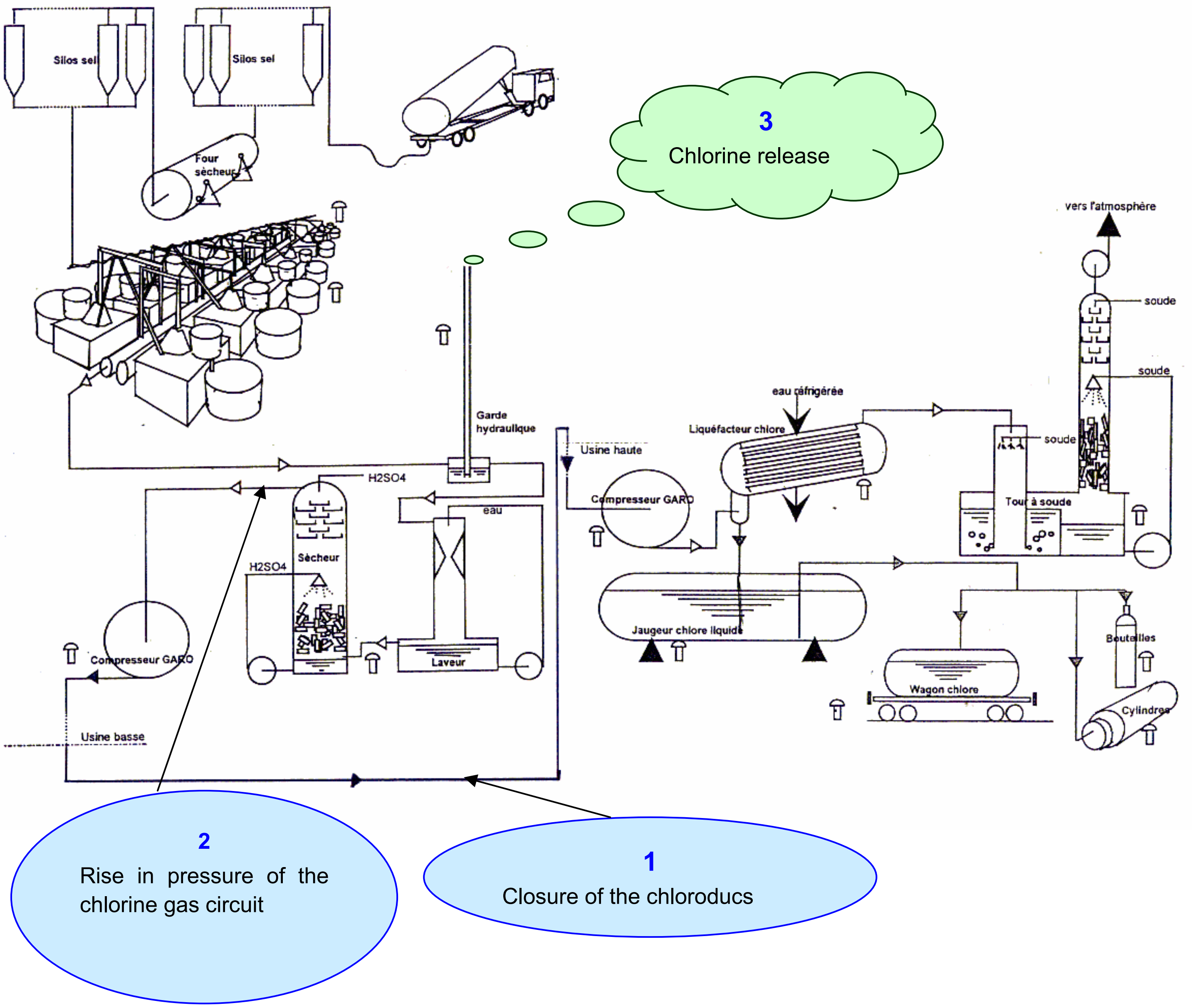
This causes the chlorine gas system to increase in pressure.

3

A burst of chlorine is then released into the atmosphere.

At first, an operating error is noted: the measures foreseen by the operator are, among others, the opening of an operating log.

More in-depth reports by the operator highlight an organisational problem, in terms of equipment management: In reality, 2 keyboards were available to the operating crews in the control room from which the changes, among different operations, are made. One was connected and the other one was not. The manoeuvres, performed on an inactive keyboard, were thus not taken into consideration. This is considered one of the causes that lead to the incident.


Silos sel
Silos sel
Four sècheur
3
Chlorine release
vers l'atmosphère
soude
soude
eau réfrigérée
Liquéfacteur chlore
soude
Garde hydraulique
Usine haute
H2SO4
eau
Compresseur GARO
Tour à soude
Sècheur
H2SO4
Jaugeur chlore liquide
Bouteilles
Compresseur GARO
Laveur
Wagon chlore
Cylindres
Usine basse
2
Rise in pressure of the chlorine gas circuit
1
Closure of the chloroducs

Accident 7 – June 3, 2000

•Lower plant, hydraulic seal

•**Nature:** Releases of 18 then 20 kg of chlorine via the hydraulic seal (the chlorine produced not being evacuated) accumulated with the return of chlorine to the level of the electrolysis cells.

•**Cause:** The air compressors and chlorine compressors had tripped following thunderstorms. The tripping of the low plant's compressors did not shut down the electrolysis, the design of the safety system not allowing it.

•**Consequences:**

Chlorine odours were smelt by the inhabitants of the nearby village, Pomblière.

•**Measures taken:**

A review of the lower plant's danger study is requested in order to integrate the design problems, namely safety devices.

In the same manner, a critical analysis of the danger study is carried out by a third-party expert.

These events actually correspond to a series of malfunctions stretching over a period of several hours: approximately 3.50 pm to 8 pm. All told, 2 chlorine releases were observed.

For better understanding, 3 diagrams are provided which summarise the main phases of the event by offering a few explanations that are by no means exhaustive.

Chronology:

First phase of the incident:

1

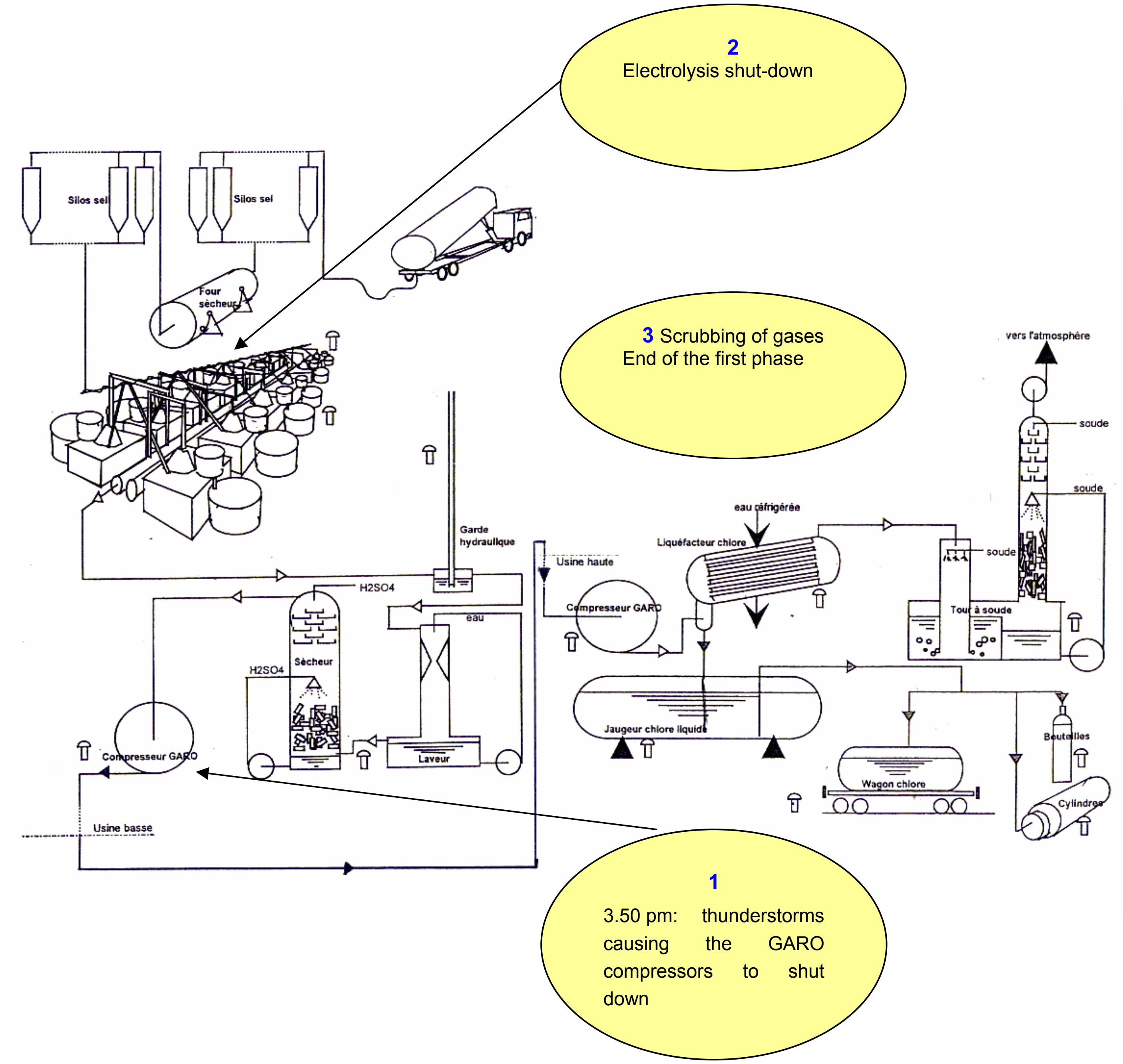
There was a thunderstorm in the afternoon: it caused the shut-down of the chlorine expedition compressors in the chloroducs (chlorine pipes).

2

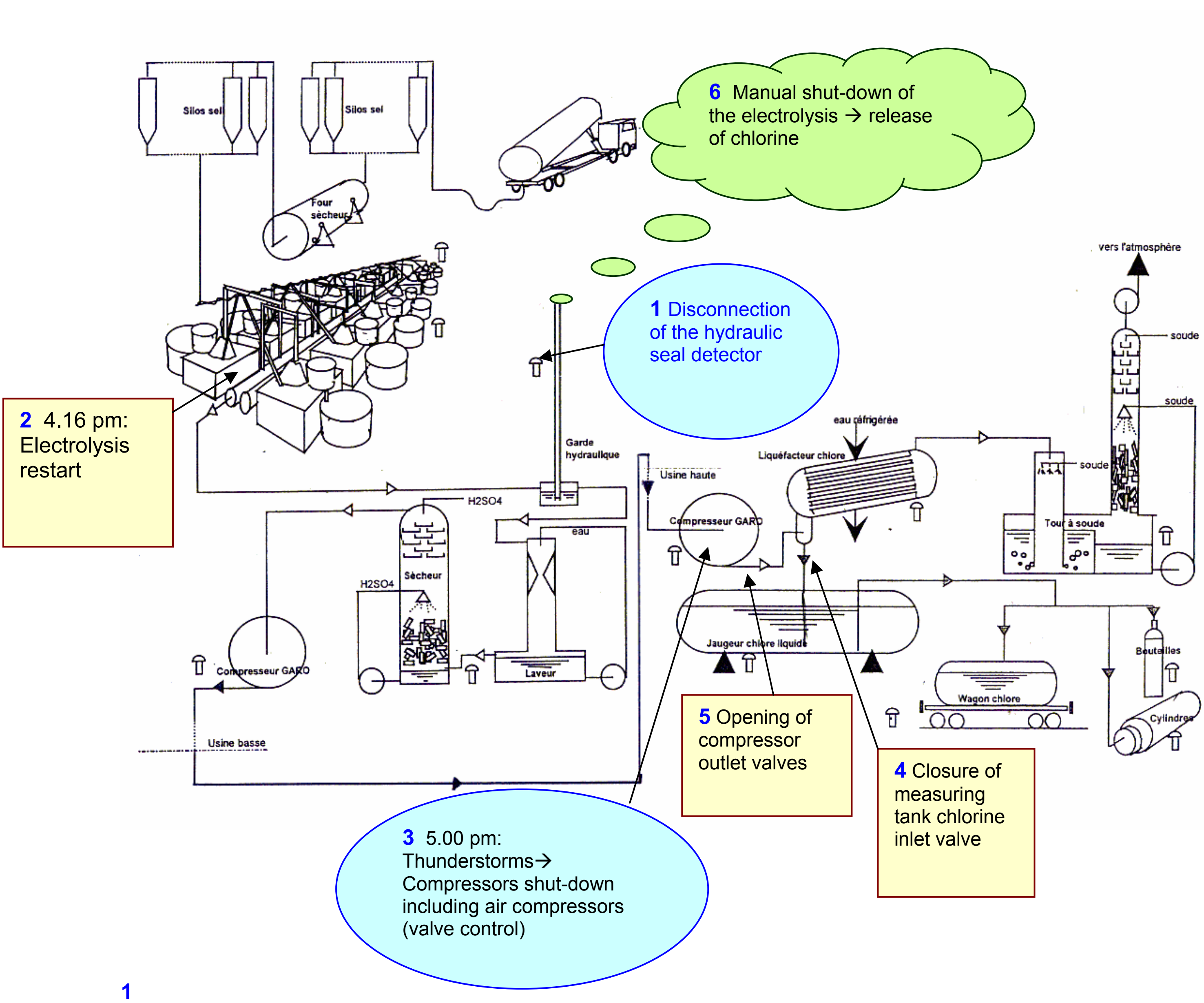
Quite normally, this caused the automatic shut-down of the electrolysis operation.

3

The chlorine is correctly evacuated by the scrubber. The management of the event is thus compliant with procedures.


2
Electrolysis shut-down
3 Scrubbing of gases
End of the first phase
1
3.50 pm: thunderstorms causing the GARO compressors to shut down
Silos sel
Silos sel
Four sècheur
Garde hydraulique
H2SO4
Sècheur
H2SO4
eau
Laveur
Compresseur GARO
Usine basse
Usine haute
Compresseur GARO
eau réfrigérée
Liquéfacteur chlore
soude
Tour à soude
vers l'atmosphère
soude
soude
Jaugeur chlore liquide
Wagon chlore
Bouteilles
Cylindres

Second phase of the incident:



1

In this configuration, part of the gases passes through the hydraulic seal: the quantity is sufficient to saturate the chlorine detector located there. The electrolysis, which restarted at the end of the first stage of the event, is automatically stopped due to the detector tripping.

In order to restart the electrolysis shop, the operator disconnected the detector and installed, for compensatory measures, reinforced monitoring conducted by the personnel.

2

The electrolysis shop restarts.

3

The thunderstorms continue and this time cause the plant's compressors to trip: this concerns the compressors up line from the liquefier, and the air compressors which control the control valves.

4

The various valves shift to their fail-safe positions: this is the case of the chlorine inlet valve on the measuring tank, which closes.

5

This is also the case of the valves on the compressor, the fail-safe position of which is open. The reason resides in the possibility, in case the chlorine compressors shut down, to evacuate the chlorine still produced by the lower plant toward the neutralisation tower.

6

The operator is finally lead to cause the manual shut-down of the electrolysis operation (there is no longer automatic shut-down as the detector was disconnected). This takes a short amount of time during which the electrolysis still is producing chlorine. A release of chlorine thus occurred (18 kg).

Third phase of the incident:

7

Electrolysis restarts and the valves return to configuration, including the valve used to isolate the measuring tank. Overall, due to the installation being secured by the closing or opening of valves owing to the previous situation, the circuits are configured as shown below: the upper plant's chlorine system is under relatively high pressure, while the lower plant's system is at relatively low pressure. Liquid chlorine from the measuring tanks returns toward the lower plant, i.e. towards the chlorine gas system. A whole series of disturbances occur and leads to the manual shutdown of the electrolysis operation.

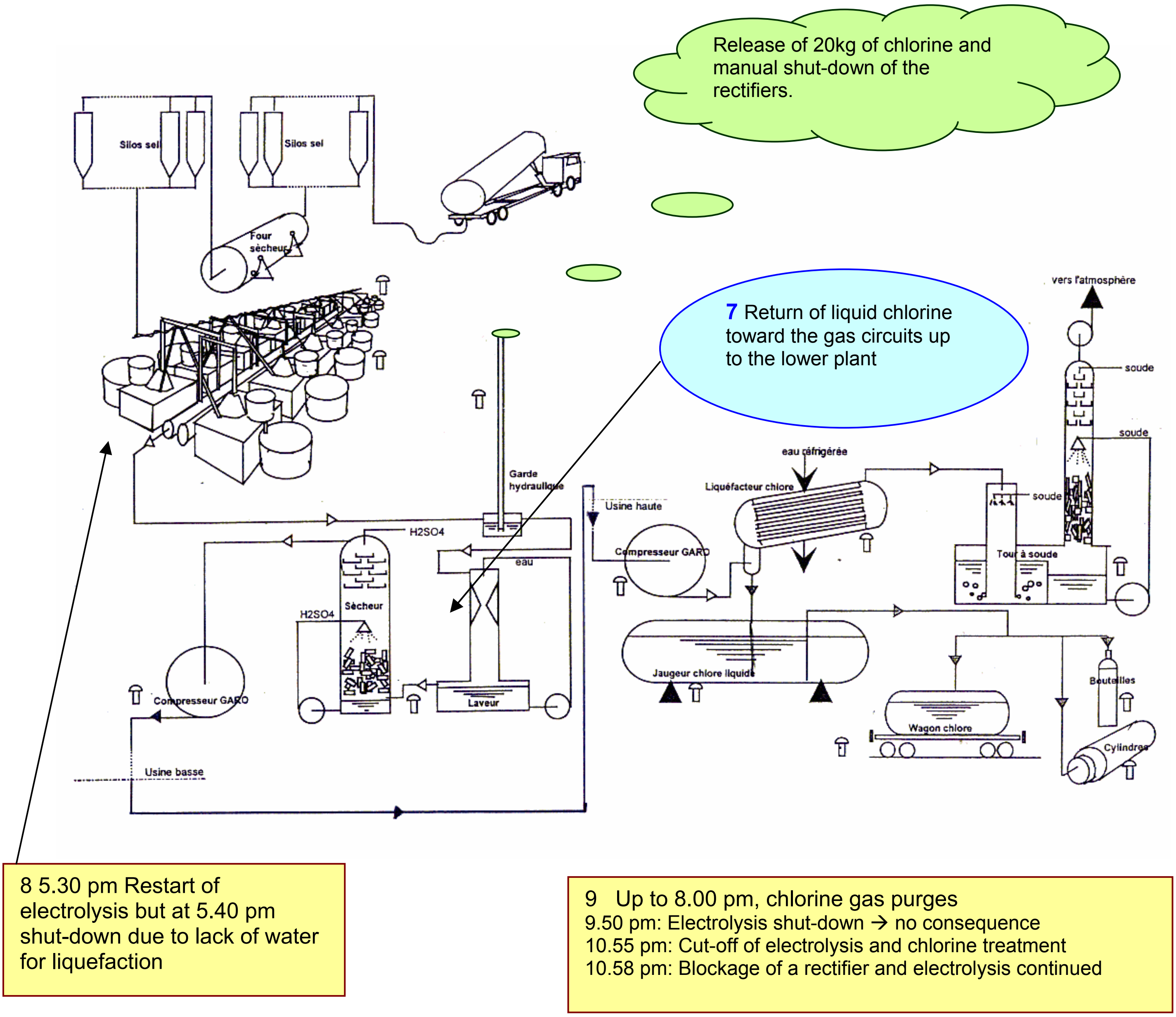
8

Electrolysis started again at 5.30 pm although must stop again due to a lack of water at the liquefaction stage (upper plant), at around 5.40 pm.

9

Up to 8 pm, the operator takes care of purging the chlorine gas circuits. At around 9.50 pm, the electrolysis stops again but without consequence and it restarts. At 10.55 pm, the electrolysis with chlorine treatment stops again but a new problem occurs: for electromagnetic reasons, the slaving of the electrical power supply is lost. The operator is required to intervene manually to unlock an incorrectly configured rectifier: the latter, having remained on line, continues to supply the electrolysis shop.

20 kg of chlorine is released into the atmosphere.



Release of 20kg of chlorine and manual shut-down of the rectifiers.
7 Return of liquid chlorine toward the gas circuits up to the lower plant
Silos sel
Silos sel
Four sècheur
Garde hydraulique
H2SO4
eau
Sècheur
H2SO4
Laveur
Compresseur GARO
Usine basse
Usine haute
Compresseur GARO
eau réfrigérée
Liquéfacteur chlore
Jaugeur chlore liquide
Wagon chlore
vers l'atmosphère
soude
soude
soude
Tour à soude
Bouteilles
Cylindres
8 5.30 pm Restart of electrolysis but at 5.40 pm shut-down due to lack of water for liquefaction
9 Up to 8.00 pm, chlorine gas purges
9.50 pm: Electrolysis shut-down → no consequence
10.55 pm: Cut-off of electrolysis and chlorine treatment
10.58 pm: Blockage of a rectifier and electrolysis continued

Accident 8 – August 22, 2000

Upper Plant, tank filling station

Nature: 50 kg of chlorine released during a tanker filling operation.

Cause:

- ✓ Human error: the valve in liquid phase is opened before the degassing valve of the liquid chlorine filling line (to the neutralisation tower) is closed.
- ✓ Temperature probe set-point not adapted
- ✓ Faulty temperature probe
- ✓ Soda tower capacity insufficient
- ✓ There is no safety equipment maintenance procedure
- ✓ Operating instructions incomplete (undergoing review)

Consequences:

- ✓ A chlorine emission is noticed by the employees of an external company working nearby.

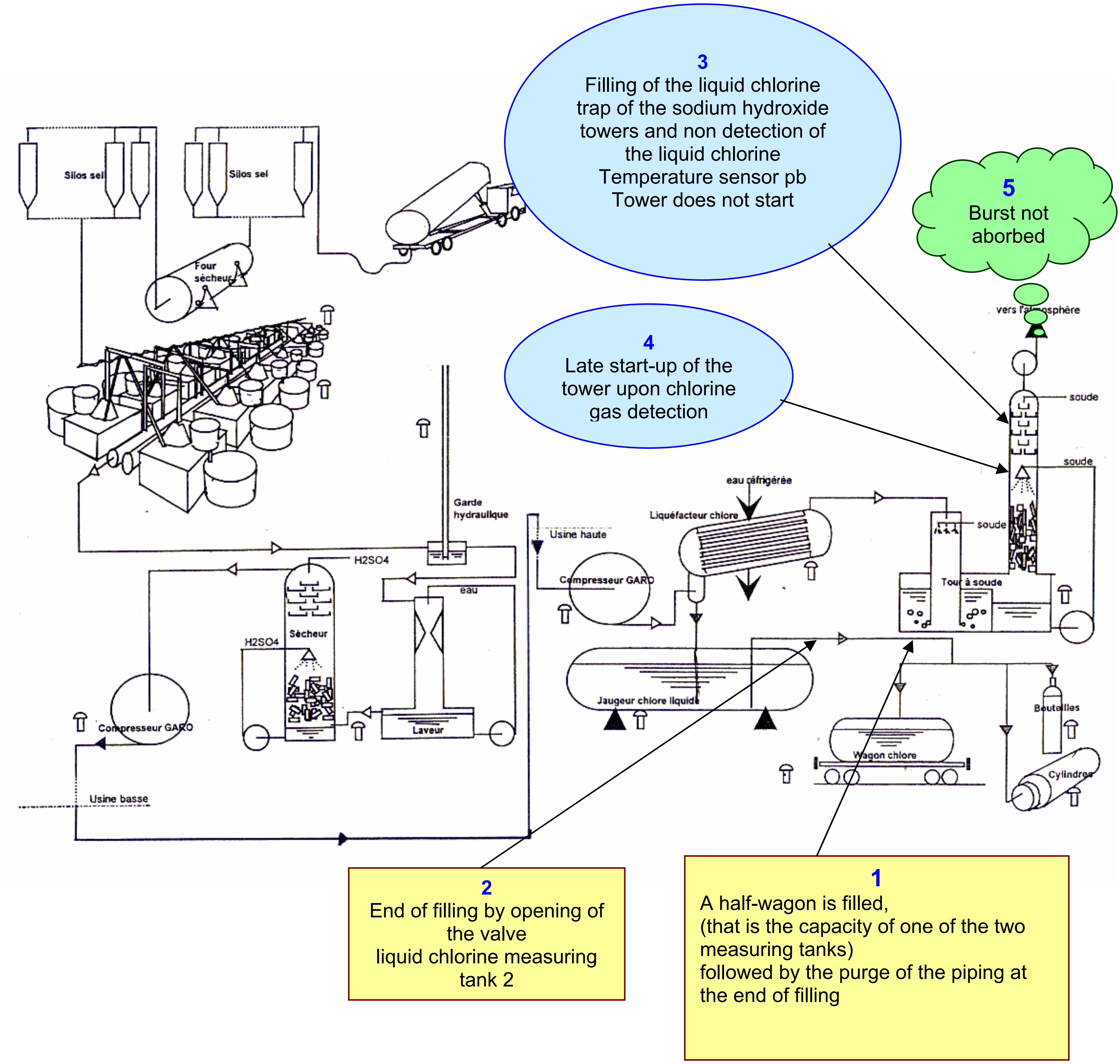
Measures taken:

- ✓ 09/2000: Return to service of the temperature probe on a liquid chlorine trap
- ✓ Modification of the PLC program
- ✓ Synchronisation of liquid/gas valves
- ✓ Slaving of closure valves when liquid chlorine is in the trap (filling stopped)
- ✓ Review of the "Tanker or container filling by pump from a measuring tank" procedure.

Measures foreseen:

- ✓ Doubling of the temperature probe on the chlorine trap at a different level
- ✓ A study was implemented for more efficient detection near possible liquid chlorine throughput in the chlorine gas degassing pipe (conclusion: HAZOP - Hazard and Operability Study)
- ✓ A request by the DRIRE to include scenarios of massive liquid chlorine input into the drainage tower in the danger studies
- ✓ Installation of the 2nd chlorine detection based on a principle which is different from the first (vibrating reed) and replacement of the existing trap
- ✓ Training of operators in the procedure and regarding the modifications made

Chronology



1

The tankers are filled in 2 phases, the measuring tanks contain only ½ of the tanker's capacity. For safety reasons, the operator has to load one half of the tanker each time. The advantage of this procedure is that it avoids possible overloading.

On the day of the incident, a first measuring tank was emptied into a tanker. The piping purge operations at the end of filling operation begin: an operator opens a valve from the control console to drain the residual contents of the pipe to the neutralisation tower.

2

The end of the filling operation is determined: this consists of draining, in a manner identical to the operation already performed, a 2nd metering tank into the tanker, which is already half-filled.

However, the pipe's degassing valve remained open. Following the previous purge operation, it was not placed in the correct configuration (closed).

3

The liquid chlorine was thus sent directly to the neutralisation tower. A sort of buffer tank is located upline from the tower, referred to as a liquid chlorine trap. The installation is equipped with liquid chlorine detection allowing the neutralisation tower to be activated rapidly (fans turned to high speed, …). This detection works on the low temperature control principle. 2 probes contribute to the detection: one is located in the chlorine trap, the other in the pipe.

In reality, detection was not operating on the day of the incident for various reasons, the principles of which are as follows:

- Owing to various operational modifications made in the past, the operator changed the detection temperature (linked with the modification of the liquefaction process). However, the threshold modification was not reflected to the probe located in the pipe. The probe does not detect the arrival of liquid chlorine.
- The probe located in the chlorine trap was poorly connected. It thus was not functioning.

4

The chlorine is not detected at the iodine trap and flashes directly in the tower. The changeover to high tower output is delayed. A burst is not absorbed and is released to the atmosphere.

SITUATION PROBLEMATICS

✓ Over a period of 2 years, a series of incident or accident situations have occurred in close succession,

✓ Nevertheless, in each the operator undertook local measures in response to each accident situation.

✓ The Inspectorate requested analysis information nearly after each even and additional requirements were also proposed in many cases.

Despite the operator's reactions and the inspectorate's vigilance, the incidents/accidents continue to be observed.

This situation is disquieting insofar as the multiplication of risky situations may be a precursor to more serious problems.

In this context, it was decided that all of the measures at the inspectorate's disposal should be used: draft orders, third-party expert evaluations, inspections, critical examination of the new files.

MEASURES TAKEN

Request for regulatory action:

The principles are as follows:

✓ **Detailed analysis** of certain accidents, validated by the installation designer. In certain cases, a technical response made in response to a given situation may turn out to be incomplete, or may even present inconveniences that are not initially apparent. Considering the multiplication of the technical measures on the installation, it was considered useful to consult the designer about some of the solutions proposed.

✓ **Lower plant:** In 1999, the administration requested the operator **to update the danger study** of the extension file (late 97) in order to take the incidents into consideration. A **critical analysis** of the file was also requested.

✓ **Upper plant:** On this part of the plant, requirements requesting the creation of **new "HAZOP"** elements on the chlorine system are adopted. In addition, as in the lower plant, the inspectorate requested that the Prefect order the **danger study be updated** in order to integrate the various incidents and accidents. Finally, again to integrate the available elements, a **critical analysis** was also requested.

✓ Under the terms of the technical measures related to the incidents, the reinforcement of the **chlorine detection network** in the environment was also prescribed.

Inspectorate:

The inspectors request to conduct a new inspection on the implementation of the various regulatory provisions adopted and their progress, in terms of installation.

During the inspection, certain things are not concrete and all of the analyses requested have not yet been performed. Clearly, the objective is to monitor the progress of the work in a highly formal manner and to report discrepancies.

The **topics dealt with** during the inspection were as follows:

✓ Respect of the Prefectoral Order (AP) following the accidents of 2000,

✓ The advancement of work programs following the HAZOP and the critical analyses,

✓ Verification in the field of a critical operation (tanker filling): Existence and application of the procedure,

✓ Human factor: actions planned by the operator.

Points to be mentioned:

✓ Inspectorate in the presence of the CHSCT secretary

✓ Preparation: it was preceded by an examination prior to the danger studies and 2 critical analyses; it gave rise to the reconstruction of the incident history and the administrative action.

Main results on site:

✓ The analyses by HAZOP are completed: it should be noted that the operator had previously evaluated the number of sessions at 8, considering the subject matter. At the end of the exercise, more than 20 sessions had been devoted to the examination of the various points concerning the lower plant and the upper plant.

Lower plant:

✓ Doubling of the automatic controller for managing safety is completed.

✓ The hydraulic seal, instead of releases and the installation's weak point, is condemned (acknowledged): its removal had been requested several times.

✓ The chlorine manifolds are connected to the scrubber (enabling the residual chlorine to be treated).

✓ A specific Hazop was created only on the scrubber.

✓ Considering the various analyses and conclusions, the list of safety-related equipment was modified.

✓ There is currently a project concerning the fail-safe principle of the chlorine leak detection system at the level of the chloroducs.

✓ An important point was brought up during discussions with the personnel: the operation of the electrolysis shop was modified. Before, an unavoidable principle was that this shop could not be shut-down without significant damage to the cells. Very recently, the personnel tested controlled-duration shut-down periods which allowed them to better manage their equipment while maintaining it in perfect condition. The shut-down of the shop is now considered possible, as this fundamentally changes the behaviour in certain situations where the shut-down was avoided, as far as possible.

Upper plant:

✓ Numerous modifications were made on the liquid chlorine network

✓ Modification of the control system.

✓ Removal of the railway crossing: it should be noted that, at the upper plant, a crossing allowed the trains to go through and the routing of tankers to the site. The drawback was that the traffic next to the site was periodically blocked at the site.

In the least, this configuration was not judicious as it was just a short distance from the chlorine storage facility. A modification of the facility's configuration now allows traffic to flow and the railway crossing no longer exists (acknowledged).

✓ The chlorine leak detection network was expanded and extended to the railway line.

✓ The chlorine tank filling station was modified: the filling and weighing configuration were redone.

✓ The filling hall, where the tank filling station is located for example, is no longer open on the sides: it is now closed, the confinement is thus greatly improved.

✓ The neutralisation column now has the possibility of manual restart, which give a certain amount of operational flexibility particularly during a situation at risk.

✓ Technical measures were adopted following a thorough analysis of the various configurations possible to avoid the return of liquid chlorine toward the chloroducs: e.g. modification of the location of certain valves which, following analysis, appeared to be place in a manner which promoted possible returns of liquid chlorine, for example.

Various measures are still projects although their realisation is planned:

✓ Implementation of a backed up supply for the liquefier pump,

✓ Installation of a programmable safety controller, like the one already installed on the lower plant,

✓ An increase in the capacity of the liquid chlorine traps.

✓ Redundancy of the level detectors (a different technology if possible).

The figures below are given to provide an idea of the **investments involved**:

✓ Overall, all of the modifications represent 2 M€ over 3 years.

✓ All of the investments in 2001 were dedicated to improving safety.

APPENDIX: list of incidents/accidents

The most recent accidents at the site:

Accident 1 - 06/12/1995 - •Upper Plant, tanker station
•Nature: Leak on a chlorine tank during the filling operation
•Cause: Human error
•Consequences:
2 works slightly intoxicated

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Accident 2 - 02/26/1999 •Upper Plant, sodium filling station
•Nature: Explosion of the sodium upon contact with the snow following a loss of confinement during a rail car filling operation
•Cause: Failure in operator surveillance in the absence of automatic safety features
•Consequences:
Building siding damaged
•Measures taken:
Slaving of the sodium transfer to the level alarms
Installation of a cold trap on the vent to solidify the sodium
Modification of the procedures

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Accident 3 - 03/27/2000 – Upper Plant, Liquefaction shop soda tower
•Nature: Release of a few kg of chlorine at the exit of the liquefaction shop soda column (saturation of the column)
•Cause: Human error: filling valve of a measuring tank not open,
Temperature set point problem
Uncontrolled excess of chlorine at liquefaction process
•Consequences:
Saturation of the soda tower and loss of confinement
Following the operator's inquiry, a set point was changed
•Measures taken:
Modification of the temperature set point
Modification of the program controlling the opening high sodium hydroxide flow
Modification of the procedures

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Accident 4 – 04/30/2000 – Upper plant, chlorine compressor
•Nature: Rupture of the turbine blades of a chlorine compressor.
•Cause: Turbine design defect
•Consequences:
No consequence for the environment

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Accident 5 - May 2000 - •chloroducs
•Nature: Chloroduc crushed
•Cause: Problem with the scrubbing process at the lower plant
•Consequences:
Exploitation of the chloroducs at a pressure above the nominal pressure
•Measures taken:
Preventive maintenance on the piping (by a scraper system)

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Accident 6: 05/22/2000 – Upper Plant, compressor room
•Nature: Release of 30 kg of chlorine into the compressor room following work on the piping
•Cause: Clogging of the compressor circuit / sodium hydroxide tower
Pressure maintained by the chlorine of an a priori empty pipe
•Consequences:
Release into the confined room, evacuation, with an open door leading to a loss of confinement

Measures taken:

Displacement of the ejector diaphragm of the sodium hydroxide tower
Connection of the chloroduc degassing element on the plant's drainage tower

Measures foreseen:

Preparation of a HAZOP to see if the 2 measures undertaken were sufficient

DRIRE actions:

Accidents occurred during the pressurisation of the new installations.
There is a need to complete the risk analysis efforts through the consideration of installation design modifications made following the malfunctions.
Proposition of AP of Formal Notice dated 02/17/2000: respect of certain provisions of the AP of 09/23/99
Proposition of Complementary AP of 08/08/2000:
Detailed reports of accidents which have occurred since the 2nd commissioning of the electrolysis facility
Finalisation of the updated Danger Study of the lower plant
Critical analysis of the lower plant (extension of due date)
Risk analysis of the upper plant (HAZOP)
Update of the Danger Study of the upper plant
Critical analysis of the upper plant (extension of due date)

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Accident 7: 06/03/2000 - Lower plant, hydraulic seal

•Nature: Release of 18 then 20 kg of chlorine via the hydraulic seal (the chlorine produced was not evacuated)
Return of chlorine to the electrolysis cells

•Cause: Air compressors and chlorine compressor tripped
Tripping of the lower plant's compressors had not stopped the electrolysis
A safety system design problem

•Consequences:

Chlorine odours were smelled by the inhabitants of the nearby village, Pomblière

•Measures taken:

Review of the lower plant's Danger Study in order to incorporate the design problems
A critical analysis of the Danger Study by the INERIS

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Accident 8: 08/22/2000 - •Upper Plant, tanker filling

Nature: 50 kg of chlorine released during a tanker filling operation

Cause: Human error (a liquid phase valve was opened before closure of the degassing valve of the liquid chlorine filling line)
Temperature probe set-point not adapted
Faulty temperature probe
Soda tower capacity insufficient
There is no safety equipment maintenance procedure
Operating instructions incomplete (undergoing review)

Consequences:

A chlorine emission was noticed by the employees of an external company working nearby

Measures taken:

09/2000: Return to service of the temperature probe on a liquid chlorine trap
- PLC program modification
- synchronisation of liquid/gas valves
- slaving of closure valves when liquid chlorine is in the trap (filling stopped)
Review of the "Tanker or container filling by pump from a measuring tank" procedure

Measures foreseen:

Doubling of the temperature probe on the chlorine trap at a different level
A study was implemented for more efficient detection as near as possible of liquid chlorine passages in the chlorine gas degassing pipe (conclusion: HAZOP)
A request by the DRIRE to include scenarios of massive liquid chlorine input into the drainage tower in the Danger Studies
Installation of a 2nd chlorine detection based on a different principle (vibrating reed) and replacement of the existing trap
Training of operators in the procedure and regarding the modifications made

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Accident 9: 04/02/2000 – Lower Plant

•Nature: Fire on a sodium peroxide mixer

•Cause: An oil leak on the double envelope of the sodium piping and oxidation if the oil by the peroxide.

•Consequences:

Fire: limited damages

•Measures taken:

Substitution of oil tracing by electric tracing

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Accident 10: 07/29/2001 - •Lower Plant
•Nature: A leak of 10 kg of chlorine when the electrolysis facility is restarted
•Cause:
A refrigeration fault on the upper plant's liquefier (loss of coolant following servicing on a cooling circuit valve)
Shut-down of the upper plant's compressor
Electrolysis shut-down
Blockage of domes connected to the chlorine manifold and release of chlorine into the electrolysis room.
•Consequences:
Chlorine detected in the environment (peak at 0.8 ppm).
Measures taken - August 2001:
Installation of a high temperature alarm on the chlorine compressors
Correction of the valve installation problem and of the PLC defect having lead to an inconsistency in the operation of the valves that control the very low level detection at the level of the coolant tank
Measures foreseen:
Reflective thinking to determine the exact origin of the chlorine release
Slaving of compressor shut-down to the high-temperature alarm on the compressors (October 2001)
Installation of a branch connection on the condensers to allow back-up operation in an open circuit (late 2001)

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Accident 11: 09/05/2001 - •Upper Plant
•Nature: Chlorine release in the upper plant's shop during a tanker degassing operation on the sodium hydroxide tower
•Cause: Insufficient absorption capacity of the tower or malfunction
The manufacturer attributed the error to an incorrect operation by the operator
•Consequences:
Chlorine leak limited to the shop

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Accident 12: 09/19/2001 - •Lower Plant
•Nature: Projection of the sodium sludge tank lid
•Cause: Handling of drums inappropriate due to the lack of safety instructions
•Consequences:
1 injured, hospitalised
•Measures foreseen:
The operators concerned are reminded of the instructions
Procedures updated

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Accident 13: 03/06/2002 - •Upper Plan, neutralisation tower
•Nature: Release of at least 10 kg of chlorine from the neutralisation tower outlet
•Cause: Breakdown of the automatic controller controlling the liquifaction process and neutralisation tower operation
•Consequences:
2 workers intoxicated
•Measures foreseen:
Rescanning of the Hazop for the control of the degassing valve of the chloroducs in case of a PLC malfunction
Study relative to the implementation of an automatic safety controller at the upper plant that is separate from the existing "process" controller
Study of chloroduc degassing on the upper plant's drainage tower

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Accident 14: 06/03/2000 – Upper Plant

•Nature: Release of liquid chlorine to the gas circuit having lead to the shut-down of the electrolysis hall (2h)
•Cause: A problem concerning the control of the safety valves of both the upper plant's compressor and measuring tank
•Consequences:
Shut-down of the electrolysis operation without any external consequences
Measures taken:
June 2000:
Control of compressors in terms of speed and not on the frequency
Supply of the control part from the UPS
May 2001:
Installation of a chlorine detection network outside the plant
Measures foreseen:
Modifications on automatic controllers to prevent liquid chlorine from returning into the gas circuit
Offtake and treatment of the chlorine gas contained in the pipes located in the Cl2 processing shop in case of incident or electrolysis shut-down.
Removal of the hydraulic seal
Processing of chlorine returns
Rewriting of the restart procedure
Improvement in the collection at the level of the electrolysis cells through better depression.

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Accident 15: 06/09/99 Lower plant, hydraulic seal

•Nature: Release of non-discharged chlorine
•Cause: Operator error during chloroduc switching
Simultaneous isolation of both manifolds for a few moments
•Consequences:
6 workmen slightly effected
•Measures taken:
Reinforcement of procedures

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Accident 16: 10/18/1999 - •Lower plant – Hydraulic seal

•Nature: 15 to 30 kg of chlorine gas released (not evacuated by the upper plant)
•Cause:
Compressor maintenance ⇨ back-up compressor start-up ⇨ Bolt broken in the electric contactor ⇨ short circuit ⇨ disconnection of the electrical power supply
Electrolysis shut-down fault ⇨ continued production of chlorine which is not evacuated
Leak via the hydraulic seal.
•Consequences:
Chlorine odours detected 1 km from the plant (DRIRE informed by a resident)
Measures taken - August 2001:
Slaving of the automatic shut-down of the rectifiers supplying the electrolysis hall
- upon the increase in pressure on the electrolysis cells
- upon the detection of chlorine at the hydraulic seal
Measurement equipment and control room supplied with 24V DC electrical power supply
DRIRE actions:
Proposition of **APMD (Prefectoral Order of Formal Notification) of 10/21/1999**
Immediate respect of certain provisions of the Prefectoral Order (AP) of 09/23/99
Inspectorate noted the situation **(Report) on 10/23/1999**
Proposition of **APMD (Prefectoral Order of Formal Notification) of 08.11.99**
Respect within 1 month of certain provisions of the Prefectoral Order (AP) of 09/23/99
Proposition of **APC of 11/08/99**
Detailed report on the causes of the incident of 10/18 1999 (submitted 11/15/1999)
Updating of the upper plant's DS
Critical analysis of the DSs of both plants.

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Fire at a warehouse complex

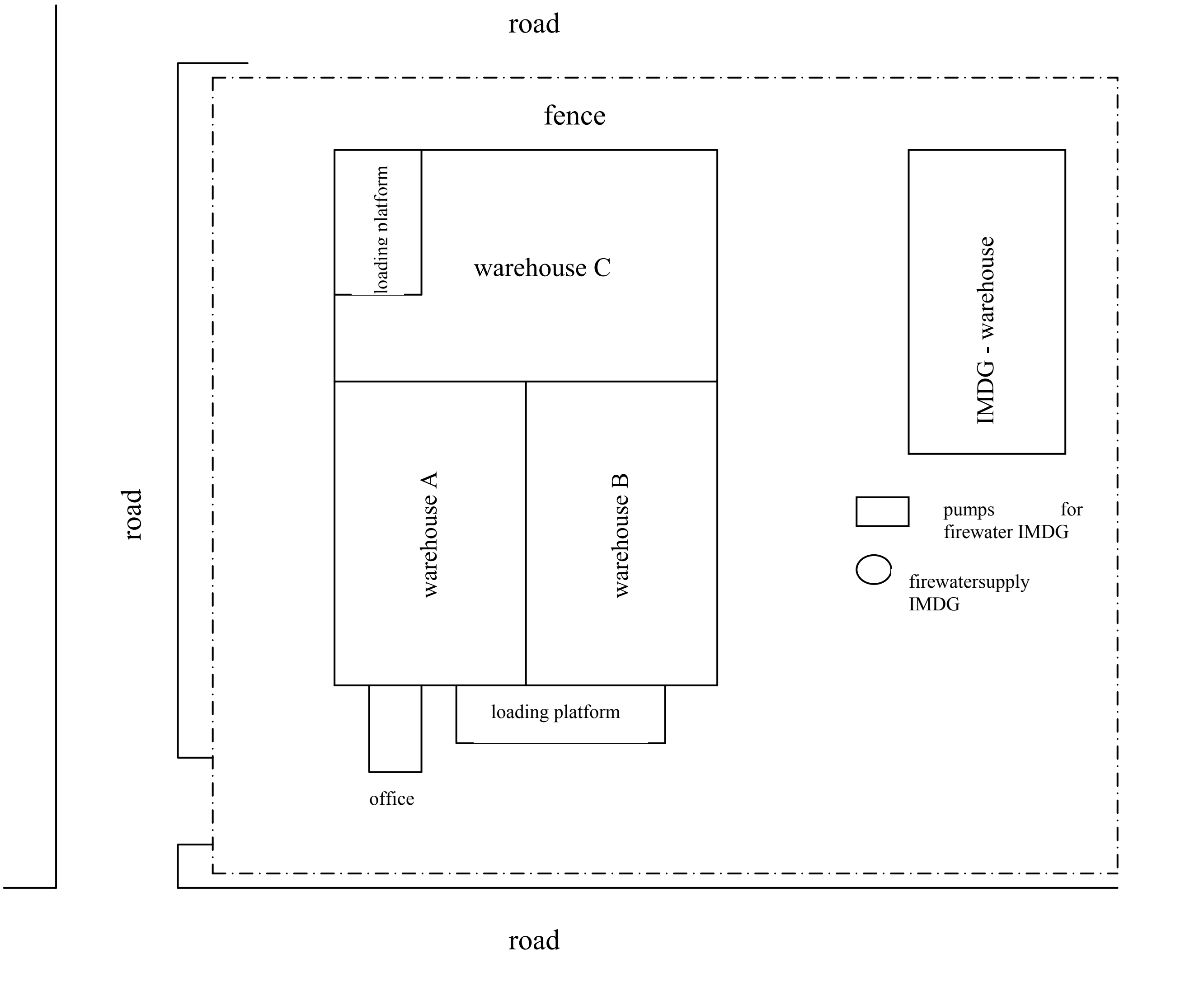
July 11th, 2001

Antwerp harbour area - Belgium

Warehouse
Handling
Fire
Pollution

PART OF THE PLANT INVOLVED

The plant were the accident occurred is a warehouse complex in the Antwerp harbour area. The firm is specialised in storage, cargo-handling and distribution. The site exists of different warehouses for non-dangerous goods and one IMDG-warehouse.



The warehouse complex is a classified establishment of class 1 and has to possess an environmental licence. In the past an official report has been drawn up because of insufficient licence. At the moment the operator is gathering and preparing the necessary information for the application for the licence. This includes an environmental safety report, with QRA for the lethal effects on man in the environment. That report will in a later stage be completed to a Seveso II safety report, including both internal and external safety. The establishment is subject to the Seveso II directive.

Due to the core business of the establishment (storage and distribution) the actual present dangerous goods vary to a large extent in time. However the exclusion for intermediate temporary storage of the Seveso II directive does not apply, since not for all products is known where and when they will be transported, i.e. storage-on-call.

THE ACCIDENT, ITS DEVELOPMENT AND CONSEQUENCES

The accident :

On Sunday July 22nd at four a.m. a fire broke out in warehouse C. Alarm was given to different fire brigades, because of the faulty assumption the IMDG-warehouse was on fire.

The consequences :

Since warehouse C was a non-dangerous goods storage little attention was given to the retention of the contaminated firewater. In first instance the contaminated water fled into the loading pit of warehouse C, but due to the limited capacity of the loading pit after a while the water ran through the rainwater drain into the municipal sewer.

The fire spread to warehouse B in which dangerous goods were stored, although that the authorities didn't know that fact.

Because of the difficulties with the extinction the chief of the fire brigade decided to push the smouldering goods out of warehouse C into the loading pit. Hence the capacity for firewater retention diminished even more.

The fire destroyed warehouse C completely and warehouse B partly. The stored goods suffered severe damage due to the fire, smoke and firewater.

Investigation learned that the municipal sewer didn't lead to the docks of the harbour as was assumed at first, but to a brook in an interesting nature area with an extensive fish population. Hence the contaminated firewater fled into the brook: surface water was contaminated over a vast area and fish mortality occurred. The discharge of the contaminated firewater lasted until the next day in the afternoon.

ORIGIN, CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

The cause of the fire isn't known to this day, but indications for arson are strong. The accident is still under investigation by the prosecutor.

ACTIONS TAKEN

Intervention :

According to the environmental legislation a classified establishment has to notify all (environmental) incidents (fire, explosion, accidental emission, …) to the Environmental Inspection. The tasks of the Environmental Inspection are focussed on the administrative investigation of the accident in order to define and enforce measurements for restoration and clean-up for the environment and to prevent any recurrence of such accident. In this case the operator didn't fulfil his notification duty and the Environmental Inspection was not present at the moment of the fire, although a permanency system is in place for cases like this.

Inspection :

On July 23rd complaints about fish mortality from some fishermen and a request from the municipal environmental service arrived at the Environmental Inspection and an inspector went on site from early afternoon till 20h00.

In the surroundings following observations were made: discharge in a brook, fish mortality, colouring of the surface water. A sample was taken of the surface water.

Corrective actions :

Back on site an oral order was given to stop the discharge and to process the contaminated firewater by legal means.

On September 27th a new inspection took place to follow-up the measures taken. Part of the retained firewater had been removed in a legal way, but no actions for clean-up and restoration of the brook were taken. The damaged goods of warehouse B were still on site. The stocklist for warehouse B of July 22th was investigated: products dangerous for aquatic fauna and biocides in great amounts were present at the time of the fire.

After some further administrative investigation (information about the stored goods, results of the analysis of the samples (very high values for COD and Na^+), …) on November 23rd on official report was drawn up for the following infractions: insufficient licence, non-compliance of the licence conditions, deficient mitigating measures.

The order was given to present a plan for the legal processing of the contaminated firewater and to engage a certified expert for the assessment of the damage in the surroundings.

LESSONS LEARNT

Although the accident is not to be considered a major accident according to the Seveso II directive some interesting lessons can be learnt.

For this specific accident the consequences for the environment could be easily avoided. As environmental inspector charged with Seveso-inspections I think it is necessary to force the establishments to give proper and extensive attention to the risks for the environment.

In this case the establishment and the fire brigade didn't pay enough attention to the prevention and mitigation of the consequences for environment. Since in this case the available retention capacity wasn't used to the full extent, the fault mainly lies in an inferior organisation of the intervention.

For the establishment it's important to draw up a good internal emergency plan in accordance with the Seveso II directive (implementing the measures necessary to protect man and environment from the effects of major accidents). Only by this preventive approach adequate intervention and mitigation can be assured.

The main lesson for the inspectorate is that early presence on site, during the accident, can avoid worse. In this case an order could have been given to use the retention capacity.

In order to achieve this objective it's important to develop an internal organisation able to respond to notifications at any time.

For the inspectorate three phases can be distinguished in case of accidents: before, during and after the accident. Before an accident, during inspections extra attention must be given to the implementation of the necessary mitigating measures (including the emergency planning). For Seveso II establishments a systematic inspection instrument checking the internal emergency plan must be developed.

During the accident the inspector must assure that the foreseen measures are put into effect.

After the accident the necessary administrative investigation has to be carried out. To that purpose a template covering the requirements of the Seveso II directive must be developed.

Explosion
Ammonium nitrate
Deaths
Physical and psychological trauma
Property damage

Explosion in a fertilizer plant

September 21st, 2001

Grande Paroisse in Toulouse (31)

France

A quantity estimated between 20 and 120 tons of ammonium nitrate residue (equivalent to 20 to 40 tons of TNT) detonated on September 21, 2001 in the GRANDE PAROISSE fertilizer plant in Toulouse, causing devastating effects at the site and beyond.

THE INSTALLATIONS IN QUESTION

The plant is located in an industrial zone to the south of Toulouse, at a distance of approximately 3 km from town centre. Created in 1924 as ONIA, it belongs to GRANDE PAROISSE since 1991. The company, with majority shares held by ATOFINA, a branch of the TOTAL FINA ELF chemical group, is the leading French producer of fertilizers and ranked 3rd in Europe. The Toulouse plant employs 469 people and has an annual turnover in the order of 100 million Euros.

Grande Paroisse Plant

The plant has two main activities: the fabrication of nitrogen fertilizer and industrial nitrates, and the synthesis of chlorine-containing compounds. The plant synthesises ammonia that it transforms into ammonium nitrate, a part of which is then used to manufacture fertilizer, the rest being marketed directly in the form of industrial nitrates. The establishment also manufactures melamine (a raw material used in the manufactures of resins), as well as adhesives and chlorinated products used for water treatment applications.

The establishment includes several large dangerous material storage facilities: Two cryogenic ammonia tanks (5,000 and 1,000 tons, 315-ton pressurised ammonia storage tanks, two 56-ton liquid chlorine tankers, 1,500 tons of oxidants, 15,000 tons of solid ammonium nitrate in bulk form, 15,000 tons in sacks and 1,200 tons of ammonium nitrate in hot liquor solution, as well as 2,500 tons of methanol.

The establishment is governed by SEVESO 1 directive then the SEVESO 2 directive owing to the presence of ammonia, chlorine, toxic or combustive substances, ammonium nitrate, and nitrate-based fertilizers… Within the scope of French legislation regarding registered installations, the establishment is subject to authorisation (AS) and must abide by the requirements of the authorisation order dated October 18, 2000 that governs it. In addition, the exact quantities of dangerous substances were regularly declared prior to February 2001 and a safety management system was in place in compliance with the 2001 deadline stipulated by the Ministerial Order of May 10, 2000.

The plant maintains an internal contingency plan and has formed part of an external special intervention plan since 1989, including the 3 plants in Toulouse's southern chemical zone (GRANDE PAROISSE, SNPE and TOLOCHIMIE). Finally, a system aimed at controlling urbanisation was implemented in 1989. A Prefectoral order based on a general interest project required communes to observe certain restrictions relative to new constructions or extensions near production facilities.

The GRANDE PAROISSE facility is operated under authorisation required under the terms of legislation governing registered installations. Finally, several danger studies have been conducted since 1982. Updated every 5 years, some of them were conducted in 2000 and the most recent was conducted in 2001. In these studies, several tens of accidental scenarios were analysed, although the detonation of ammonitrates was disregarded based on the available feedback; the contingency plan did thus not foresee a scenario of this type.

The site is inspected periodically (approximately twice / year). The last inspection, conducted May 17, 2001 by the Registered Installations Inspectorate (DRIRE), focused on several elements of the safety management system.

THE ACCIDENT, ITS BEHAVIOUR AND CONSEQUENCES

The accident:

At 10.17 am, a severe explosion occurred in hangar 221 (2,400 m²) located in the plant's nitrate sector. The explosion, felt several kilometres away, corresponded to a magnitude of 3.4 on the Richter scale. Significant dust fallout from the installations and a crater were observed outside the plant.

View of the AZF plant

A large cloud of dust from the explosion and red smoke drifted to the north-west. The appearance of the smoke is linked to the emergency shutdown of the nitric acid manufacturing installation. Before rapidly dissipating, the cloud containing ammonia and nitrogen oxides sickened witnesses who complained of eye and throat irritations. The atmospheric pollutants released after the explosion lead to the formation of nitric acid (HNO_3), ammonia (NH_3), nitrogen dioxide (NO_2) and nitrous oxide (N_2O) from ammonium nitrate. As a precautionary measure, the Haute-Garonne Prefecture requested that the population of Toulouse confine themselves to their homes. This measure, the efficiency of which was limited owing to the damage to numerous homes, nevertheless reduced the number of traffic problems after the accident.

Human and social consequences:

At the time of the explosion, 266 plant employees and 100 agents from sub-contracting companies were present at the site.

The accident resulted in many casualties: 21 at the AZF site, 1 at SNPE and 8 people outside the site (2 of which were in hospital) who were killed by the explosion or deceased in the days that followed, 29 people were seriously injured of which 21 remained hospitalised for more than one month (300 more than 6 days). A student at the Gallieni professional college, located 500 m from the epicentre, was killed and several other injured when a concrete structure collapsed. Two people also died in a vehicle maintenance establishment located 380 m away and one person died in the EDF (Electricité de France) building located 450 m from the epicentre.

Thousands of people were hospitalised; the Haute-Garonne Prefecture counted a total of 2,442 people as of October 17, 2001.

The injuries included mutilations, pierced eardrums, pleura damage, contusions to organs (spleen, liver), as well as compound fractures and injuries… due to the shock wave, collapsing structures, broken glass, and flying debris…

The INVS (Institut national de veille sanitaire) and the Midi-Pyrénées DRASS (Direction régionale de l'action sanitaire et sociale) published a progress report in July 2002 and a final report in March 2003 on the sanitary consequences of the explosion. The information gathered during this epidemiological study allowed the short term impact of the catastrophe to be assessed by clearly identifying the sanitary effects of the environmental exposures and by describing the physical and psychological traumas. The main information provided in these reports are summarised below.

Numerous physical traumas: wounds, fractures, amputations, contusions… Auditory troubles resulting from the double effect of the blast and to the acoustic trauma due to the explosion were extensive: partial or total deafness, pierced eardrums, hypoacousia, tinnitus, otalgia… Among the nearly 6,000 students located in a radius of 2 km around the site who underwent testing 8 to 10 weeks after the explosion, 5.5% of the secondary school children and 6.3% of the primary school/kindergarten children suffer from hearing deficiencies (> 25 dB). Health professionals were recommended to conduct hearing deficiency examinations on the individuals who were within a radius of 1.7 km at the time of the explosion.

The NO_2, the NH_3 and the particles released by the explosion were responsible for transitory ocular (conjunctivitis, vision disabilities…) and respiratory irritations (tracheobronchitis…) in the population living near the site. These problems appeared to decrease within 5 weeks after the accident. The short and long term risk has been precluded for the pollutants released into the atmosphere on the day of the accident (NH_3, HNO_3, NO_2, Cl_2…) as the data collected showed that no notable sanitary effects potentially linked to these substances are present.

Site clean-up operations

According to the heath services and considering toxicological and epidemiological knowledge on the exposure-hazard relationship, it appears that there are no disquieting consequences concerning the health risk associated with the release of asbestos (cancers, fibrosis). However, labour protection regulations must be carefully applied for individuals working on site cleanup operations.

The water monitoring system allows any alteration in raw water quality and the water distributed in the hours following the catastrophe to be detected. The occasional overshoot of quality limit values for NH_4^+, NO_3^- and NO_2^- do not represent a health risk for consumers. The risks associated with soil contamination (soil thrown from the crater), both direct and indirect (food) have been disregarded.

More than 8,000 people consulted their general practitioner for acute post-traumatic stress in the weeks following the explosion. Five thousand people began a psychotropic treatment (anxiolytic, antidepressant, hypnotic). According to the experts, these numbers are underestimated as they only take into account the individuals who sought medical care. The explosion had a major impact on psychological problems (depression, anxiety…). In addition, two studies conducted jointly with the French National Educational Service show that one year after the accident, one out of seven students still displays clear signs of post-traumatic stress.

Continued monitoring of the medium and long-term health effects will be conducted via various elements of the epidemiological system. A cross-section study (a descriptive epidemiological study at time t) concerning approximately 50,000 salaried employees of the greater Toulouse community and 5,000 rescue personnel, on the one hand, and monitoring of a cohort of 5,000 salaried employees derived from this study (biological examinations), on the other hand. Finally, long-term analysis is planned to identify the causes of death (changes in the mortality rate) of the employees who agreed to give their addresses during the initial study.

The information systems of the heath care structures which supplied the data are independent from one another and the databases cannot be made between them when they exist. A person may be recorded in several of these systems without it being possible to detect the error and may be counted more than once. Also, the results do not allow precise quantitative estimates to be made regarding the overall number of different troubles observed.

In addition to the physical and psychological trauma suffered by the population of Toulouse, there are significant social disturbances notably linked to the destruction and damage to homes, community equipment, buildings, technical unemployment, and to the loss of work… Associations and a collective have been organised to combat industrial hazards and to defend the interests of the populations concerned.

Environmental consequences:

The explosion destroyed storage tanks containing ammonium nitrate solutions and caused nitric acid leaks. However, no leakage on a damaged hot ammonium nitrate solution (95%) tank was observed. On the day of the explosion, the fire and rescue services noted the release of nitric acid into the Garonne River. These releases of nitrogen-containing solutions from the AZF site polluted the river.

Of the 120 parameters measured on the raw water, only an increase in NH_4, NO_3 and COT was observed. The highest values were measured in the Garonne oxbow. The passage of the pollution was identified between September 22 and 27, 2001 with maximum concentrations from the 22nd to the 24th: for the NH_4, 331 mg/l in the oxbow and 16 mg/l in the Garonne; for the NO_3, 1,277 mg/l in the oxbow and 63 mg/l in the Garonne; for the COT, 23 mg/l in the oxbow and 8.7 mg/l in the Garonne.

A few days later, on October 17 and 18, the release of ammonia into the Garonne exceeded the values authorised by prefectoral order. As the ammonia network was no longer pressurised after the explosion, the release of gas into the atmosphere caused the residents discomfort. A water-borne ammonia collection device with the release of ammonia-containing effluent into the Garonne was set up. An incorrect estimation of this release of ammoniated water resulted in the authorised values being exceeded; approximately 9 tons of ammoniated solution thus significantly polluted the Garonne which killed off the aquatic fauna (several tens of kg of fish killed). The concentrations measured by the DDASS are lower than at the time of the explosion. The mortality noted is essentially associated with the ammonia contents associated with a high pH (up to 8.6), thus promoting a shift in the chemical balance toward a non-ionised form of ammonia (free NH_3), which is toxic to fish.

Atmospheric measurements conducted by the ORAMIP (Observatoire régionale de l'air de Midi-Pyrénées) allow the chemical pollutants released into the atmosphere to be determined. For the most part, the gaseous releases contained NH_3, NO_2, N_2O, and dust… For the NO_2, the estimated exposures on the neighbourhoods nearest the site and within the trajectory of the cloud, are short of the guideline values for one hour recommended by the WHO (200 µg/m³).

Economic consequences:

A large part of the AZF plant's 70 ha, belonging to GRANDE PAROISSE, is devastated and all type of debris is strewn about the site:

Crator made by the explosion (ground zero)

- ✓ The detonation of the depot dug a crater measuring roughly forty meters in diameter and 7 m deep in relation to the ground, causing considerable destruction in the northern part of the plant.
- ✓ Brick and concrete buildings of roughly one hundred meters in length were partly collapsed,
- ✓ For certain buildings of lighter construction, only the completely deformed metal framework remains,
- ✓ Certain storage tanks containing ammonium nitrate solution were destroyed causing the Garonne to be polluted,
- ✓ Nitric acid leaks were observed,
- ✓ A hot solution of ammonium nitrate at 95% was damaged but no leak was observed,
- ✓ 2 of the site's stacks collapsed,
- ✓ Several structures were leaning after the explosion...

The explosion also caused significant damage in the chemical companies located on the chemical platform outside GRANDE PAROISSE, on the other side of the Garonne and which are also governed by the SEVESO 2 directive: SNPE and ISOCHEM, a subsidiary of SNPE. Two establishments located on the grounds of the SNPE plant were subjected to very heavy damage (RAISIO and AIR LIQUIDE). The TOLOCHIMIE plant (part of the SNPE group), also governed by the SEVESO 2 directive and located to the south of the Grande Paroisse plant was only slightly damaged. The activities of these establishments were suspended by a Prefectoral injunction to secure the sites. More than 1,100 employees were concerned.

The consequences of the accident could have been much worse owing to a "domino effect" namely due to the many chemical storage tanks located nearby: chlorine, ammonia and fertilizer at GRANDE PAROISSE, phosgene units and piping belonging to SNPE and TOLOCHIMIE… Quite thankfully, no notable "domino" effect occurred, except for leaks on nitric acid tanks which were rapidly brought under control. The experts offer various explanations as to why the "domino" effect did not occur:

Impact made by flying debris on a water pipe

Building housing the chlorine stocks and tankers

For GRANDE PAROISSE, the pressurised ammonia storage tanks located 300 m from the explosion were relatively protected by a building which suffered extensive damage but which acted as a screen. The liquid ammonia storage tank located more than 600 m suffered no direct damage. The building sheltering the chlorine storage tank more than 500 m was damaged, although the railcars located inside were not touched. Finally, the railcars containing chlorine and ammonia located to the south of the site and at more than 400 m, were protected by buildings whose structure resisted the shock.

The explosion did not spread to the other ammonium nitrate storage tanks located within the zone, although the integrity of other locations designated for the storage of dangerous substances was seriously damaged however (namely the collapse of a building housing ammonium nitrate) thus creating a situation at risk requiring additional operations to secure the site.

- ✓ For SNPE and TOLOCHIMIE, owing to the precautions applied to the powders and explosives based on 3 principles: fractioning, partitioning and the overabundance of safety features.
- ✓ For the ISOCHEM plant which is relatively near ground zero of the explosion, owing to the distance which lowers the secondary effects of an accident, as well as the small quantity of products stored or undergoing preparation, which allows them to be held in protected areas.

Warehouse destroyed by the explosion

Six months after the catastrophe, the *Prefecture* published a report of the establishments that were directly affected by the explosion.

Nearly 1,300 companies, representing approximately 20,000 employees, claimed losses to various degrees. The French government released 10.4 million Euros in help to companies and proposed 1.7 million Euros in tax exemption.

	Significant impact		**Limited impact**	
	Nbr of establishments	**Nbr of employees**	**Nbr of establishments**	**Nbr of employees**
Industry	58 (including 30 small/medium sized industries and 28 groups)	5,408	54 (including 25 small/medium sized industries and 29 groups)	6,358
Service	33	511	285	4,368
Commerce	81	767	461	2,775
Total	**172**	**6,686**	**800**	**13,501**

Source: Toulouse, six mois après la catastrophe (Six months after the catastrophe) – A Prefecture brochure

Vehicle maintenance company destroyed

Significant property damage was also observed around the industrial zone in an extensive oval-shaped perimeter oriented toward the south of the city: a nearby urban boulevard, several public buildings which can no longer be used, windows broken up to 7 km away according to several sources. Residents in towns 75 km away (Castres) and 45 km away (Montauban) claim to have heard the explosion. The shock wave and various projectiles damaged 82 schools, 19 middle schools and 15 high schools (36,000 students), as well as 4 establishments of higher education and 3 university dormitories. In front of the factory, a depot containing roughly one hundred busses was destroyed (200 MF) and numerous other stores facilities were damaged. A household appliance store located 320 m from the explosion's epicentre, as well as a vehicle maintenance facility at 380 m, collapsed also claiming victims.

Many other constructions were also damaged, some of which had to be evacuated given the extent of the damage or the risk of collapse (psychiatric hospital, schools, homes…). A total of 25,550 homes were damaged to various degrees, 11,180 of which were seriously damaged. More than one thousand homes were completely destroyed and more than 1,200 had to be relocated immediately. Certain people were housed in private homes under a specially implemented temporary housing program. Relocation efforts were set up in both the council housing and private sector to find shelter for numerous individuals. Hundreds of homeless families were relocated to mobile homes. The last emergency housing centre was closed October 30, 2001. The French government released 24 million Euros for support measures dealing with housing and the construction of new public equipment began in the months that followed.

Bus depot destroyed

Finally, telecommunication was disturbed in a 100 km radius and the cellular telephone networks were completely saturated for several hours after the explosion.

According to information provided by insurance companies, the damage is estimated between 10 and 15 billion French francs. Several tens of accident victims whose homes had their windows shattered and still not replaced were forced to endure the initial winter weather conditions several months after the accident.

Severity scale:

According to the severity scale made official in 1994 by the Committee of Competent Authorities of the member States which oversees the application of the 'SEVESO' directive, the explosion of September 21, 2001 in Toulouse is characterized by the following indices:

Index relative to the quantities of dangerous materials at issue: 4

Human and social consequences	■ ■ ■ ■ ■ ■
Environmental consequences	■ ■ ■ ■ □ □
Economic consequences	■ ■ ■ ■ ■ ■

The severity scale only considers the true effects and consequences of the accident based on 18 technical parameters. The level retained for each index corresponds to the highest value attained by any of the technical parameters which make up each index.

The information which makes up the severity scale is collected. When unknown, the evaluation is performed by default.

× The index relative to "the quantities of dangerous materials" corresponds to 4 on the severity scale.

For the release of chemical products, the scale is as follows:

Parameters	Selection criteria	Scale level
Quantity Q of substances actually lost or released in relation to the "Seveso" threshold	10% < Q < 100%	4
Quantity Q of explosive substances having actually participated in the explosion (equivalent in TNT)	5 t > Q > 50 t	4

× Level 6 was attained for the human and social consequences, considering the number of deaths, slightly injured and homeless or jobless individuals following the accident.

For the human and social consequences, the scale is as follows:

Parameters	Selection criteria	Scale level
Total number of deaths:	20-49	5
Employees	20-49	5
Outside rescue personnel	0	0
General public	≥ 6	6
Total number of injured with hospitalisation ≥ 24 hours:	≥ 200	6
Employees	Not precisely known	-
Outside rescue personnel	0	0
General public	≥ 50	6
Total number of slightly injured cared for on site or with hospitalisation < 24 hours:	≥ 1,000	6
Employees	Not precisely known	-
Outside rescue personnel	0	0
General public	≥ 200	6
Total number or homeless or unable to work (outbuildings and work tool damaged…)	≥ 500	6
Number N of residents evacuated or confined at home for more than 2 hours (persons X nbr hours)	5,000 ≤ N ≤ 50,000	4
Number N of persons without drinking water, electricity, gas, telephone, public transport for more than 2 hours X nbr of hours (persons X hour)	1,000 ≤ N ≤ 10,000	3
Number N of persons requiring extended medical supervision (≥ 3 months)	Not precisely known	-

× For the environmental consequences, level 4 corresponds to the pollution of the Garonne caused by the release of nitrogen-containing solutions.

For the environmental consequences, the scale is as follows:

Parameters	Selection criteria	Scale level
Quantity of wildlife killed, injured or rendered unfit for human consumption (t)	several tens of kg of fish	1
Proportion P of rare or protected animal or vegetal species destroyed (or eliminated by biotope damage) in the zone of the accident	Not precisely known	-
Volume V of water polluted (m^3) (*)	0.1 million < V < 1 million	4
Surface area S of soil or underground water surface requiring cleaning or specific decontamination (ha)	Not precisely known	-
Length L of waterfront or water channel requiring cleaning or specific decontamination (km)	Not precisely known	-

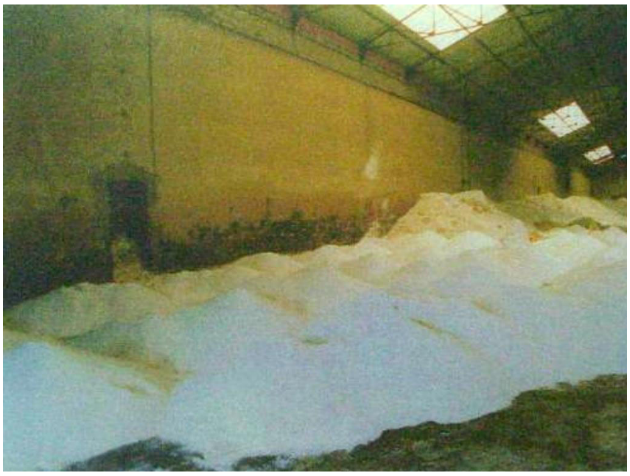
× The amount of property damage in the establishment, the loss of production following the explosion and the cost of site rehabilitation measures represent level 6 in terms of the economic consequences.

The following table represents the overall economic consequences estimated at more thant 2 billion Euros:

Parameters	Selection criteria	Scale level
Property damage in the establishment (C expressed in millions of €)	$C \geq 200$	6
The establishment's production losses (C expressed in millions of €)	$C \geq 200$	6
Production losses or property damage outside the establishment (C expressed in millions of €)	$C \geq 10$	6
Cost of clean-up and rehabilitation measures (C expressed in millions of €)	Not precisely known	-

ORIGIN, CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

Hanger 221 was used to stock industrial and agricultural nitrates considered "below grade" owing to their grain size and off-spec chemical composition. At the time of the accident, the hanger contained 300 to 400 tons of ammonium nitrate. From the various workshops, this rejected material is brought to an inlet area by three subcontractors. It is then pushed by transport equipment into the building. This scrap material is removed periodically and oriented to the SOFERTI plants (ATO Group) in Toulouse and Bordeaux to be recycled to be used the manufacture of complex fertilizers.



On the eve of the explosion, 15 to 20 tons of ammonitrate with an additive in qualification phase was brought into the building. On the morning of the explosion, products derived from the packaging of the ammonitrates and the manufacturing shops were also transferred into the building. The last addition of material by bin coming from another storage zone was made less than 30 min before the explosion.

Bulk storage of ammonitrates

Several inquiries and expert evaluations were conducted:

✓ judicial inquiry,

✓ administrative inquiry conducted by the French Ministry of the Environment with the participation of the INERIS,

✓ ATOFINA internal inquiry,

✓ inquiry by the CHSCT ("comité d'hygiène, de sécurité et des conditions de travail", the committee for hygine, safety and working conditions) with the participation of a surveyor's office.

The inquiries raised many hypotheses were formulated to explain the explosion*:*

✓ Unintentional external causes associated with accidental technological or natural phenomena (methane due to underground bacterial activity, meteorite, falling aircraft parts, explosion of a bomb or nitrocellulose underground following previous site activity); all of these hypotheses proved to be unfounded.

✓ Intentional external causes (attack, malicious mischief, missile) conjured up and spread by public opinion in the same context as the "Twin Towers" terrorist attack in New York, on September 11, 2001. From a legal standpoint, this hypothesis is not supported by any tangible facts.

✓ A process incident (an internal electrical fault at the plant, electric arc, missile effect from a part projected at high speed…). An examination of manufacturing parameters at the time of accident however did not show that this type of incident occurred. Concerning the possible high speed projection of a piece of metal causing a primary explosion in a filter at the top of a tower near the site of the explosion, experts feel that the kinetic energy developed by the projection of debris from the filter would be insufficient to cause the nitrate contained in hangar 221 to explode.

✓ As far as an accidental chemical reaction is concerned, the nitrates used were polluted by iron oxides, sulphur and in contact with bitumen used to pave the floor of building 221 or following the mixture of incompatible chemical substances, such as ammonium nitrate with sodium dichlorocyanurate (a product used in treating swimming pools); the incompatibility of these substances was highlighted during court-ordered laboratory tests.

Favoured differently by the entities concerned, none of these hypotheses have lead to a consensus. The judicial inquiry leans strongly toward an accident having accidental origins, while favouring the hypothesis of a mixture of ammonitrate waste with chlorine derivatives.

ACTION TAKEN

Immediate firefighting and rescue measures:

The Prefecture and several departments activated emergency centres, the municipality set up a support centre for the population and the operator installed a crisis centre within the establishment.

The PPI ("plan particulier d'intervention", special intervention plan) and the emergency plan were put into action; reinforcements were requested to assist the departmental firemen, the civil protection mobilised a chemical hazard evaluation cell and technological catastrophe specialists. During the first 6 days,1,430 people were thus mobilised, including 460 firemen from Haute Garonne, 620 firemen from other *départements* and 350 military personnel of the UIISC ("Unités d'Instruction et d'Intervention de la Sécurité Civile). Roughly fifty doctors, 32 nurses or health care practitioners and more than 80 ambulance drivers were also mobilised.

The monitoring of access routes, looting protection and guarding required 500 to 600 policemen and 13 companies of special CRS (riot control) policemen rotating between September 21 to October 3, 2001. Crisis management operations also mobilised 350 gendarmes and a squadron of 80 mobile gendarmes primarily for traffic control, reinforcement and sanitary convoys.

Considering the extent of the collateral damage and the inherent risks, numerous buildings and schools were evacuated. A security perimeter was set up in a radius of 500 m around the site. Thoroughfares around the site were closed. Traffic on the freeway, the southern ring road, the A62 and A64 motorways, the RN 20 highway, the metro, the railway station and Blagnac airport was interrupted.

The nearby hospitals were able to accept the very large number of injured.

The population was ordered to remain confined as a precautionary measure and masks were distributed around the site. In late morning, the Prefecture announced that the toxic risk was under control and that all danger of atmospheric pollution had been dismissed. The precautionary confinement order was lifted around 4.00 pm, and rail and air traffic was reestablished. Nevertheless, the population was asked not to consume the tap water. The pollution of the Garonne was also brought under control.

The PPI was lifted September 28, 1.00 pm.

Securing of the site:

At the request of the Registered Installations Inspectorate, on September 2001 the *Préfet* issued an order and according to an emergency procedure, suspending the activity of 6 companies operating within the chemical zone (GRANDE PAROISSE, SNPE, TOLOCHIMIE, ISOCHEM, AIR LIQUIDE and RAISIO) requiring them to secure their sites. One company, SOFERTI in Fenouillet, which recycles off-spec products coming from the storage facility that exploded, was also the subject of an emergency prefectoral order requesting it to secure its chemical substances; inerting operations were set up for this purpose.

Dilution of NH_3 by water curtains

The crisis centre of the Registered Installation Inspectorate remained active for 3 weeks after the accident in order to ensure that the various sites were secure.

That of AZF GRANDE PAROISSE site included several delicate operations: recovery and removal of stocks of ammonium nitrate in hot solution, industrial nitrates buried near the crater, liquefied ammonia, nitric acid… Expert evaluation and validation of the procedures was requested prior to certain operations.

During the drainage of a liquefied ammonia storage tank, an uncontrolled release of approximately 9 tons of ammoniated solution resulted in significant pollution to the Garonne killing fish which was noted by the Registered Installations Inspectorate.

It took several months to secure the AZF site and the other plants concerned, which namely involved the evacuation of dangerous substances. At the request of the *Prefect*, the corresponding operations were carried out by the operators under the control of the Registered Installations Inspectorate. In this manner, according to the latter's estimates and for the GRANDE PAROISSE plant alone, 4,000 tons of agricultural nitrates (fertilizer) and 800 tons of industrial nitrates buried under the gravel and rubble of buildings destroyed by the explosion, were to be cleared out and removed in the 4 months following the explosion.

SNPE, ISOCHEM and TOLOCHIMIE were required to conduct an audit of the property damage and conduct analysis of the safety conditions. Based on a proposal by the Registered Installations Inspectorate, the *Prefect* also required that a third-party expert evaluation be conducted, as defined in article 3-6 of the order dated 09/21/77.

In addition to this, 150 agricultural or industrial nitrate storage installations are monitored throughout France.

Legal action:

The public prosecutor's office in Toulouse opened a judicial inquiry for "involuntary homicide and injury". The inquiry conducted in this framework mobilised up to 140 policemen (SRPJ (regional judiciary police) and forensic and technical police laboratories) for long-term investigations. According to the press, 1,500 reports and 800 to 900 statements were had already been entered in the case file one month after the accident.

Emergency financial aid:

In addition to the housing support provided, emergency relief funds for the accident victims (> 18 M€) was released by the government, the regional authorities, the departments and communes… The assistance provided to accident victims was not considered compensation but allowed them to deal with primary needs for the individuals whose homes had been destroyed or significantly damaged.

The reconstruction of damaged public and private buildings outside the chemical sites was launched in the month following the accident. In the Midi-Pyrénées region, the "Direction générale de la concurrence, de la consommation et de la répression des fraudes" (the French general directorate for competition, consumption and the prevention of fraud) set up a monitoring system to detect possible abuse by companies performing repair operations.

Proposals and national measures:

An inquiry by the Parliamentary Commission was opened October 24, 2001 relative to the safety of industrial installations and research centres, and relative to the protection of persons and the environment in the case of a major industrial accident. As of January 29, 2002, this commission had formulated 90 proposals along six major themes: reducing the risk at the source, the human factor notably with the employees playing a role in the prevention of accidents, the implementation of greater openness and pluralistic expertise with regard to risks, urban planning questions, the adaptation of judicial procedures and the compensation of the victims of industrial catastrophes.

Within a few months, the French public authorities undertook different reflective thinking and actions:

× In the field of prevention, in order to:

  - ✓ Broaden the field of application of the SEVESO 2 directive by lowing the ammonium nitrate threshold,
  - ✓ Limit the danger presented by ammonium nitrate-based fertilizers by adapting their technical specifications to make them intrinsically less explosive,

- ✓ Improve the prevention of major accident risks in ports and railroad yards,
- ✓ Ensure the continuity of the security between fixed installations and the transport of dangerous materials,
- ✓ Reinforce the exchanges between member States relative to the hazards associated with ammonium nitrates (fertilizer and industrial nitrates),
- ✓ Reinforce the exchanges between member States relative to the cohabitation of activities at risk with other economic activities, residential housing and thoroughfares,
- ✓ Harmonise the risk evaluation methods between France and the member States,
- ✓ Accede to improved harmonisation of methods and inspection means of establishments at risk by the public authorities,
- ✓ Reinforce cooperation between research and expert assessment organisations in the European Union,
- ✓ Reinforce the budget of the INERIS and develop expertise associated with research,
- ✓ Reexamine the safety conditions of high-level SEVESO facilities,
- ✓ Conduct third-party expert evaluations of each SEVESO establishment.

× In the field of inspection, in order to:

- ✓ Reinforce the inspectorate throughout the DRIRE by creating more than 400 jobs between 2004 and 2007,
- ✓ Reinforce the inspectorate through technical support for the examination of danger studies,
- ✓ Check the fertiliser storage and ammonium nitrate storage facilities governed by legislation on the ICPEs.

× In the field of openness and information to:

- ✓ Create more than 80 experimental local information and joint action committees (circular of July 12, 2002),
- ✓ Publish (via Internet) the new operating authorisation orders accompanied with the inspection reports.

The actions conducted between September 2001 to September 2002 concern the organisation of national and regional debates on risk evaluation and management, the organisation of a European seminar on urban planning control (12-14/02/2002 in Lille, France), the installation of several theme- and sector-based workgroups on the risk control and evaluation, as well as the preparation of regulatory text concerning major risks.

LESSONS LEARNED

As the causes of the explosion that the judicial inquiry must decide upon have not yet been clearly established, the lessons learned from the still partial analysis remains incomplete.

It should be recalled and emphasized, however, that in the AZF danger study updated slightly prior to the accident, the explosion scenario was not retained by the operator, by a third party expert, or by the inspectorate, as the feedback lead us to believe that the explosion of ammonitrates in compliance with the standard was improbable.

This catastrophe clearly shows that the contingency plans must consider a series of scenarios of the type, severity and kinetics representative of probable accidents even if their probability is considered extremely low.

The method for evaluating the risk proved to be insufficient. The danger study must consider the danger potential of installations, examine possible scenarios and their consequences including the most dramatic or improbable, estimate probabilities and characterize the modes of occurrence. Reducing risks at the source must aim at reducing the potential for danger, the probability of accidents occurring and limiting the consequences through appropriate organisational and technical systems.

The legal system did not enable sufficient control in terms of urban planning, particularly for the existing industrial sites whose surrounding area had already been urbanised. This point was brought up in the bill concerning the introduction of a technological risk protection plan foreseeing pre-emption, abandonment and expropriation mechanisms.

This bill also emphasises information and joint action on the risks, in terms of both employees and the surrounding area. It broadens the role of the CHSCTs (Comités d'Hygiène de Sécurité et des Conditions de Travail, Committees for hygiene, safety and working conditions) and creates local information and joint action committees. The implementation of the law concerning the prevention of technological risks will this enable the various actors intervening on the site to be implicated, the release of information to the public, and urban planning control around installations at risk. It will also improve the compensation paid to victims of industrial accidents.

From a strictly technical point of view, and according to the measures and observations made by the INERIS, it should be noted that the explosion of September 21, 2001 gives rise to a overpressure in the order of 140 mbar (threshold retained to characterise the lethal effects in the danger studies) at a distance between 280 and 350 m and 50 mbar (threshold retained to characterise the irreversible effects on human health in the danger studies) at a distance between 680 and 860 m. This observation can be constructively compared to the fact that there were victims resulting from indirect effects up to 500 m away on the one hand, and injuries caused by broken glass at distances of a few kilometres away, on the other hand.

Agropharmceutical
Phytosanitary
Works
Fire-permit

Fire in an agropharmaceutical products storage area

February 1st, 2001

Port-la-Nouvelle (11) - France

THE INSTALLATIONS IN QUESTION

This is an old installation (100 years old) and has been the subject of the usual successive authorisation and related orders issued by the Prefect; its activities have evolved from the formulation of agropharmaceutical mixes (without chemical reaction) to the simple packaging of these products.

For decades, the site has been used for grinding sulphur for use in the preparation of agropharmaceutical products.

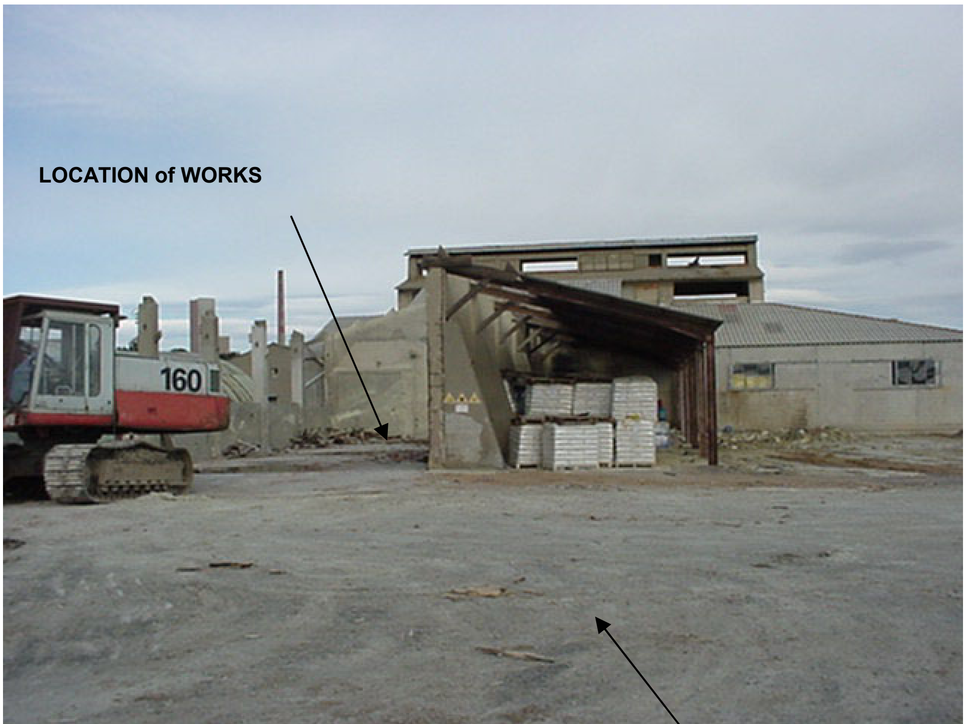
Storage sites were set up in connection with this activity; they are located at various points around the site, and comprise a total authorised capacity of 400 tonnes of agropharmaceutical materials, less than 200 t of which is composed of toxic materials. At the time of the fire, the installation was classed at the lower end of the Seveso 2 Directive. This is no longer the case (reduced quantities).

The site where the fire broke out is a storage area located under a canopy and back-to-back with a small building.

The building is covered with fibre-cement roofing panels supported by a timber frame whose beams traverse the common wall and support the roofing panels that cover the storage area under the canopy.

A total of around 50 tonnes of agropharmaceutical products are stored in sacks on pallets on this site.

In the past, these premises contained sulphur in bulk.



THE ACCIDENT, ITS BEHAVIOUR AND CONSEQUENCES

The accident:

On February 1st, 2001, an outside company began removing the roofing and the timber frame of the adjoining building, which had previously been emptied of its entire contents.

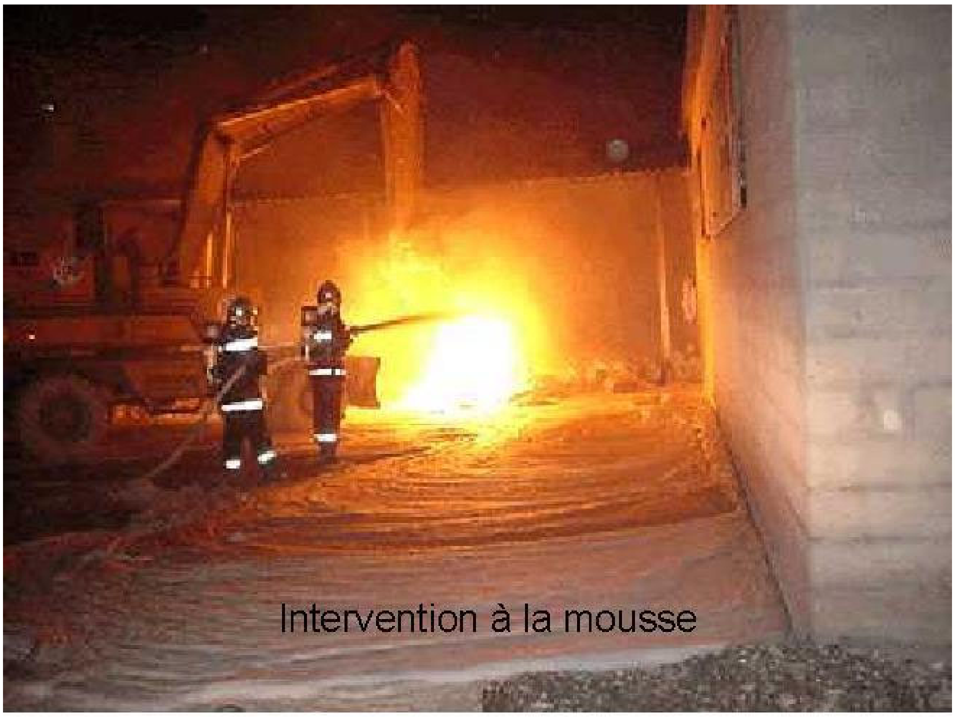
The frame was cut up using a circular saw, and the rubble and chunks of framework were loaded into a lorry by means of a hydraulic shovel.

Activity on the worksite ended at 5.45 p.m. (the installation's normal working hours are 8 a.m. – 6 p.m.). At the site where the works were carried out, a work permit procedure was not obligatory; nevertheless, a permit had been issued and a clean-up inspection was performed at 5.45 p.m.

Alerted by neighbours at approximately 7.30 p.m., the fire department arrived on the site immediately and saw that part of the materials being stored under the canopy was on fire.

The firemen rapidly began to spray down the fire (7.45 p.m.), but without success.

The fire was brought under control at approximately 10.30 p.m., after several minutes of using a water-foam concentrate mixture, consecutive to the initial attempt to extinguish it by applying water.



Consequences:

Twenty-four tonnes of phytosanitary products of the 50 tonnes being stored were destroyed; the materials involved in the fire were:

✓ 16 t of fungicide in 25 kg cardboard packaging (powder containing 80% of the active ingredient mancozeb– based on manganese ethylene bisdithiocarbamate –Xi label);

✓ 1 t of nematocide-fungicide in 10-litre cans (aqueous solution containing 51 g/l of the active ingredient metam-sodium – sodium dithiocarbamate $C_2H_4NS_2Na$ - Xn label);

✓ 7 t of plant growth regulator in 10-litre cans (aqueous solution containing 520g/l of the active ingredient hydrogen cyanamid – CH_2N_2 derived from carbonic acid – T label).

The firefighting water caused mud containing agropharmaceutical materials to spread over approximately 300 square metres, leading to the excavation and incineration of 120 tonnes of polluted soil.

Product loss is estimated at 38,000 Euros; the cost of incineration is estimated at 185,000 Euros.

Neighbouring sites were unaffected by the smoke.

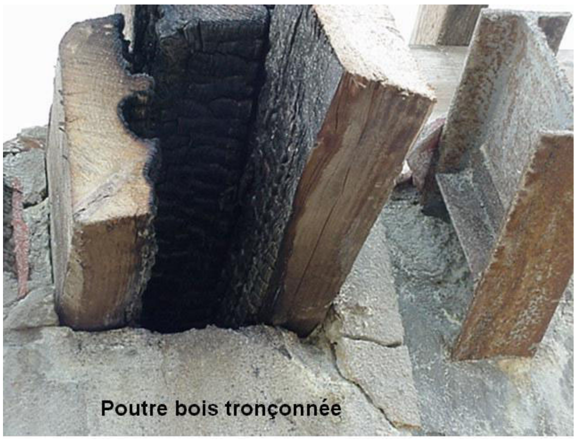
ORIGIN, CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

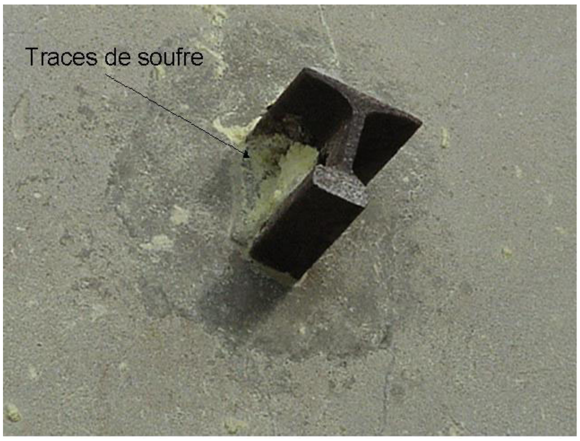
The frame was cut up using a circular saw which, according to findings made on the site, heated the wood to the point of triggering, on part of one beam, a slow, imperceptible phenomenon of combustion at the time the work stopped and the worksite was evacuated at 5.45 p.m..

The beam in question had been cut off at the level of the wall on the building side, but its end, which remained inside the wall, was sticking out under the canopy (roofing support).

The heating phenomenon was probably amplified due to sulphur residue present in the cracks and cavities in the frame and the wall.

Burned particles fell onto the plastic sheeting, causing the fire to spread more easily to the packaging and then to the materials being stored and the pallets.





ACTION TAKEN

According to a written report made by the operator on the day of February 2nd, the following measures were taken:

× Analysis of the soil.

× Clean-up of the soil by strip excavation to a depth of 20 cm and incineration of the 120 t of products collected in an authorised waste disposal site.

× Updating of the procedure and records concerning work permits and fire permits:

- ✓ extension to all locations on the site,
- ✓ obligatory work stoppage at 3 p.m.,
- ✓ inspection 1 h after work stops on the site.

× Setting up of an internal contingency plan;

× Purchase of foam concentrate and periodic fire drills with fire-fighters;

× Monitoring of ground water pollution by means of analyses, as the installation has an internal and external piezometric network. No pollution peaks were recorded.

LESSONS LEARNED

This fire highlighted the following:

- ✓ The role of structural and covering elements of a building in the propagation of a fire when they are made of combustible material.

- ✓ The importance of fire permits and related inspections, not only when closing the site but also in the hours that follow.

- ✓ The importance of the information firemen can provide concerning the nature of extinguishing products and agents to be used in case of fire, by means of the scenarios developed in the internal contingency plan and periodic fire drills.

Other documents

Sheet presenting the gravity scale

Presentation of industrial accident severity scale

1 – Changes in the industrial accident severity scale since 1990

The first version of the scale was created in 1989. It was actually a triple scale which separately measured the potential danger, the consequences of the accident and the emergency response resources used. Tested in 1990-91, the scale was considered to be unsatisfactory for the following reasons:

- ✓ the use of a system with three indices was considered to be too complicated;
- ✓ the distribution and the severity levels associated with certain criteria revealed inconsistencies and lead to the interlacing of real accident consequences and potential effects, which rendered interpretation difficult;
- ✓ the consideration of the quantity of dangerous product potentially involved, and the efficiency of the prevention or protection systems present were difficult. It introduced a bit of subjectivity that was particularly difficult to control.

A new scale was developed in 1993 by a task force represented by the SEI/BARPI. In February 1994, the Committee of Competent Authorities of the member States, which oversees the application of the 82/501/CEE "Seveso" directive, decided to adopt this scale for experimental use over a 2-year period. Subsequently, no specific comments were made by the member States of the European Union regarding the scale and it continues to be used.

2 – Characteristics of the current industrial accident severity scale

The current instrument provides a set of objective criteria quantified to access the severity of an accident based on its true effects. It is primarily designed as a classification tool to be used by experts. Its simplicity and objectivity should enable it to also fulfil the needs of the media and the public regarding the severity of accident consequences.

The industrial accident severity scale considers only the actual consequences of the accident according to 17 technical criteria. These criteria correspond to the quantities of dangerous materials released, as well as the consequences to man, the environmental and property. It was scaled based on accidents already observed in the past. The principle is as follows: the greater the severity level, the rarer the event. The distribution of accidents by severity level thus follows a decreasing exponential function.

The scale includes 6 levels of severity used to evaluate the consequences of an accident. A correspondence table is used to determine the severity level reached for each of the 17 technical criteria. This table is enclosed in the appendix hereto.

Applying the scale for a given accident gives a single severity index, corresponding to the highest level reached by any one of the technical criteria for which the information is available.

3– Comparison with the nuclear event scale

The Agence Internationale de l'Energie Atomique (AIEA) published the International Nuclear Event Scale (INES) in 1990. France adopted this scale in 1994 (from 1987 to 1994, nuclear events were classed on a French scale made up of 6 levels and whose principles were similar to those of the INES).

This scale includes 7 levels. The levels are broken down as follows:

- 1 to 3 – incidents without consequence,
- 2 to 5 – events with radiological consequences inside the site or serious damage to the reactor core,
- 3 to 7 – events with radiological consequences outside the site.

The method for classifying incidents without consequences is based on the maximum potential radiological exposure level and on the defence in depth, namely the evaluation of lines of defence which prevented an incident from transforming into an accident.

The main differences between the INES and the industrial accident severity scale are :

- ✓ INES only handles proven or potential radiological consequences in a global manner,
- ✓ the incidents without direct consequence are handled by INES,
- ✓ INES is a purely media scale and is not used for conducting technical analysis,
- ✓ 150 basic nuclear installations for 65,000 registered installations subjected to authorization and 500,000 subjected to declaration,
- ✓ 500 nuclear incidents per year compared to 2,000 events recorded annually in the ARIA database, including more than 90% accidents. In France, only one level 4 nuclear accident is recorded: damage to the reactor core of Saint Laurent A in 1980.

4 – Difficulties encountered in using the industrial accident severity scale

The main difficulties encountered stem from the attribution of an overall severity index covering the consequences that are completely different according to the accidents, while these consequences can only be directly compared between themselves: death, length of waterway polluted, harm to the fauna, flora, property damage, operating losses… Dialog is often difficult with the media or victim associations which poorly understand the mixture of various categories of consequences formed within a single and obscure index. No one deduces that a valuation system between the various interests involved in the industrial accidents was knowingly established.

Classing incidents characterized by potential effects and consequences is not possible. However, the scale can be used to classify incidents in which dangerous material (governed by the SEVESO directive) was released, even when it did not result in human, environmental or economic consequences.

The lack of sufficient information about certain pertinent technical criteria can lead to an under classification of the accident. This difficulty, however, must not be attributed to the severity scale, but to deficiencies in the acquisition and communication of the information about the accident by the private or public entities concerned.

5 – Improvement proposals

The purpose of these proposals is to allow more efficient communication of information to the media and public (beyond experts).

5.1 - Accidents

× To describe an accident, the current single severity level can be substituted by three or four groups of homogenous consequences:

- ✓ 1° - human and social consequences,
- ✓ 2° - environmental consequences,
- ✓ 3° - economic consequences,
- ✓ 4° - possibly quantities of dangerous materials released.

At present, the scale's seventeen parameters will be approved according to three or four separate groups, each assigned a coefficient of one to six for each accident.

Examples:

Current scale

AZF Toulouse	ERIKA	Crédit Lyonnais fire
Level 6	Level 6	Level 6

In its only level 6, the current scale does not differentiate these three accidents, although the Toulouse accident caused 30 deaths and more than 5,000 injured, 56 people were slightly intoxicated during the Crédit Lyonnais fire and the sinking of the Erika had no known human impact. The environmental consequences of the pollution caused by the Erika (300,000 birds and 150 ha of oyster beds polluted, the coastline of the Finistère, Morbihan, Loire Atlantique, Vendée and Charentes Maritimes *départements* were polluted) cannot be compared to the other two accidents. All three accidents had serious economic consequences (AZF: 15,000 MF, Erika: 1,200 MF, Crédit Lyonnais: 1,956 MF).

Consequences classification proposal

AZF Toulouse	ERIKA	Crédit Lyonnais fire
Human: 6	Human: 0	Human: 1
Environmental: 1	Environmental: 6	Environmental: 0
Economic: 6	Economic: 6	Economic: 6

The quantities of materials released or which had exploded can be considered as a consequence of the accident, or as the origin of human, environmental or economic consequences. Assuming this, and for the sake of simplification, only three parameters are required.

Alternative consequences classification proposal

AZF Toulouse	ERIKA	Crédit Lyonnais fire
Human: 6	Human: 0	Human: 1
Environmental: 1	Environmental: 6	Environmental: 0
Economic: 6	Economic: 6	Economic: 6
dangerous material: 4	dangerous material: 4	dangerous material: 0

This second proposal allows a degree of precision to be added relative to the quantities of materials released during the accidents and to characterize the incidents without any other consequence, although its presentation is more laborious.

- The current rating system gives a different magnitude for recording the dead or injured. In the eyes of the victims' families, the "value" of a dead or injured person is not different whether the person is an employee, a rescue worker or an individual. For the public, the media and the administration, the distinction has been played down considerably over the last decades. For the technician, this differentiation provides an implicit indication of whether or not the effects of the accident extend beyond the limits of the installation. Simplification of the current system may possibly be considered while excluding the status of the victims.

- Certain accident classification parameters that are rarely or never used may be removed. For example, the proportion of rare or protected vegetal or animal species destroyed is never known. The removal of these parameters would have no consequence in the publication of the severity level disclosed to the public and media.

5.2 – Incidents

× It does not appear possible to cover both incidents and accidents with the same scale (contrary to basic nuclear installations, the two types of events exist in high proportions).

The design of a severity scale based on two types of parameters (potential severity and the number of lines of defence crossed or non-existent) presents significant difficulties for registered agricultural and industrial installations as well as for the transport of dangerous materials inasmuch as there is a vast variety of consequences and their potential level appears difficult to establish in nearly all cases (as opposed to basic nuclear installations whose unique parameter of potential consequences is the effective dose, measured in Sievert). By the same token, in the majority of cases, the fault trees are not established by the operators for the accidents and let alone for the incidents.

× For the moment, the BARPI proposes to further rationalize the exchange of information between the inspectorate and the operators along the following lines:

- ✓ the operator records all incidents, analyses them (with the cause and consequence tree), defines the appropriate corrective measures and follows up their actual implementation. Its "record" enables the danger study to be updated and is maintained at the inspectorate's disposal.

- ✓ The inspectorate requests to be systematically informed of a limited number of incidents, for example those which indicate defects of more than X% of the defence barriers foreseen and those for which the accident could have been avoided using a single line of defence on the path of an event likely to lead to consequences outside the limits of the establishment's premises or to cause the release of a quantity of dangerous material exceeding Y% of the upper SEVESO 2 threshold classification.

Reference to regulations

Article 38 of Decree No. 77-1133 of September 21, 1977 modified, stipulates:

"the operator of an installation subject to licensing or to declaration is required to declare to the Registered Installations Inspectorate as expeditiously as possible the accidents or incidents that have occurred due to the operation of this installation which may harm the interests mentioned in Article 1 of the Act of July 19, 1976.

The operator shall transmit an accident report or, upon request by the Registered Installations Inspectorate, an incident report, to said Inspectorate. The operator shall stipulate the causes of the accident or the incident, the effects on individuals and the environment, the measures taken or foreseen to prevent a similar accident or incident or to mitigate the effects in medium or long term".

Industrial accident severity scale (main criteria)

	1	2	3	4	5	6
human and social consequences						
Total number of deaths: including - employees - external rescue personnel - persons of the public	- - - -	1 1 - -	2 - 5 2 - 5 1 -	6 - 19 6 - 19 2 - 5 1	20 - 49 20 - 49 6 - 19 2 - 5	≥ 50 ≥ 50 ≥ 20 ≥ 6
Total number of injured with hospitalisation ≥ 24 hours: including - employees - external rescue personnel - persons of the public	1 1 1 -	2 - 5 2 - 5 2 - 5 -	6 - 19 6 - 19 6 - 19 1 - 5	20 - 49 20 - 49 20 - 49 6 - 19	50 - 199 50 - 199 50 - 199 20 - 49	≥ 200 ≥ 200 ≥ 200 ≥ 50
Total number of slightly injured cared for on site or with hospitalisation < 24 hours: including - employees - external rescue personnel - persons of the public	1 - 5 1 - 5 1 - 5 -	6 - 19 6 - 19 6 - 19 1 - 5	20 - 49 20 - 49 20 - 49 6 - 19	50 - 199 50 - 199 50 - 199 20 - 49	200 - 999 200 - 999 200 - 999 50 - 199	≥ 1000 ≥ 1000 ≥ 1000 ≥ 200
Total number or homeless or unable to work (outbuildings and work tool damaged…)	-	1 - 5	6 - 19	20 - 99	100 - 499	≥ 500
Number N of residents evacuated or confined in their home > 2 hours x nbr of hours(persons x nbr of hours)	-	N < 500	500 ≤ N < 5 000	5 000 ≤ N < 50 000	50 000 ≤ N < 500 000	N ≥ 500 000
Nbr N of persons without drinking water, electricity, gas, telephone, public transport for more than 2 hours x nbr of hours (persons x hour)	-	N < 1 000	1 000 ≤ N < 10 000	10 000 ≤ N < 100 000	100 000 ≤ N < 1 million	N ≥ 1 million
Number N of persons having undergone extended medical supervision (≥ 3 months after the accident)	-	N < 10	10 ≤ N < 50	50 ≤ N < 200	200 ≤ N < 1 000	N ≥ 1 000
environmental consequences						
Quantity of wild animals killed, injured or rendered unfit for human consumption t)	Q < 0,1	0,1 ≤ Q < 1	1 ≤ Q < 10	10 ≤ Q < 50	50 ≤ Q < 200	Q ≥ 200
Proportion P of rare or protected animal or vegetal species destroyed (or eliminated by biotope damage) in the zone of the accident	P < 0,1 %	0,1% ≤ P < 0,5%	0,5 % ≤ P < 2 %	2 % ≤ P < 10 %	10 % ≤ P < 50 %	P ≥ 50 %
Volume V of water polluted (in m^3)	V < 1000	1000 ≤ V < 10 000	10 000 ≤ V < 0.1	0.1 Million ≤ V< 1 Million	1 Million ≤ V< 10 Million	V ≥ 10 Million
Surface area S of soil or underground water surface requiring cleaning or specific decontamination (in ha)	0,1 ≤ S < 0,5	0,5 ≤ S < 2	2 ≤ S < 10	10 ≤ S < 50	50 ≤ S < 200	S ≥ 200
Length L of water front or water channel requiring cleaning or specific decontamination (in km)	0,1≤ L < 0,5	0,5 ≤ L< 2	2 ≤ L< 10	10 ≤ L < 50	50 ≤ L< 200	L ≥ 200
economic consequences						
Property damage in the establishment (C expressed in millions of € - Reference 93)	0,1 ≤ C < 0,5	0,5 ≤ C < 2	2 ≤ C< 10	10 ≤ C< 50	50 ≤ C < 200	C ≥ 200
The establishment's production losses (C expressed in millions of € - Reference 93)	0,1 ≤ C < 0,5	0,5 ≤ C < 2	2 ≤ C< 10	10 ≤ C< 50	50 ≤ C < 200	C ≥ 200
Property damage or production losses outside the establishment (C expressed in millions of € - Reference 93)	-	0,05 < C < 0,1	0,1 ≤ C < 0,5	0,5 ≤ C < 2	2 ≤ C < 10	C ≥ 10
Cost of cleaning, decontamination or rehabilitation of the environment (expressed in millions of €)	0,01 ≤ C < 0,05	0,05 ≤ C < 0,2	0,2 ≤ C < 1	1 ≤ C < 5	5 ≤ C < 20	C ≥ 20
quantities of dangerous materials						
Quantity Q of substance actually lost or released in relation to the "Seveso" threshold	Q < 0.1%	0.1% ≤ Q < 1%	1% ≤ Q < 10%	10% ≤ Q < 100%	1 to 10 times the threshold	≥ 10 times the threshold
Quantity Q of explosive substance having actually participated in the explosion (equivalent in TNT)	Q < 0.1 t	0.1 t ≤ Q < 1 t	1 t ≤ Q < 5 t	5 t ≤ Q < 50 t	50 t ≤ Q < 500 t	Q ≥ 500 t

Conclusions

Closing speech

IMPEL seminar June, 11th and 12th, 2002

Seminar closing speech

Philippe Lucas
Assistant Head of the Industrial Environment Department.

Following these two days of exchanges and reflective thinking, I would first like to thank you for making this event a success. I would like to extend special thanks to:

- ✓ the DRIRE AQUITAINE for their much appreciated warm welcome,
- ✓ our foreign colleagues who spontaneously accepted to come to Bordeaux to present several accidents,
- ✓ as well as the registered installation inspectors and agents of the Service de l'environnement industriel (SEI) who were able to reserve enough time to prepare a presentation,
- ✓ and to all of the participants who, through their questions and experience, enriched our exchanges.

I would also like to place emphasis on the exceptional clarity of the presentations. Each time, the known or presumed causes were presented thoroughly while making the appropriate technical, organisational or human distinctions. Even if all the questions did not receive a definitive or all-encompassing answer, everyone was able to gauge the interest in sharing feedback.

Without reiterating the wide variety of topics addressed, I would like to go over just a few of them:

- ✓ the silo accidents, whose potential consequences must incite the utmost vigilance to ensure backfitting. This is not yet fully achieved, particularly for the grain installations; the death of an operator in Albert (Somme) reminds us of this.
- ✓ combustible material warehouses, for which the draft ministerial order is nearly finished.
- ✓ the presence of PCB in transformers in installations subject to licensing must lead to their consideration in the danger studies, pending the definitive elimination of these materials as programmed by European directive.
- ✓ the installations using liquid chlorine; the INERIS, the BRTICP and the BARPI will organize a technical seminar on this theme next autumn.
- ✓ the fertilizer warehouses for which feedback on the inspectorate's findings will be established by the SEI in order to better discern what action should be taken. Reworking of French regulations has now begun. During the European seminar

held at ISPRA early in the year, France also proposed to modify the classification of ammonitrates in the SEVESO directive.

- ✓ Of course, the Toulouse accident and its unbearable human consequences including 30 deaths, numerous mutilated, disabled and thousands of injured, was the subject of special development and will keep us busy for still a long time to come.

For a certain number of these sensitive topics, technical workgroups with the DRIRE and the STIIIC were created by the risk department. Field inspectors are invited to participate.

In a more general manner, our action must first be aimed toward installations which harbour a notable energy or toxicity potential that, if released, is likely to lead to human consequences during an accident where rapid kinetics are involved such a an explosion, a fire or the dissemination of toxic materials or even by the insidious diffusion of pathogenic organisms such as Legionella.

The accidents which occurred in these installations confirm the need to maintain a high level of vigilance when examining danger studies and inspecting these installations. In this respect, it is our job to openly develop a set of efficient players guided by the application of the law:

- ✓ Firstly, danger studies must be tailored to the severity of the possible accidents,
- ✓ Recourse to third-party expertise for the installations subject to licensing with public easement (AS) deserves to be generalized,
- ✓ The danger study must lead the inspectorate to request that the operator provide improvement proposals,
- ✓ The inspectorate's action must first bear on actions at the source (substitution, reducing quantities…),
- ✓ And finally, the inspectorate must not remain isolated in the face of the difficulties encountered, particularly when they result from inherited ones.

Of course, feedback must for a central role in this approach. This point was highlighted considerably in the parliamentary committee's report following the Toulouse catastrophe. Today, nobody disputes this necessity. In addition, several professional organisations (UIC, GESIP…) have initiated reflective thinking on this topic.

Also, it is the responsibility of the Registered Installations Inspectorate to consider the analysis of passed accidents as part of its daily duties:

- ✓ Firstly by ensuring that the mandatory declaration of accidents and certain incidents is respected,
- ✓ Beyond accidents, by strongly urging operators to record the incidents, analyse them and to follow-up the actual implementation of corrective measures; in this respect, it is an important factor in the ongoing improvement of the safety of installations.

- ✓ All significant accident or incident must be a serious motive in the operator's reexamination of the danger study, as its demonstration of safety had in fact failed.

For the Inspectorate, these points are concretely translated:

- ✓ by the input of information into the accident database in order to benefit the entire organization,
- ✓ in the handling of danger studies in which the accidentology of the site or the activity sector must be treated very seriously. We must ensure that the danger study is not a theoretical exercise void of realities.
- ✓ in the on-site inspections where the recording of failures and the implementation of corrective measures must be able to be verified.

These aspects often turn out to be essential when it concerns processing an extension authorisation request. Conversely, when accidents or incidents occur, the fact that they are described or covered by the danger study must be examined.

In conclusion, I would like to mention that the BARPI remains at the disposal of all the inspectors in providing its assistance in this field. Beyond the consultation of the ARIA's internet site which contains a number of help documents, the BARPI can conduct accidentology research upon request. I would also like to remind you that it does this throughout the entire year for operators in an attempt to assist them in reducing risks.

Of course, sharing feedback data in order to benefit the various member states of the European Union represents an undeniable element of progress. As such, the Enschede accident motivated classification modification proposals, in the same manner as the Toulouse explosion induced reflective thinking on new changes in the risk prevention mechanism. For the Inspectorate, the severity of the consequences of these accidents represents an urgent reason to maintain unrelenting vigilance and efficiency in an unfavorable field where prior knowledge is rarely defined.

I would like to again thank you for your contribution in making this seminar a success and hope that our work will be useful to you in performing your vital tasks.

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