Explosion / Fire
Chipboard
Silos
Dust
Risk analysis
Organisation
Uncoupling
Thermal imaging camera
Vents

Explosion of a wood chip refiner and fire

January 20 and 25, 2005

Corbenay – [Haute-Saône] France

THE INSTALLATIONS CONCERNED

The site

The chipboard manufacturing plant, located in Corbenay, in the region of Haute-Saône, was set up in 1969 to produce chipboards for the furniture industry. The company then diversified to manufacture specific products for hardware stores. The main activities include :

- ✓ Furniture manufacturing,
- ✓ Specific products intended for the general public via hardware stores.

Since 1981, the company has been a 99.9%-owned subsidiary of a group, which is the leading furniture manufacturer in France and its primary customer.

In 2006, the plant manufactured 430,000 m^3 of chipboard produced from 542,000 tons of wood.

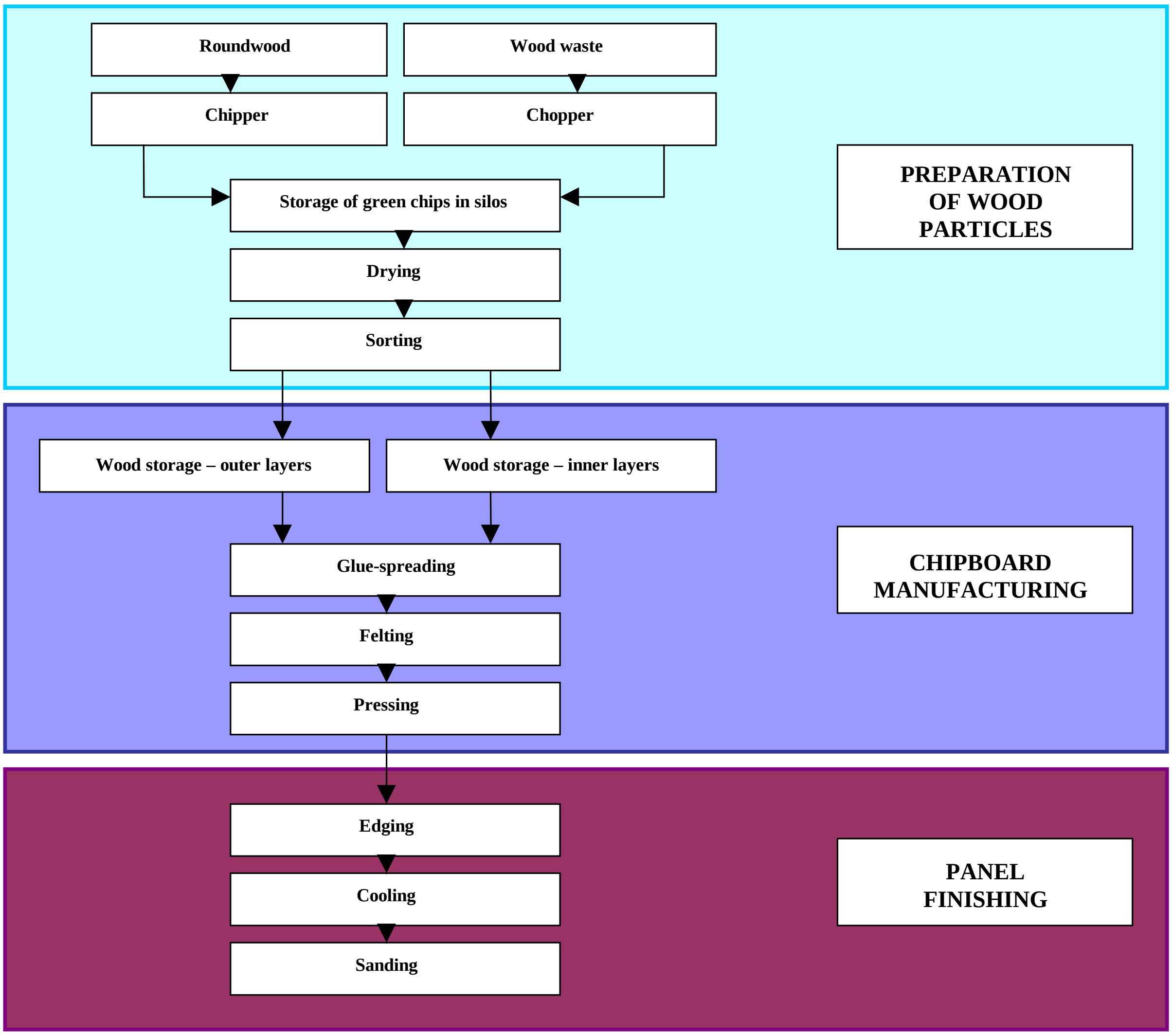
The plant employs 200 persons and posts sales of 75M euros.

This plant is a "classified" installation whose operation is subject to authorisation governed by the Prefectoral order of March 8, 2005.

The sector involved:

Chipboard is produced by hot-pressing a mixture of wood chips and glue. The wood chips are obtained by chipping up green wood, which is then dried and sorted. The chipboards are then produced through a series of glue-spreading and pressing operations.

The manufacturing process can be illustrated as follows:



The accident occurred in the wood chip preparation sector, after the chips had been dried.

Photo Drire France-Comté

THE ACCIDENTS, THEIR COURSE, EFFECTS AND CONSEQUENCES

The accident of January 20, 2005:

January 20, 2005 at 2.58 am, at part of the refiner breaks (the mill grinder that transforms large dry chips into small dry chips). The resulting spray of sparks is carried along by the suction and ventilation equipment.

At 2.58’02’’, the refiner's cyclone explodes. The force of the explosion causes it to rupture, despite the presence and operation of the vents. The fire spreads to all the adjoining installations: redler conveyors, suction equipment, air graders, sorters, dry silos, etc.

At 2.58’07’’, an explosion occurs in the suction equipment causing the vents to open.

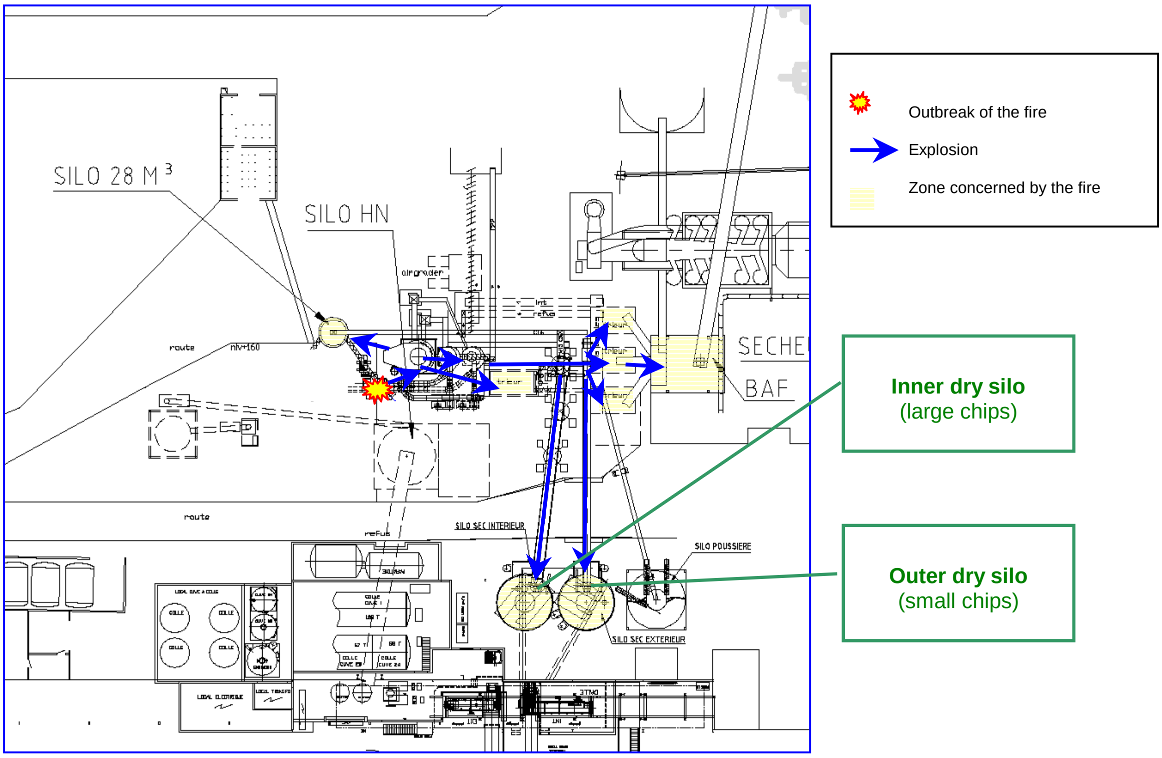
At 2.58’10’’, the "inner" and "outer" dry silos explode. The fire reaches the refiner silo, cyclones, cyclofilters and suction equipment, sorters, fire boxes and the "inner" and "outer" dry silos.

At 5.00 am, the fire was brought under control by the plant's firemen, and the public fire protection departments.

The following day at 8.30 am, the silos containing the dry chips were emptied to ensure that no embers remained.

Production operations resumed at 10.30 pm.

Schematic diagram of the chronology of explosions on January 20, 2005



The consequences:

The accident had no human casualties.

Material losses were evaluated at 250,000 euros, attributed to the replacement of the refiner (at the origin of the accident), and the damage caused to the sorter and cyclofilter. The silo and cyclofilter vents also have to be replaced. The plant also reported 750,000 euros in production losses due to the production line being shut down for two days.

The wood chips in the damaged silos were used in one of the plant's boilers. The fire fighting water was collected in a retaining pond and analysed before being released into the natural environment.

Photo Drire Franche-Comté

European scale of industrial accidents

By applying the rating rules of the 18 parameters of the scale made official in February 1994 by the Committee of Competent Authorities of the Member States which oversees the application of the 'SEVESO' directive, this first accident can be characterised by the following 4 indices, based on the information available.

The parameters that comprise these indices and the corresponding rating method are available at the following address: http://www.aria.ecologie.gouv.fr

The level 1 rating of the "Dangerous materials released" index characterises the explosion that occurred (parameter Q2 : the quantity of explosive substances was estimated to be < 100 kg of TNT).

The index relative to the economic consequences is rated level 2 due to the production losses that were evaluated at 750,000 € (parameter €16).

The accident of January 25, 2005:

On January 25, 2005 at 6.10 am, an explosion followed by fire occurred inside the "inner" dry chip silo. The silo's vents opened, thus limiting the effects of the shock wave.

The production crew and the plant's firemen triggered the manual water injection system inside and outside the dry silos as well as inside the redler conveyors supplying the "inner" silo.

The firemen set up a water nozzle upon their arrival to cool down the silo. A second explosion occurred during the cooling operations.

This explosion caused the fire to spread to the building behind the silos.

The fire was quickly brought under control. Production operations resumed in the evening after the two "inner" and "outer" dry chip silos had been emptied.

The consequences:

The consequences were minimal in comparison to the first accident. The production shut-down was limited to 14 hours; the storage silo's explosion vents and electrical cable that melted during the fire must be replaced.

Operating losses were evaluated at approximately 45,000 euros.

Photo Drire Franche-Comté

European scale of industrial accidents

By applying the rating rules of the 18 parameters of the scale made official in February 1994 by the Committee of Competent Authorities of the Member States which oversees the application of the 'SEVESO' directive, the second accident can be characterised by the following 4 indices, based on the information available.

Dangerous materials released	■	□	□	□	□	□
Human and social consequences	□	□	□	□	□	□
Environemental consequences	□	□	□	□	□	□
Economic consequences	€	□	□	□	□	□	□

The parameters that comprise these indices and the corresponding rating method are available at the following address : http://www.aria.ecologie.gouv.fr

The level 1 rating of the "dangerous materials released" index characterises the explosion that occurred (parameter Q2 : the quantity of explosive substances was estimated to be < 100 kg of TNT).

ORIGIN, CAUSES AND CIRCUMSTANCES OF THE ACCIDENTS

The cause of the first accident was easily determined during the examination of the refiner. The breakage of the metal part created sparks that caused three explosions and the subsequent fire. The various safety devices installed by the operator were triggered :

- The vents on the silos and the cyclofilter opened, thus limiting the consequences of the explosions. The cyclofilter, however, had been torn open.
- The spark detection system coupled to the water injection points had reached alert level number 2, injecting water on a permanent basis.
- The sounding of the alarm in the control room enabled the company's firemen to intervene in less than 10 minutes. The internal response teams are organised in synergy with the firemen of the neighbouring company, a subsidiary of the same group. Furthermore, the operator had developed an emergency response manual outlining the emergency procedures to be followed in the event of an accident.
- The silos' sprinkler system was put into operation by a manual valve.
- Immediately following the explosion, the burners were shut down thus securing the chip zone, the driers were reversed to stop the flow of dry chips and thus stop the supply of fuel.

The cause of the second accident was attributed to embers that had remained in the bottom of the "inner" dry chip silo, following the fire of January 20, 2005. Smouldering embers had been trapped under a very heavy bell-shaped piece of equipment, the silo's extraction unit. The fire had been smouldering for 4 days. In the morning of January 25, 2005, the silo's level had dropped until it was empty and the embers ignited the cell's dusty atmosphere, resulting in an explosion. The cause of the second explosion, which occurred while the installations were being cooled down (accident of January 25), was not determined. Several hypotheses were submitted : BLEVE, water gases, dust particles in suspension, etc.?

ACTION TAKEN

The operator implemented several protective measures following the first accident :

- the refining installation was uncoupled from the rest of the installations. As a result, a cyclofilter dedicated to the refiner was installed and a fire box was added.
- the emergency response procedure, comparable to an internal contingency plan, was submitted to evaluation by a third party.
- the rupture of the cyclofilter, even though vents had been installed, led the operator to check their dimensions.

As for the second accident, failing to check for embers under the dry chip silo's extraction unit is the reason behind the accident. The following improvements were recommended :

- Modification of procedures dealing with accident intervention and post-accident silo restart operations, with the addition of the verification of the extraction unit.
- the purchase of a thermal-imaging camera to check installations after a fire.
- call upon a third-party expert to inspect the installations, the safety systems and the intervention procedures. The main conclusions of the third-party inspection are presented below.

LESSONS LEARNT

The chipboard industry is subject to fire and explosion hazards, considering the manufacturing processes used, the presence of large quantities of combustible materials and the production of dust.

The safety measures implemented at the site, including spark detection equipment coupled with water injection systems, proved their efficiency. Feedback from the detections recorded by these systems will certainly reduce the frequency of fires and explosion.

The installation of uncoupling systems, separating the installations in to distinct units, prevents an explosion or fire from spreading to other equipment. The most recent one implemented corresponds to the installations downstream from the refiner vis à vis other cyclofilters and dry chip silos (following the accident of January 20, 2005).

The third-party inspection opened up avenues of improvement in terms of site safety, with namely:

- creation of an Internal Contingency Plan,
- the installation of vents on the buffer storage systems,
- the modification of safety instructions,
- the installation of a new flooding device in sorter T4,
- protection of the manual valves enabling the sorters to be sprayed down.

Toxic releases
Surface treatment
Cyanides
Equipment (failures)
Organisation
Human factor
Intervention / Rescue
Fish mortality

Polluted effluents released into the Cher River

September 14, 2005

Saint Victor – [Allier] France

THE INSTALLATIONS CONCERNED

The site

The plant, located in the town of Saint Victor in the French region of Allier, was built in 1994 and designed to perform surface treatment operations on metal parts, particularly various grades of zinc plating on automobile parts. In 2005, the plant employed 34 persons and posted sales of 1.6 M euros.

The plant consists of a 3,530-m² covered building housing 2 surface treatment lines, a rack system and a bulk system. Both systems represent a total bath volume of 196 m^3.

Effluents from the surface treatment operation are treated in an internal detoxication station before being released into the Cher. This physico-chemical station includes a dechromatation, decyanidation, neutralisation and flocculation reactor and 2 filter presses designed to recover the metal hydroxides in the form of sludge and to reintroduce the filtrate (the "juice" extracted from pressing the flocculated effluent) into the top of the neutralisation stage.

This plant is a classified installation whose operation is authorised by the prefectoral order dated April 7th, 2005.


Photo DRIRE Auvergne

The unit concerned:

The metal treatment line concerned is used for the bulk treatment (in barrels) of automobile parts. It includes : zinc plating (galvanising), nickel plating and alkaline cyanide copper plating.

The accident was caused by a leak which occurred during a pumping operation on the treatment line's catchpit. It also involved the internal detoxication station used to treat industrial effluents.

THE ACCIDENT, ITS COURSE, EFFECTS AND CONSEQUENCES

The accident:


Photo DRIRE Auvergne

On Wednesday, September 14th, 2005 around 8.15 pm, a technician discovered a leak on the multiple treatment line slightly before the end of his shift; a filter outlet pipe on a tank containing alkaline copper cyanide had become disconnected causing the bath (approx. 1,000 l) to flow into the concrete catchpit.

The technician **immediately** informed the laboratory/environment supervisor at his home. The supervisor ordered that the surface treatment line be stopped (including the shut down of the heating system) and that the liquid be left in the catchpit. The incident was recorded in the logbook used for this purpose.

On Thursday, September 15th, another technician, with 25 years experience in surface treatment, began his shift at **5 am**. The technician observed that the multiple surface treatment line's catchpit was full of liquid, and took note of the previous day's incident entered in the logbook. He decided to use a mobile pump to transfer the product into the tank containing concentrated alkaline cyanide effluents. During normal operation, an internal system recycles this bath which neutralises the cyanides before they are released into the natural environment.

At 8 am, the laboratory/environment supervisor discussed the incident of the previous day with this technician who explained that he had pumped the liquid from the surface treatment line's catchpit into the tank reserved for concentrated alkaline cyanide effluents. Then, as he does every morning around **9 am**, he read the pollutant concentration levels at the plant's final waste release point (by colorimetric analysis).

He noted that the cyanide content was abnormally high : above 2mg/l, with a limit value set at 0.1 mg/l. He **immediately** decided to close the final waste valve and shut off the water supplies to the surface treatment lines. The final waste was directed to the safety tank designed for this purpose.

After consulting the technician once again, the laboratory/environment supervisor realised that the liquid in the catchpit had been pumped into the chromic rinse tank instead of into the tank reserved for concentrated alkaline cyanide effluents.

Throughout the day of **Thursday, September 15th, 2005,** the laboratory/environment supervisor decontaminated the polluted reactors with sodium hypochlorite and transferred the water into the safety tank.

Cleaning operations on the chromate removal system continued throughout the entire day **of September 15th, 2005**.

On Friday, September 16th, 2005 at 8 am, the laboratory/environment supervisor performed a cyanide analysis on the outlet of the dechromatation and neutralisation system: no abnormal readings were noted. The internal treatment station was thus put back into operation.

Tests were taken hourly up to **11 am**, confirming the absence of cyanide.

At 12 pm, the filter presses used for sludge recovery were placed back into operation.

At around 3.30 pm, residents living along the Cher informed the Vallon-en-Sully *gendarmerie* of dead fish in the river. The National Commission for Fishing was informed and arrived at the site around **4.30 pm**. The inquiry to determine the origin of the fish mortality was rapidly directed toward the pipe releasing the surface treatment company's effluent into the Cher River.

At around 5 pm, the laboratory/environment supervisor was contacted by telephone at his home and informed of the findings. He returned to the site and analysed the industrial wastewater final release point : he again recorded the presence of cyanide. He immediately shut down the water supply to the detoxication station and the final waste release point. After analysing this new incident of pollution, the laboratory/environment supervisor determined that the sludge treatment operation caused the cyanides contained in the filter presses to be released.

All production operations were suspended **at 6 pm**.

On Monday, September 19th, 2005, the laboratory/environment supervisor cleaned the "sludge recovery" system, the neutralisation system, the flocculation chamber and the settling tank, as these reactors had become polluted by the cyanide after the sludge was recovered on the filter presses on **Friday, September 16, 2005**.

On Tuesday, September 20, 2005, the detoxication station was re-commissioned and checks were performed throughout the day : no trace of pollution was detected. All parameters of the effluents released were below the authorised limit, in compliance with the prefectoral order dated April 7, 2005.

The consequences:

Despite risks involving the release of hydrocyanic acid during the transfer of cyanide effluents in a treatment unit which may contain acid effluents, none of the technicians were injured in the accident.

With regards to the installation :

✓ the surface treatment line was not damaged,

✓ some elements of the internal detoxication station were polluted but they were able to be returned to operational condition rather quickly.

Outside the site:

✓ according to the plant operator's estimate, approximately 20 m^3 of effluents containing cyanides at a concentration of 3 to 5 g/l was released into the Cher River,

✓ fish mortality (approximately 2.5 tons) was reported by agents of the National Commission for Fishing,

✓ no health problems were reported by residents living near the site or near the point where the effluents were released into the Cher.

Photo DRIRE Auvergne

European scale of industrial accidents

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The "Dangerous materials released" index received a rating of 2 as, according to the estimate, 70 kg of cyanide was released, which represents 0.35% of the SEVESO Directive's upper threshold for T^+ products (20t).

The level 3 of the "Environmental consequences" index is attributed to the 2.5 t of fish that were killed (parameter Env 10).

In addition, the lack of quantified data does not allow the "economic consequences" index to be determined.

ORIGIN, CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

The investigations conducted during the accident, on the products and the process helped determine the causes of the accident rather quickly.

The release of pollutants into the river can be attributed to organisational and human errors:

✓ a technician transferred liquid containing dangerous products (alkaline copper cyanide) into a rinsing tank whose contents were not clearly and legibly indicated,

✓ as this rinsing tank was connected to a chromium detoxication treatment system, the cyanides were not eliminated and were thus released into the Cher at a concentration well above the authorised level,

✓ the lack of written instructions regarding the actions to be taken in the case of a malfunction of the surface treatment line lead the technician to rely on his own initiative, which proved to be unfortunate,

✓ after having detected non-compliant releases of effluent, the operator stopped its operations and cleaned the treatment installations. The cleaning operations were in fact incomplete and the cyanides which remained in a portion of the industrial wastewater treatment facility (filter press) were responsible for a second release of polluted effluent two days later.

ACTION TAKEN

The operator was formally notified that it must comply with the requirements applicable to the operation of its installations, and as stipulated in the authorisation order of April 7, 2005, **within 2 months**:

"✓ the operations involving dangerous handling operations and the operation of installations in which a malfunction could result in prejudicial consequences for the surrounding area and the environment... shall be the subject of written procedures.

✓ without prejudice to the regulatory provisions concerning worker hygiene and safety, safety instructions were drawn up and permanently displayed in the workshop. In particularly, these instructions specify :

✓ the intervention procedures in the event of abnormal or accidental situations".

In the days following the accident, the operator initiated the following actions within its facility :

✓ the identification of the tanks was improved on the surface treatment lines and the associated piping,

✓ all pumping operations performed by technicians must be monitored by a supervisor,

✓ increasing technician awareness through the creation of new procedures and posters.

These measures were established and implemented in **January 2006**.

LESSONS LEARNT

A process, even through performed on a regular basis, may still be a potential source of accidents.

Following the investigations conducted after the accident, it was noted that the operation of a surface treatment line requires that the following conditions be controlled, as a minimum:

✓ the formalisation of documents stipulating the action to be taken in case of an atypical situation,

✓ information and training of technicians in the use of these documents through regular situational exercises.

Spill of heavy fuel oil in an oil terminal

21 June, 2003

Oil harbour of Göteborg

Sweden

Suface water contamination
Flammable liquids farm
Storage tank
Manhole
Heavy fuel oil
Maintenance
Procedures

THE INSTALLATIONS IN QUESTION

The accident happened at an oil terminal in the oil harbour of Göteborg, Sweden. The oil terminal is one of several oil terminals and oil storage companies in the oil harbour. It handles mainly petroleum products, of category 1, 2 and 3 inflammable liquids. It has a storage capacity of approximately 700 000 cbm, in 160 storage tanks and a few rock caverns, and is classified as a "Seveso II" company at the higher level according to the "Seveso II" European directive.

The oil harbour is located in the port of Göteborg at the estuary of the river Göta Älv at the west coast of Sweden. The oil harbour is responsible for the common service systems outside each oil terminal. The rain water drainage systems from the oil terminals end up in the harbour rain water drainage system. The rain water passes a contol basin, K1, a gravity separator and goes through a tunnel and a caisson to the estuary of the river Göta Älv in the open harbour.

THE ACCIDENT, ITS BEHAVIOUR, ITS EFFECTS AND CONSEQUENCES

The accident

At Saturday night 21 June, on Midsummer Eve holiday in Sweden, there was a spill of 328 metric tons of heavy fuel oil in the oil terminal during discharge of the product from a ship vessel to a storage tank. Approximately 50 tons of the heavy fuel oil reached the recipient. The oil passed the rain water drainage system, reached the open sea and contaminated beaches and seashores in the coast archipelago outside Göteborg.

On Friday 20 June 22.30 p.m., after a maintenance work, the discharge of heavy fuel oil from a ship vessel to storage tank No 375 was started by two operators. At the same time discharging to tank No 304 was ongoing.

At Saturday 21 June 00.30 a.m. when reading the level indicator the operators noticed that the level in tank No 375 did not continue to increase. The operators tried to increase the flow to tank No 375 by reducing the valve to tank No 304.

At 01.52 a.m. the operators discovered that the manhole of tank No 375 was open and oil was flowing out to the ground outside the tank and to a neighbour company in the harbour. The operators closed the valve to tank No 375 and also the manhole.

Oil spill outside tank No 375 was spread on the surrounding ground. Under the pipe rack (in the left) there was a rain water drainage sewer.

Photo: the insurance company (21 June 2003).

At 02.00 a.m. the terminal manager and a local cleaning company were informed about the accident.

The terminal manager arrived at 02.30 a.m., took over and informed the harbour service.

At 03.00 a.m. the cleaning operation started.

The ground at a neighbour company was filled with oil.
Photo: the insurance company.

At 03.15 a.m. the harbour service staff inspected the harbour rain water drainage system and closed the outlet from the rain water drainage system basin K1. The basin K1 was full of oil.

At 04.15 a.m. oil booms were placed in the open port harbour at the outlet from the rain water drainage system. Oil lumps could be seen in the rain water drainage system outlet caisson and there was oil in the skimmer.

Cleaning procedures continued during Saturday and the authorities were informed about the accident. The Fire Brigade was informed on Saturday morning and they did not notice any oil in the open sea. The first indication of large environmental effects of the oil spill came on Sunday morning 22 June when the Swedish Coast Guard noticed oil on the opposite side of the river estuary.

The consequences

Human effects.

- ✓ There were no personal injuries.

Material effects.

- ✓ The spill resulted in a contaminated area in the harbour of approximately 2000 – 2500 sq metres including the oil terminal and two neighbour company sites.
- ✓ The heavy fuel oil contaminated the harbour open rain water drainage system and the harbour oil contaminated drainage water system.
- ✓ Fishermen tools were contaminated and hundreds of yachts in several Göteborg harbours were contaminated too.

Environmental effects.

- ✓ Approximately 50 metric tons of the spilled heavy fuel oil reached the recipient.
- ✓ The spill resulted in environmental damage of a wide area at the coast archipelago outside Göteborg. The sea water was contaminated with high polyaromatic hydrocarbon (PAH) containing oil, beaches were contaminated, a small number of sea birds died and many birds were contaminated.
- ✓ The emitted heavy fuel oil contained high amounts of toxic PAH´s. In July 2003 significantly high levels of PAH metabolites were found in eelpouts caught in the area close to Fiskebäck, south of Göteborg. In November 2003 the levels of PAH metabolites in eelpouts caught in the same area were not higher than in eelpouts from other areas. The PAH containing oil had severe local effects shortly after the spillage but most of the area seemed to be recovered in November 2003.

The area outlined on the map shows how the oil was spread in the coast archipelago outside Göteborg. The oil spread in two main directions, south and west from the harbour of Göteborg.

Economic consequences.

- ✓ The total economic loss for the oil terminal was approximately 2,7 millions of EUR.

European scale of industrial accidents

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The irrelevance of the index concerning the quantity of dangerous materials released (in the meaning of the SEVESO Directive parameter Q1) is based on Concawe classification recommendations for heavy fuel oils, risk phrases R52/R53, which is not classified as a Seveso substance. The heavy fuel oil which was released was not classified with risk phrases and therefore it is not clear if it was a Seveso substance or not.

The level 4 of environmental consequences is due to the length of the water front which was approximately 20 km (parameter Env14). There were also consequences of contaminated surface of soil at a level 1, approximateley 0,2-0,25 ha. (parameter Env13).

The level 4 given to the economic consequences is due to the high cost of the loss of 328 tons of product and to cleaning and decontaminations costs of total 25 million Swedish kronor, i.e. almost 2.7 million euros (parameter €16 and €18).

There were no noticeable consequences regarding human aspects.

ORIGIN, CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

The direct cause of the accident was the discharging of oil to a storage tank with an open manhole. The major latent factors which contibuted to the accident with the open manhole were :

- ✓ Communication. The accident happened after a shift take over after a maintenance work on the tank, and there was not enough information and communication between the two shifts.
- ✓ Operational procedures. Only a common practice procedure was available. Detailed check lists were missing for tank preparation and start-up process. Activities were carried out based on experience.
- ✓ Existing operational procedures were not followed and no double checks were made. The experienced operators did not double check the equipment before start-up. According to normal operation routine the operators should have done a control round out at the tank after the discharge had started. This check was not done.

Due to the Midsummer Eve holiday there were less personnel in the oil terminal than usual. The shift foreman was on vacation and the terminal manager had taken over the foreman’s work.

The wide consequences of the accident were caused by a number of parameters :

- ✓ Wrong reaction. When the level in tank No 375 did not continue to increase the operators assumed there was some problem with the incoming flow. The operators did not go out and inspect the tank. Instead they increased the flow to tank No 375 by closing the valve to tank No 304. The oil was flowing out of the open manhole during one and a half hour before the operators went out to inspect the tank and discovered the open manhole.
- ✓ The normal emergency routines were not followed. According to harbour emergency plan, the harbour should be informed directly. It took more than one hour before the harbour staff was informed. When the harbour was informed the harbour staff inspected the rain water drainage basin K1 and noticed that it was filled with oil. Then the outlet of basin K1 was closed, too late.
- ✓ Cleaning activities started up early after the accident by the staff of the oil terminal. The behaviour of the operators and the terminal manager indicate that they were very stressed because of the accident. The Midsummer Eve holiday would also have some impact since the operating staff did not want to disturb people on vacation.
- ✓ The oil terminal is an old installation and therefore there were no bunds around the tank area where the accident occurred. The spilled oil was spread over a wide area on the surrounding ground. In a low point under a pipe rack close to the storage tank there was a rain water drainage sewer. A huge amount of heavy fuel oil reached the harbour rain water drainage system.
- ✓ There were no valves in the oil terminal rain water drainage system and therefore no possibility to shut off the contaminated part of the rain water drainage system.
- ✓ The density of this heavy fuel oil was higher than the density of water. The rain water drainage system is designed for oils lighter than water, based on gravity separators. There were no oil alarms installed in the rain water drainage system. The oil could not be seen on the surface in the open port and there were no specific routines for handling this kind of heavy fuel oil product.
- ✓ The booms that were placed in the open port harbour were not designed for heavy products. The heavy fuel oil formed clusters which were later detected between different layers of water where the river and the salt sea water meets, at 1-3 meters below the water surface in the river outside the harbour. Oil clusters were detected 2-10 meters below the surface in the sea south of Göteborg.

- ✓ The heavy fuel oil was probably mixed with lighter high aromatic oil and therefore the oil did not behave as expected. This heavy fuel oil formed clusters in the water and were spread over a wide area in the coast archipelago. The clusters dispersed and oil were detected on the sea water surface and on several beaches and harbours outside of Göteborg.

The oil formed clusters that did not float on the water. The diameter of the clusters was 3 to 10 centimetres. Photo: Swedish Coast Guard.

ACTIONS TAKEN

The accident occurred under normal operations, discharging of product from a ship vessel to a storage tank, and under normal conditions. The investigation team found five critical areas which were considered as relevant for actions:

- ✓ Operational procedures
- ✓ Emergency response
- ✓ Organisational related areas
- ✓ Communication
- ✓ Design

1. Operational procedures. Detailed procedures have been implemented for following operations:

- ✓ Detailed check list for shut down and preparation of equipment before start-up. Double checks between maintenace department and operating department.
- ✓ Detailed procedures for preparation of pump ways including all used pipes and tanks.
- ✓ One operator shall always be out at the tank at start of discharge until the tank level is above the manhole and above pipe connections and valves at the bottom of the tank.
- ✓ More routines and focus of the tank level increase rate have been implemented.
- ✓ A new routine for handling of heavy oil products has been implemented in the harbour system. The oil terminals have to inform the oil harbour staff before the arrival of ships with heavy oil products.
- ✓ Routines and procedures for work permit have been reviewed and improved.

2. Emergency response. The accident made it clear that the terminal staff did not fully understand what actions they were supposed to take in case of an emergency situation.

- ✓ The emergency plans of the oil harbour and the Oil terminal have been improved.
- ✓ A program for “Emergency response“ training is being implemented in the oil harbour together with the different oil terminals.
- ✓ The function of the tank level indication system has been clarified.

3. Organisational related areas. The accident showed that the operators had a tendency to use short cuts if possible. This behaviour indicated that there was a lack of risk and safety awareness in the oil terminal organisation.

- ✓ A yearly schedule for operator training has been implemented at the oil terminal.
- ✓ “Safety observation rounds” have been implemented at the oil terminal to verify safety awareness and that the operators work according to the procedures.
- ✓ The project “Safe Harbour” has been started in the oil harbour together with the different oil terminals. The project consists of 12 action areas of which some are described in this report.
- ✓ Different competence levels for all workers in the harbour have been defined and a safety course and “green card” for work in the harbour have been implemented.
- ✓ The involved terminal manager was replaced and lost his managing position. The involved operators were placed on daytime work after the accident. The CEO of the oil terminal lost his job due to the accident.

4. Communication.

- ✓ Routines for shift take over have been improved with a “shift take over checklist”.
- ✓ Emergency routines have been clarified at the oil terminal and at the oil harbour.

5. Design. The harbour systems are designed based on the principle that oil is lighter than water. The tank installations in the harbour are old and tank bunds are missing or are not sufficient in many cases. The following improvments have been made:

- ✓ The sewer under the pipe rack in the oil terminal has been connected to the harbour oil contaminated drainage water system and is no longer connected to the rain water drainage system.
- ✓ Oil alarms have been installed in the rain water drainage basins. In each basin there is now one oil alarm located at the surface and one oil alarm located in the bottom of the basin.
- ✓ Installation of oil alarm in the rain water drainage system at each oil terminal has been started.
- ✓ Installation of shut off valve of the rain water system at each oil terminal has been started.

The status of the storage tank bunds in the harbour is discussed and there will be improvements in the future.

LESSONS LEARNT

Lessons learnt from this accident include:

- ✓ The human factor has to be considered during design of process systems, operational procedures and check systems. There is always a possibility that routines will not be followed.
- ✓ The handling of heavy oil products in oil harbours has to be considered in safety reviews. Adjustments of system designs and operational procedures may be necessary for a safe handling of heavy oils.
- ✓ The characteristics of the heavy oil products have to be communicated to all persons involved.
- ✓ Safety awareness, frequent training of emergency plans and operational trainings are very important to avoid this kind of accidents.

Environmental consequences of the spill of heavy fuel oil in the oil harbour.

Photos: Stefan Larsson, West Water enterprise.

Refinery

Aromatic extraction unit

Distillates (vacuum)

Thermcouple well

Works

Sub-contracting

Safety management svstem

Fire in an aromatic extraction unit in a refinery

April 21, 2006

Notre-Dame de Gravenchon – [Haute-Normandie] – France

THE INSTALLATIONS IN QUESTION

The site

For more than 60 years, the refinery has been located on the banks of the Seine in the Port-Jérôme industrial estate, within the commune of Notre-Dame de Gravenchon. The plant transforms crude oil into fuel (LPG, petrol, diesel fuel and kerosene), heating oils, bitumen and oils. The establishment includes all the conventional petroleum processing units (atmospheric distillation, vacuum distillation, catalytic cracker, catalytic reforming, isomerisation, and alkylation).

The unit concerned

The unit involved in the accident is an aromatic extraction unit which uses NMP solvent (N-methyl-2-pyrrolidone, formula: C_5H_9NO). It is an oil processing unit based on vacuum distillation (distillates). The oils are processed oils with solvent in order to selectively extract certain compounds and thereby improve viscosity, colour, oxidation resistance and the lubricants' emulsion tendency.

The contact between the distillate and the solvent takes place in a counter current circulation system in a liquid/liquid extraction column in proportions and at a temperature which varies according to the nature of the distillate and the desired viscosity index. Two non-miscible phases form by gravity in the extraction tower: the "mixed raffinate", paraffin-based by nature and containing a small amount of solvent (10 to 20%), collected at the top of the column; "mixed extract", rich in solvent (85 to 95%) containing components that are eliminated and collected at the base of the tower.

After extraction and prior to storage, the raffinate and the extract are stripped of nitrogen to eliminate any traces of solvent.

The section of the unit involved in the incident is that involved in stripping the raffinate.

THE ACCIDENT, ITS BEHAVIOUR, EFFECTS AND CONSEQUENCES

Context

After a major shutdown for regulatory inspection and work, the extraction unit was placed back into service on Tuesday, April 19th, 2006. Before being placed back into production, the unit was in recirculation phase and up to temperature (320°C / 3.5 bar) when the fire broke out.

The accident

April 21, 2006 at 10.15 am: a fire was reported by an employee of an external company working in a structure of the extraction unit.

At 10.20 am: The unit's fixed firefighting means were manned by the operators pending the arrival of the mobile units: cooling and protection of the structures.

From 10.22 to 10.52 am: The mobile and fixed firefighting resources on the extraction unit were put into action (foam truck, foam nozzles, …).

At 10.40 am: The Internal Contingency Plan is put into motion.

At 10.56 am: The extraction tower and ancillary units decompressed and liquid inventories reduced to a minimum.

At 11.00 am: The fire was put out but structural cooling operations continued.

At 12.20 pm: The product leak is located (bottom line of the raffinate stripping tower) and continued spraying of the product leak.

At 1.25 pm: The internal contingency plan is lifted (prevention ensured by operators with the portable water canon).

At 3.00 pm: End of operations.

The fire was not sustained and remained localised in the raffinate stripping tower. The flames were quite high (in the order of 15 m), followed by decreasing and recovery periods.

Consequences:

The accident had no human consequences. The environmental impact was limited to smoke released by the fire. The liquid effluents generated by the firefighting operations (firefighting water, foam blanket…) were directed to a catch tank and no increase in pollution was noted in the Seine on the day of the incident. The release standards were respected.

On the equipment level, the following was established after the fire:

- Several main circuits were exposed to the flames, notably:
  - ❑ the bottom line of the raffinate stripping tower,
  - ❑ the transfer line between one of the two extract reheating ovens and the first nitrogen stripping column,
  - ❑ the line supporting the raffinate supply control valve from the extraction tower to the raffinate stripping column.
- The fire-resistant concrete protecting the skirts around the stripping and extraction towers received only superficial damage.
- The framework elements trapped in the fire were not deformed, except for two supporting beams.
- The aluminium sheeting covering the heat insulation of certain circuits were partially melted.
- Approximately 70 electrical and instrumentation cables were damaged by the fire.
- The junction boxes were not harmed in the fire (paint still intact).
- The heat lagging protected the metal enclosures of the equipment and piping from the fire.
- The scaffolding installed in the zone and engulfed in the flames remained intact, except for a single element whose tubing was seriously deformed and whose wood planks fuelled the fire.

It should be noted that the property damage remained essentially within the unit.

European scale of industrial accidents

By applying the rating rules of the 18 parameters of the scale made official in February 1994 by the Committee of Competent Authorities of the Member States which oversees the application of the 'SEVESO' directive, the accident can be characterised by the following 4 indices, based on the information available.

The parameters that comprise these indices and the corresponding rating method are available at the following address: http://www.aria.ecologie.gouv.fr.

The "dangerous materials released" is ranked 1 as 1.4 tons of raffinate (easily flammable liquid as per the Seveso Directive, Appendix I, part II) was released during the accident (parameter Q1).

The "economic consequences" index is rated 2 as the economic impact of the incident was calculated to be approximately 1 million euros in production losses, with property damage being evaluated at less than 40 k€ (parameter € 16).

The accident had no human or significant environmental consequences. The liquid effluents generated during the fire were recovered and processed in one of the refinery's treatment stations (in particular, no dangerous product was released into the Seine).

ORIGINE, CAUSES AND CIRCONSTANCES OF THE ACCIDENT

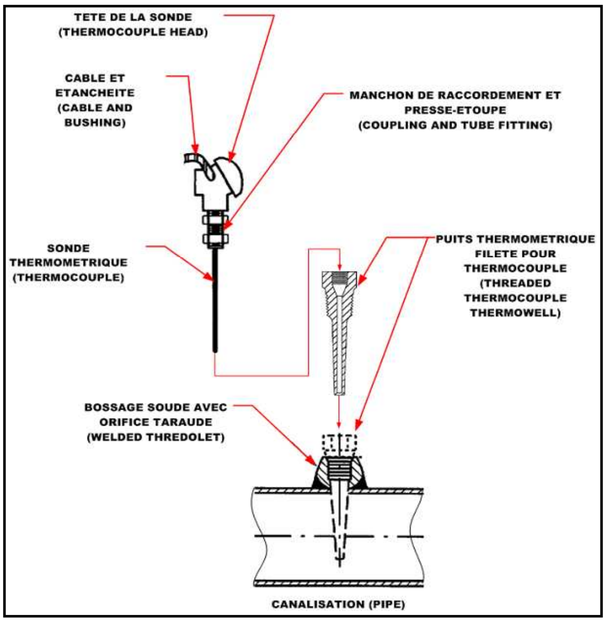
Origin and causes of the accident:

The analysis of the incident discovered that the thermocouple was improperly installed on the bottom circuit of the raffinate stripping tower. The installation was not in compliance with the construction drawing of a thermocouple well on a pipe.

A proper installation of a temperature sensor (see diagram below) adapted to the installations' service conditions would consist of the following:

1. A threaded boss on the pipe wall intended to receive the thermocouple;
2. Screwing of a "sensor pocket" on the aforementioned boss and reinforcement by means of a weld bead;
3. The thermocouple is then screwed into the pocket;
4. The wires are connected to a signal transmitter, once the cable is connected to the sensor by means of a coupling.

In this configuration, while ensuring a reliable temperature measurement, the thermowell guarantees that there will be no direct contact between the process fluid (for which we are attempting to measure the temperature) and the thermocouple. In the case of accidental rupture (contact between the process fluid and the thermocouple), the tube fitting limits/prevents the loss of confinement provided that the leak is not excessive.



Temperature sensor assembly diagram

The investigations conducted following the incident showed that the thermocouple had been installed without a "sensor pocket", thus without protection. The hot raffinate was thus in direct contact with the sensor. As the quantity of product was excessive and the fluid very hot (320 °C), the tube fitting was unable to properly maintain the seal, leading to self-ignition of the product released and in contact with the air. The equivalent diameter of the break at the pipe level is roughly 10 mm.

A pool of flame quickly spread across the ground, forming flames of 5 to 6 m. The fire reached the scaffolding planks within the structure, increasing the height of the flames up to approximately 15 m for 8 minutes. The firemen were able to put out the burning wood, allowing only the initial pool to burn.

Analysis of the fundamental causes of the incident

1) Traceability of job site phases

The operator conducted more extensive research to determine the reasons behind the faulty thermocouple installation. During the major shutdown for regulatory inspection and work on the NMP extraction unit, the following elements were brought to light:

- The replacement of the line on which the thermocouple was installed, was planned and undertaken during the unit's major shut down.
- An initial request for work was not requested for the disassembly of the thermocouple on the button line of the raffinate's stripping tower. According to the individual managing instrumentation work, this procedure is normally performed by "Piping" crew supervisor. The "Instrumentation" organisation did not issue a permit authorising the disassembly of the thermocouple of the line to be replaced.
- No permit was issued to install a thermowell on the new bottom line of the raffinate stripping tower. No request was submitted to the "Instrumentation" organisation to provide the company working on the unit with a thermowell notably consisting of a "sensor pocket".
- The isometric drawing of the circuit and the list of required materials were given to the external company to perform the work on the new bottom line of the raffinate stripping tower. When the company's pipe fitter arrived at the site, the thermocouple had already been removed from the old line. He thought that it was an element reduced by ½" in diameter on the 1" dia. boss. (it was in fact a "sensor pocket" and not a ½" adapter fitting). He thus welded a 1" x ½" adapter fitting on the new section of line to have the same configuration as the old line.

- Once the welding operations were completed, the adapter fitting was equipped with a threaded plug to allow the new circuit to be tested. Once the leak test was performed, the plug was removed, thus leaving the pipe open.
  - A work request was not made concerning the reinstallation of the thermocouple (normally submitted to the "Instrumentation" crew by the "Piping" crew); no permit was issued to reinstall the thermocouple on the new line.
  - The piping company did not refit the thermocouple. The pipe work acceptance sheet relative to the extraction unit shows that the instrumentation was in place and reconnected just prior to restart. In the end, only three permits were granted for the following work: blinding, cold cutting, welding, grinding, testing and blind removal.
  - It was not possible to establish who actually removed the thermocouple from the old line and who put it back in place on the new line.

2) <u>Analysis of the failure of the safety bars</u>

The piping company did not inform the operator that it had removed the adapter fitting which was not requested, nor that the thermowell indicated in the list of equipment had not been supplied.

The refinery's instrument specialists had never been involved in this operation.

The line's testing procedure had been accepted with an adapter fitting that had not been requested. The boss designed to receive the thermowell had also been plugged: it was thus impossible to identify that is was not in place.

When the line was accepted, neither the presence of the non-requested adapter fitting, nor the presence of the thermowell were identified.

The nitrogen flushing, leak testing and the introduction of cold then hot product, did not allow the well's absence to be detected prior to the incident.

ACTION TAKEN

The Classified Installations Inspectorate visited the facilities on the day of the incident. The Inspectorate requested that the operator provided an incident report before authorising the unit to restart. Owing to the operator's reactiveness in managing the incident and the "post-incident" measures taken, no administrative penalty was proposed.

The property damage was essentially limited to the instrumentation and pipe elements without involving all of the pressure tanks. The main work performed on the unit prior to its restart after the incident consisted of the following:

- partial or total replacement of approximately 70 instrument cables;
- the overhaul of certain control valves and various level measurement accessories;
- reworking of seals and the replacement of the threaded fasteners of parts exposed to the fire, in accordance with the inspection service's recommendations;
- the installation of a thermowell for a thermocouple on the bottom line of the raffinate stripping tower;
- the refurbishing of the analyser circuit and its support elements;
- reworking of the stuffing boxes on the valves exposed to the fire;
- replacement of destroyed or impregnated heat lagging;
- inspection of the electrical insulation of pumps and their drying;
- replacement of damaged spring boxes.

The damage to the guniting was also considered to be minor. The necessary repairs were undertaken to allow the installations to be placed back into service safely just a few days after the incident (the Classified Installations Inspectorate granted restart authorisation of the unit on April 25, 2006).

LESSONS LEARNT

In addition to the human error that resulted in significant property damage to the unit, the faulty installation on the thermocouple resulted in a **failure of the Safety Management System**:

- lack of communication between the refinery's "Piping" and "Instrumentation" departments,
- poor definition of each department's role,
- incorrect application of the procedures,
- non-compliant work acceptance,
- poor definition of the work requested of the external company.

The operator proposed to implement the following avenues of improvement with regard to the acceptance of piping work and the thermocouple installation process as defined in the Safety Management System:

1. Establish a "maintenance procedure" clearly stipulating the work to be performed by each trade (notably, "Piping" and "Instrumentation"). These procedures are developed by the refinery personnel and must be applied by the external companies. They describe the individual steps to follow regarding the inspection, repair and maintenance of technical systems. They must also display the list of spare parts required for the work to be performed and to establish the time required to perform the work.
2. Stipulate in the specific "Piping/Valves" Specifications intended for external companies, that the piping company is responsible for the installation of wells. This company must also procure the parts from the refinery's supervisory department, and so that all modification in relation to the isometric drawings must be reported to this same department.
3. Stipulate in the specific "Instrumentation" Specifications what verifications must be performed in order to ensure that a thermowell is present before installing a thermocouple.
4. Work with the platform's Inspection Department so that the lines equipped with thermowells are tested with the "sensor pockets" in place (plugging the pipe bosses intended to receive the thermowells is prohibited).
5. In the pipework acceptance phase, refuse all additional part added by the external company that does not appear on the isometric drawing.
6. Add a "thermowell" line to the "piping/valves" acceptance sheet.
7. Reinforce the message that only the refinery's instrumentation specialists are authorised to remove/install instruments.

This feedback, rich in information, was shared among other refinery units in which similar incidents could occur.

Slaughterhouse wastes

Fermentation facility

Defective installation

Unloading

Bacterial activity

Chemical reaction

First aid versus self -rescue

Emission of H_2S in a Waste Treatment Facility

November, the 5th, 2005

Rhadereistedt - Germany

THE INSTALLATIONS IN QUESTION

The site involved is a fermentation facility where vegetable and animal waste are fermented under production of heat and energy. The waste was transported from the Netherlands. The site is located in Rhadereistedt (Germany) but may be representive for fermentation facilities in general.

THE ACCIDENT, ITS BEHAVIOUR, ITS EFFECTS AND CONSEQUENCES

Waste that remains after slaughtering animals must rapidly be removed and processed. This prevents unpleasant odours and unsanitary situations. An important method which is used is processing the animal waste in fermentation facilities as a result of which biogas is generated. It is obvious that this biogas can be used for heating or electricity production. Also vegetable wastes can be processed in this manner and often these wastes are processed simultaneously with animal wastes.

Besides their energy-content waste also can have other useful applications, for example in the case of intestinal membranes of pigs. These membranes contain the substance Heparin which is used by the pharmaceutical industry as an anti-coagulant for human blood. For the transportation and the extraction process the waste is, due to pharmaceutical demands, stabilized with sodium bi-sulphite ($NaHSO_3$). The Heparin is separated by means of hydrolysis. Afterwards the remaining material is processed in a fermentation installation as described before.

The accident

On the 5th of November 2005, after collecting the Heparin by a pharmaceutical company in the Netherlands, the remaining material was transported by truck to a fermentation facility in Rhadereistedt, Germany.

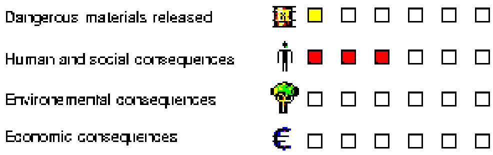
On site the normal unloading procedure was not followed due to a failure of the unloading equipment. The pit was open because the hoist used to close the heavy metal doors was defective. In this pit there were some remains present from earlier loads. While unloading the material a large quantity of hydrogen sulphide (H_2S) was emitted.

The consequences

Due to the H_2S emission an operator was poisoned. Another operator, the truck driver and some other people who were present and/or came to rescue also suffered the toxic effects of H_2S. The outcome was 4 fatalities and one seriously ill in hospital.

European scale of industrial accidents

By applying the rating rules of the 18 parameters of the scale made official in February 1994 by the Committee of Competent Authorities of the Member States which oversees the application of the 'SEVESO' directive, the accident can be characterised by the following 4 indices, based on the information available.



The parameters that comprise these indices and the corresponding rating method are available at the following address: http://www.aria.ecologie.gouv.fr

The index concerning the quantity of dangerous materials released is set on level 1 because of the small quantity of hydrogen sulfide released (in weight). Although the concentration of hydrogen sulfide was very high from the point of view of toxicity for humas present.

The level 3 given to the human and social consequences is due to the number of casualties (4 fatalities and 1 person hospitalized).

No level was given to the environmental consequence because the emission in cubic metres/weigth was small and was vented away resulting in non-harmfull concentrations.

The level of economic consequences of the accident was low (no loss of expensive products, no damage).

ORIGIN, CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

Facts

1.Dutch pharmaceutical company extracts Heparin from intestinal membranes of pigs, stabilized with $NaHSO_3$.

2.Remainders are dipatched by closed truck to a fermentation facility in Germany: Rhaderreisted.

3.Truck arrives too late and stays overnight outside the gate (150 mtrs from the entrance).

4.The next morning (ca. 6:00 am) unloading of 25 tons of waste into a pit takes place. The driver opens pressure release truck.

5.The pit (100 m^3) contained 20% sticked material. Previous unloading consisted of animal waste and lactic waste.

6.Unloading did not taken place through the air tight valve connection but through an open cover: => malfunction of a hoist to move the heavy metal doors which normally cover the pit.

7.The air exhaust and the stirring device were in operation.

8.Large quantity of H_2S was emitted !

9.Acidity of the waste:

- On dispatch: pH= 8.5-8.6
- After unloading in the pit: pH= 5.6-5.9

11. Temperature:

- On dispatch: T= 60-65 ºC
- During unloading: T= ? (no thermal insulation of the truck)

12.Operator collapses during unloading.

13.Truck driver and other personell rush in for assistance.

14.Outcome: 4 fatalities and one seriously ill in hospital.

Scenario

1.Possible origin of Sulfur:

- Intestinal membranes
- Stabilizer $NaHSO_3$ (1.5%)

2.Acidity:

- Lowered by the presence of products from a previous load (20%) => dairy material (containing lactic acid).

3.Escape of H_2S gas:

- Possible because using an opened cover during unloading.

4.Operator does not know the possibility of H_2S release (hazard assessment) .

5.Concentration of H_2S is too high to be noticed by smell.

6.No detection / alarm/ measurement equipment present.

7.No emergency training means that those trying to help were killed too. 1st rule of First Aid is that the helper is not endangered.

ACTIONS TAKEN

Investigation of the site took place by the Dutch inspectorate: Visiting the site and communicatiion with local personnel and local authorities took place.

Research questions were given to a research institute (Rivm a.o.) about the correlation pH and H_2S-release with stabilisized and non stabilized waste. Results are expected mid 2007. The research is doen because It is likely that similar accidents may occur with other kinds of wastes in fermentation facilities, large and small, industrial and on farms. When proven the licensing authorities will be informed.

LESSONS LEARNT

1.Lack of caution with a familiar, but not well understood issue: smelly waste.

2.Do not take rescue actions without thought.

3.Knowledge is important about possible generation of H_2S .

•Hazards •Safety measures •Measurements

4.Always assess possible chemical reactions.

5.Good maintenance. Malfunction = non-use!

6Measuring equipment H_2S and pH should be available.

7 Research should be done to find a alternate stabilizing agent (non S). At the moment the agent is obligatory for the farmaceutical process of extracting heparin from the membranes. Within about 10 years the heparin wil possibly be produced synthetically and the agent will not be nescesarry for this application any more.

8 The accident could possibly also occur with other types of fermentation facilities that don’t have proper equipment and procedures.

Toxic release
Hazardous waste
Vacuum truck
Safety management

Release of toxic gas from a vacuum truck at an installation for treating hazardous waste

29th December 2005,

Stuttgart – Germany

THE INSTALLATIONS IN QUESTION

The hazardous waste treatment facility is located in the commercial port area of Stuttgart. The facility receives a wide range of hazardous wastes in a variety of containers. Some wastes can be treated on-site and others must be transported to other facilities to be treated.

THE ACCIDENT, EFFECTS AND CONSEQUENCES

The accident

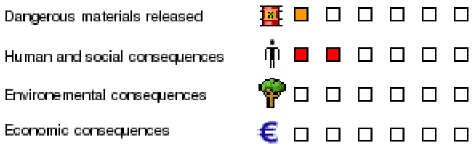
On 29th December 2005 an accident took place in a hazardous waste treatment facility in which an employee was killed and six others (two employees, two members of the emergency services, and two employees of contact companies) suffered injuries and required hospital treatment.

The cause, based on current knowledge, was the release of hydrogen sulphide (H2S) from the tank vent of the vacuum-truck whilst liquid wastes were being pumped from steel drums into the vacuum-truck. A fork-lift truck driver who happened to be in the immediate vicinity was found dead near by; the cause of death being the toxic effects of hydrogen sulphide. Five of those treated in hospital were also suffering from the health effects of hydrogen sulphide

The fire-brigade could not identify any hazardous gas concentration on arrival at the scene. The fire-brigade then left the site. To secure the scene for the police investigation, the police ordered that the contents of the suction hose should be drawn into the vacuum-truck. The vacuum pump was restarted and once again hazardous sub-stances were released from the tank vent. This process led to the collapse of the vacuum-truck driver. As a result the police ordered that the operation should cease and the fire-brigade and an emergency doctor were called to the scene.

European scale of industrial accidents

By applying the rating rules of the 18 parameters of the scale made official in February 1994 by the Committee of Competent Authorities of the Member States which oversees the application of the 'SEVESO' directive, the accident can be characterised by the following 4 indices, based on the information available.



The parameters that comprise these indices and the corresponding rating method are available at the following address: http://www.aria.ecologie.gouv.fr

The level 1 of the index concerning the quantity of dangerous materials released (in the meaning of the SEVESO Directive) expresses the small quantity of toxic substance (H_2S) which was released (parameter Q1).

The level 2 given to the human and social consequences is due to the one fatality and the number of people suffering from the effects of the toxic substance (H_2S) (parameter H3, H4 and H5).

The economic consequences was not evaluated.

Finally, there is not any noticeable consequence regarding environmental consequences.

ORIGIN, CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

The immediate cause of the production of toxic gas was the combining of liquid wastes which on mixing react together releasing H2S. An organo-sulphur (thio) compound was mixed with an organic, acidic compound leading to an unexpected liberation of hydrogen sulphide

The indications are that the organisational measures which had been taken were not adequate to prevent this event.

The operator was not able to demonstrate that adequate measures for the identification, assessment and documentation of the hazards of the individual containers of hazardous waste received. The hazardous wastes which were received in drums and brought together in a vacuum-truck were to be transported from the waste treatment facility to another location because they could not be treated on site. The operator was not able to demonstrate that adequate measures were in place to regulate how the drums should be pumped into the vacuum-truck (order, ruling out of any hazardous chemical reactions). There were no adequate measures for the safe discharge of gases vented from the vacuum-truck.

ACTIONS TAKEN

As a result of this incident there is a criminal investigation which is ongoing. This is also a reportable incident under Seveso II.

The mixing of hazardous waste in the vacuum-truck is no longer carried out and the operator transports the drums of waste, untreated to another location.

Operators and inspectors need to be made aware that vacuum trucks have potential hazards relating to their operation and that under no circumstances should it be tolerated that chemical reactions be carried out in the tank of the vacuum-truck. The treatment of hazardous waste should be carried out in a controlled manner in designated reactors with suitable monitoring equipment.

Vacuum-truck operations may be carried out at a number of sites; therefore the State Institute for Environment, Measurement and Nature Conservation Baden-Württemberg issued the following recommendations to the regional governments of Baden-Württemberg.

Prevention measures

1. Problematic wastes, that is, wastes which either have hazardous characteris-tics themselves or on mixing with other substances may release hazardous sub-stances must receive special consideration.

2. The safety critical parameters / characteristics for these wastes must be de-fined.

3. The safety critical characteristics which have been defined for the identification of the waste and which regulate the further treatment, e.g. pH, must be tested for every container (drum, IBC, tank) which is delivered, documented and confirmed with a signature

4. Procedures must be defined for the handling of containers which deviate from the criteria.

5. If more than one container of problematic wastes are to be combined (in a vacuum-truck), then a list of the containers together with their hazards, and the safety critical parameters is to be made and the operation assessed as to its feasibility. Following this a mixed-sample of those wastes which are to be combined is to be taken. The order of mixing is to be noted.

6. If it becomes apparent that a combining of the wastes is only possible under compliance with a particular order of mixing, then this order is to be laid down in writ-ing and the adherence to this order is to be controlled and documented.

7. Before initiating the pumping process the tank vent of the vacuum-truck is to be connected to a suitable exhaust gas system. If this is not possible, then the location and orientation is to be chosen so as the vapours may be vented safely at all times.

8. Access to the area in which the vacuum-truck and pumping operation are lo-cated for persons not involved in this procedure is to be prohibited. The area is to be clearly marked and cordoned off.

LESSONS LEARNT

- ✓ Operations involving the use of vacuum-trucks may lead to the release of hazardous gases / vapours.
- ✓ Where ever possible, measures need to be taken to avoid the release of toxic (or flammable) vapours from the vent of the vacuum truck tank and to prevent the exposure of employees and others to such hazards.
- ✓ Vacuum trucks are not suitable for processes involving the mixing of hazardous wastes which may lead to a chemical reaction and the subsequent release of hazardous gases or vapours.
- ✓ The treatment of hazardous wastes requires a robust safety management system with:
  - ✓ Clear definition of responsibilities for all operations within the treatment facility
  - ✓ Definition of and testing for safety relevant criteria and characteristics (e.g. pH, Temperature, colour, viscosity, odour, phase separation) to enable hazardous wastes to be accepted and treated or transported safely,
  - ✓ Documentation of the .whole process from the acceptance of a hazardous waste to its disposal including all safety critical criteria and characteristics

Tank failure in a bitumen storage unit of a refinery

September 8, 2004

Italy

Refinery
Storage unit
Tank
Bitumen / hot-oil
Failure
Overpressure
Victims

THE INSTALLATIONS IN QUESTION

The site

The refinery is located in the centre part of Italy, and is strategically situated in the middle of the Adriatic coast to cover a large area of eastern Italy. it is part of one of the top 20 private industrial groups in Italy.
It has been operating since 1950, and has about 500 employees. It has a production capacity of 3.9 million tons/year, and represents nearly 5 % of national refining capacity. Its storage capacity is over 1.500.000 m3 of oil products in 128 tanks.
The plant, cover 70 ha of area, and is located in an urban site (Fig. 1), near the city, the motorway, the railways, the port (slipway) and the airport.
The plant is under Seveso II Directive (upper tier plant).

Fig. 1 Photo DR

The unit concerned

The unit consists 12 fixed roof tanks, 8 loading arms and 6 pumps for transfer/loading of bitumen, 1 heat-exchange for possible additional heating of stored bitumens.

The accident took place in the cylindrical atmospheric tank of bitumen (TK145), operative since 1970 and extended in the near loading/unloading areas. With 1200 m^3 of capacity, 12 m of height, the tank was equipped with an internal heating coil, positioned at the bottom, in order to assure an internal temperature of 170℃. The coil was feed with hot-oil at 280℃.It was also equipped with level indicator, temperature indicator, and a mixing stirrer.

There were about 592 m^3 of bitumen inside the tank, and about 150 m^3 of hot-oil inside the heating circuit, at the moment of the accident.

THE ACCIDENT, ITS BEHAVIOUR AND CONSEQUENCES

The Accident

At 07.25 a.m., a catastrophic tank (TK145) failure occurred: the shell and roof tore off the foundation were projected in vertical direction, and were moved laterally 15 m away. Along the way, they broke some pipe rack, at about 5 m of height, and then fell and on a 2nd bitumen storage tank, causing a massive total leakage of bitumen (about 550 t) and hot-oil (about 120 t) at 170°C, and their spreadin g all over the areas.

The missile-tank exploded fell down on a 2nd bitumen tank (TK166) of 8000l of capacity. The missile roof entered in the TK166 shell, then squeezed itself into the TK166 basin (Fig. 2,3).

A pool-fire was then ignited in the TK145 basin, other fires followed involving equipments in sight, with domino effect on others tanks and on some tank-trucks under loading, located in the area. The fire was then fed by the hot-oil releasing from the heating circuit, due to the tear of the circuit lines connected to the tank coil.

At the moment of the accident, there were 8 tanker in the area, ready to loading/unloading operations and 9 persons in the site: 7 drivers, one internal shift operator and the site-head which is inside the building located in the area, and had just finished the line preparation for tanker n°1 loading from the TK145. The operator was monitoring the TK252 level, installed on the basin wall in common with the other bitumen storage tanks (TK251, TK252, TK253 e TK328).

The emergency alarm started and the internal emergency measure, cooling and spread-foam systems activation, were immediately applied. The internal fire team's intervention was immediate, involving 6 fire-men and 2 fire-trucks.

After 25 minutes from the internal emergency alarm, the external Fire Brigades arrived. All the units area involved was put in safety condition.

After about 3 hour the fire was controlled, and the emergency was closed.

The consequences

The accident caused effects to people and to environment, and did non lead to significant off-site consequences, even if the accident generated distress in the population, which was taken into account by the media and the public authorities.

Human effects

One driver burned by bitumen and projected inside a tank basin, where his body was found 3h later the fire extinguished. Three other drivers differently injured by the contact with the hot bitumen: 2 hospitalised and 1 treated and released.

Environmental effects

The bitumen released expanded in a vast area of about 13.000 m^2 (2% whole refinery area). Part of the product (6-34 t) involved the external site, releasing in the sea through an internal ditch of the refinery.

The effects of the smoke plum on the near city population were judged at low impact by the Regional Agency for the protection pf Environment.

Consequent to the accident, the central scientific research institute for the sea performed a series of controls in the sea, and recovery operations of spread bitumen. Moreover, sanitary local authorities conducted some shellfishes analysis.

Limited quantities (some hundred of kg) of bitumen were recovered in the sea near the establishment, or in the seaside beach for 8 km far away.

Economic consequences

According to a preliminary costs estimation made by the society:

-3 millions of euros for structural losses

-0.5 millions of euros for emergency

-3 millions of euros for clean up

-31 millions of euros for response and restoration of the establishment

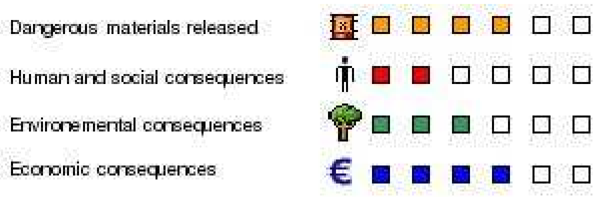
-25 millions of euros for production loss (for 1 year, which is the time estimated for the bitumen plant activity recovery)

Fig. 2 Photo DR

Fig. 3 Photo DR

European scale of industrial accidents

By applying the rating rules of the 18 parameters of the scale made official in February 1994 by the Committee of Competent Authorities of the Member States which oversees the application of the ‘SEVESO’ directive, the accident can be characterised by the following 4 indices, based on the information available.



The parameters that comprise these indices and the corresponding rating method are available at the following address: http://www.aria.ecologie.gouv.fr

About 120 tons of hot-oil (classified as dangerous for the environment R51/53) have been involved (5% of 500 tons Seveso threshold) justified the level 3 for "dangerous materials released" (parameter Q1).

With one person death and three other injured, the parameter "human and social consequences" reached the level 2 (parameter H3)

The level 3 for "Environmental consequences" is explained by the pollution of the seaside beach for 8 km far away (parameter Env14).

The production losses, estimated at 25 M€, explain the level 4 for the “economic consequences” (parameter €16).

ORIGIN, CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

The two principal hypotheses assumed based on a preliminary analysis conducted by the society, are:

- an internal overpressure in the tank caused by explosion of light flammable hydrocarbons, wrongly introduced in the tank

- an internal overpressure in the tank caused by rapid phase transition of water, wrongly introduced in the tank, (internal temperature 170°C)

Further following investigations lead to consider the first one, related to the wrong introduction of light flammable hydrocarbons compounds during unloading to the tank of bitumen in excess present in tank-trucks.

ACTIONS TAKEN

Emergency measures

Internal fire-team immediately was activated, followed 30 minutes later, by Fire Brigades (15 trucks and 35 fireman).

The external emergency plan was activated with:
- interruption of railways traffic, which runs inside the plant
- interruption of the near roads traffic
- reduction of the near airport activity, without practical consequences
- blockage of electrical feeding of 132 kW line which runs along the railways
- start-up of the mixed advanced coordination centre
- start-up of the procedure for the information to population.

Fire was handled through water and foam, while tanks and browsers involved were been cooled (Fig. 4, 5, 6).

After about 2 hours the fire was under control, and the railways traffic was opened 3 hours later.

The emergency was concluded with the put in safety of the plant, according to the dispositions of the judicial authority, who sequestrated the whole area.

Fig. 4 Photo DR


Fig. 5 Photo DR


Fig. 6 Photo DR

2) Official action taken

A detailed investigation is still in course, to understand the causes of the accident.

The regional technical committee immediately disposed to the operator after the accident:

- detailed technical report of the accident, containing the design solutions adopted in similar bitumen plants
- request of a new SMS inspection
- adoption in short/medium period of the following measures acted to move the loading ramp away from the storage area and verify the safety conditions of all the hot-oil circuit of the refinery
- improve the internal emergency plan, in particular the time to evacuate operators, and the interface between internal and external fire-teams.

LESSONS LEARNT

The accident put in evidence some SMS issues that had an important role in the event occurred. The table here below explains, for each SMS issue identified, the principal corrective actions taken or planned

Description	Actions taken	Actions planned
Operating procedures and instructions in normal, abnormal and emergency conditions	More attention for process parameters monitoring, providing a temperature controller of bitumen inside, and blockage in case of over temperature max. The same for temperature and flow of hot-oil in the coil.	Realization of temperature control systems for bitumen in the tanks, with heating system blockage and bitumen feeding blockage Realization of blockage system of hot-oil line to tank coils, in case of over temperature Realization of blockage system of hot-oil flow-rate, in case of different flow-rates in input/output from plants
Emergency team organization. Alarm systems and communication and support to the external intervention	Difficult communication among fire teams. Need of a more rapid recognition of possible persons missing. Need of an improvement in information exchange between the emergency centre (in the offices) and the operators in site. Need of a more integration between the internal fire team and the Fire Fighting	Internal emergency plan improvement, in particular for the involved personnel control and census, and for the operative emergency procedure of internal fire team
Controls and verifications of the management of emergency situations	2 bitumen tanks involved didn't have the cooling system active	
Identification of substances and processes hazards; definition of safety requirements and criteria. Emergency management	Plant lay-out, storage area too close to loading area, few space available for emergency team intervention….	Remove the loading platforms from the storage area
Planning and updating of technical and/or managerial solutions for the reduction of risks	Need of a more congruency between safety analysis, operative procedures on normal, abnormal and emergency conditions, and actions for risk reduction. The safety analysis should consider a possible introduction of lights compounds by unloading the bitumen from the overloaded tank-truck	realization of automatic system for tank-truck loading, equipped with weigh at prefixed load, too-full detectors and systems "at present man", to avoid or limit overloading prohibition of direct unloading of overloads to bitumen tanks adoption of management and technical measures to avoid water and lights introduction in bitumen tanks provide an explosive atmosphere presence monitoring inside the bitumen tanks
Maintenance procedures	Necessity of systematic control of restoring and washing for the tank-trucks	Adoption of system to verify the presence of the recovery and clean-up certificates for the tank-trucks

Rupture of a crude oil storage tank

October, 25th, 2005

Kallo – Belgium

Rupture
Flammable liquids farm
Storage tank
Crude oil
Corrosion
Periodic control
Thickness measurements

THE INSTALLATIONS IN QUESTION

The oil storage terminal contains 7 storage tanks in one large bund made with earth dikes. Between the tanks there are lower inner dikes.

- ✓ 4 crude oil storage tanks with a content of 40 000 m^3 each: D1, D2, D3 and D4;
- ✓ 2 storage tanks for the multifunctional storage of crude oil or rainwater contaminated with crude oil, slop oil, with a content of 24 000 m^3 each: D10 and D11;
- ✓ 1 small tank D26, with a content of 730 m^3 which is out of service.

The crude oil is delivered by pipeline from the port of Rotterdam and after some storage at the terminal at the left bank of the river Scheldt the feedstock is pumped by pipeline to a refinery, which is situated at the right bank of the river, where it is further processed.

The oil storage terminal was licensed by a decision of the Permanent Executive of the Province of East Flanders on February 7th, 1991 for a period expiring on February 6th, 2011.

The establishment falls within the scope of application of the Seveso II Directive because of the presence of more than 50.000 tonnes automotive petrol and other petroleum spirits. The license allows the company to store 208.000 m³ of crude oil. For that reason the terminal is an upper tier establishment.

On September 12th, 2005 a minor incident occurred at the storage tank D3. During this incident crude oil leaked from the bottom of the tank. In October 2005 the exact cause of this incident was not yet known, because the tank bottom was not yet fully cleaned to start the investigation of the incident. At the moment the major accident occurred with tank D2 cleaning operations for storage tank D3 had just started in order to inspect storage tank D3.

The storage terminal is permanently manned during daytime. In the evening and at night inspection rounds are performed by an external security company. The permanent supervision of the terminal (by means of cameras) and the filling and discharging operations of the storage tanks are completely managed from the control room at the refinery.

THE ACCIDENT, ITS BEHAVIOUR, ITS EFFECTS AND CONSEQUENCES

The accident

On October 25, 2005 around 18.15h a major leak at tank D2 was detected. The operators in the control room of the refinery were alerted by a low level alarm for tank D2. Storage tank D2 contained almost 37 000 m^3 crude oil before the release. The level history in the control system situated in the control room of the refinery indicates that after a short period of increasing leakage almost the full inventory of storage tank D2 was released within 15 minutes.

The accident has been considered a ‘major accident’ according to the criteria set in Annex VI of the Seveso II Directive:

The consequences

Consequences for the installation

Because the content of the storage tank was released in such a short time, an enormous crude wave was created. This wave moved in the direction of the several meters high earth dike, which fortunately resisted against the power of the wave. The released crude oil filled the whole bund (40 000 m^2 large) with crude up to a height of 1 m.

After the release the storage tank was leaning forward and a part of the foundation of the storage tank had disappeared.

Consequences for the environment

- ✓ *Air pollution:* the enormous amount of crude oil that was captured in the bund caused strong odour pollution in the wide surroundings of the depot. Odour pollution was reported close to the border with the Netherlands due to the very strong wind in Northwest direction that evening. Although the company took several measures to fight the odour pollution (like covering the bund with sand and foam), odour complaints were reported during several days after the accident. Another series of odour complaints occurred two weeks after the accident at November 11th 2005, at the moment that the floating roof of the tank has landed by which means the function of the seal of the floating roof was lost.
- ✓ *Surface water pollution:* There was a very slight contamination of surface water in the surroundings. Due to the height of the dike only a small amount of crude oil (approximately 3 m^3) was ejected out of the bund. This caused a confined pollution of the polder ditch which is situated at the outside of the terminal.
- ✓ *Soil pollution:* the upper layer of the bund is a clay-layer. In the past a layer of sand of approximately 50 cm was placed above this clay-layer in the area of the bund where there are no tanks. Under this layer, about 1,2 m deep, there is a sand layer. Samples of the soil were taken to determine the soil pollution. These samples showed that the clay-layer stopped the pollution. The part above the clay-layer was polluted over the whole area of the bund, the depth of this pollution varied from 10 cm up to 1 m.

  Also on the other side of the road near the terminal samples of the soil were taken because of the presence of a nature area. Due to the accident some of the grass in this area was covered by a mist of crude oil. Analysis of these samples showed that no soil pollution occurred in this area.

Figure 1 shows a picture of the situation in the bund the morning after the major accident happened.

- ✓ *Groundwater pollution:* analysis of the groundwater showed that there was no groundwater pollution due to the accident. First some increased concentrations of benzene were measured near tank D2, but after the removal of the polluted soil the situation was normalised.

Consequences for the people : There were no injuries caused by this accident.

European scale of industrial accidents

By applying the rating rules of the 18 parameters of the scale made official in February 1994 by the Committee of Competent Authorities of the Member States which oversees the application of the 'SEVESO' directive, the accident can be characterized by the following 4 indexes, based on the information available.

The parameters which compose these indexes and the corresponding rating method are indicated in the appendix hereto and are available at the following address: http://www.aria.ecologie.gouv.fr/

The level of the dangerous substances index is 4 because approximately 30.000 tons of crude were released (parameter Q1).

The level of the human and social index is 0 because there were no injuries.

For the environmental consequences the index is 3 because the surface area of soil requiring cleaning is 4 ha (parameter Env 13) .

The index for the economic consequences is 5 due to the high cleaning costs (€ 18).

ORIGIN, CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

History and construction information of the storage tank D2

The storage tank was an atmospheric storage tank with an external floating roof and with a cone-up bottom. The storage tank had a diameter of 54,5 m and a height of 17 m. Because of the cone-up bottom the present water in the crude oil flowed towards the shell of the storage tank, where one water sump system was installed. The storage tank also contained two mixers, to put a part of the sludge back into suspension.

The foundation of storage tank D2 consisted of a crushed rock annular ring. The rocks had a diameter between 50 mm and 150 mm. The crushed rock annular ring had a height of approximately 120 cm of which a part was below the ground level. The crushed rock ring had a width of approximately 340 cm at the bottom and 100 cm at the top. The shell was situated in the middle of the width of the crushed rock ring. The inner part of the annular ring was filled with compacted sand. Above this sand there was a layer of 5 cm consisting of oiled sand, to avoid external bottom corrosion. Figure 2 provides a schematic view of the foundation of storage tank D2.

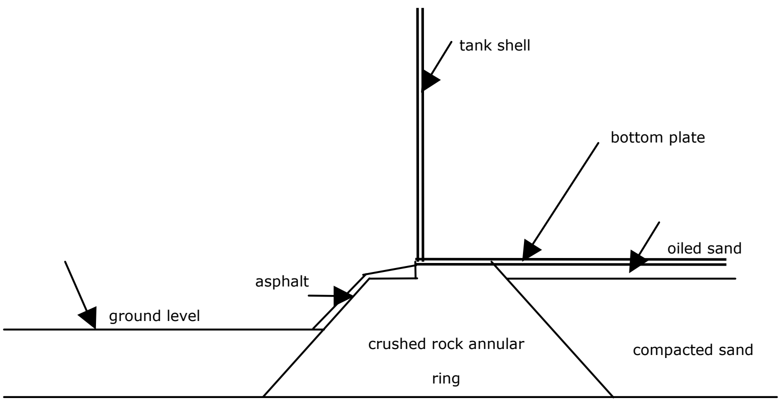


Figure 2: Schematic view of the tank foundation

The annular plates, these are the bottom plates on which the shell of the storage tank is welded, have a design thickness of 12,7 mm. The other bottom plates are designed with a thickness of 6,35 mm.

The underground of the storage terminal existed of a soft clay layer with a thickness of 1 m with a sand layer of 3 m underneath.

The storage tank was built in 1971 according to specific construction standards code API 650. At that moment the storage terminal belonged to another owner. In 1990 the storage terminal was sold to the refinery. At that time all the storage tanks were fully inspected and repaired if necessary. Storage tank D2 was fully inspected in 1990 and was put into service in 1991.

Since 1994 each 3 years external inspections were performed on storage tank D2. The reports of these inspections showed almost no remarks. A full inspection of storage tank D2 was scheduled for 2006, after the full inspection of D1 had been finished. Each three years foundation settlement measurements were performed on the storage tanks. The latest measurements were performed in 2004 and showed no abnormal results.

Findings after the tank rupture

The investigation of tank D2 showed that the bottom plates in a long, small circular band at approximately 1,5 m from the shell of the storage tank were extremely weakened due to internal corrosion. In this band the thickness of the bottom plates was nearly reduced to zero. This band had a length of approximately 35 m and a width of approximately 20 cm.

In this band the bottom of the tank formed a gutter. In this gutter uniform, internal corrosion was found and no pitting corrosion.

The bottom plates showed no external corrosion in the long, small band. The other bottom plates indicated no extreme corrosion.

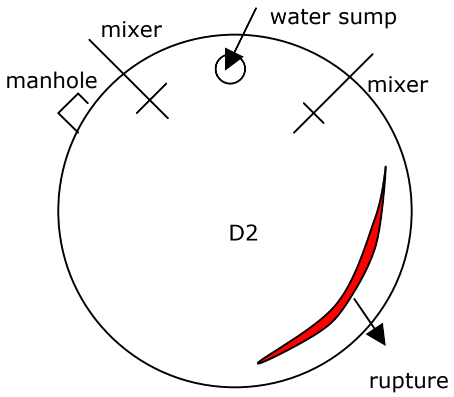


Figure 3: Schematic view of the bottom of storage tank

Primary causes

During the exploitation of storage tank D2 a gutter was formed in the bottom of the tank. This gutter is situated at a distance of 1,5 m from the tank shell. Due to the formation of the gutter the present water could not longer flow to the drain water system to be removed. The accumulation of stagnant water in the gutter caused strong corrosion which strongly reduced the thickness of the bottom plates in that area.

The major release initially started with a small leak. Due to this small leak the compacted sand underneath the tank bottom was saturated with oil and a kind of quicksand of oil and sand is formed. This small leak has not been visually detected because the crushed rock annular ring had a lot of holes, which were initially filled with crude oil. In the second phase of the accident the resistance of the foundation under the tank was locally strongly reduced (due to the fluidisation of the sand bed) and due to the hydrostatic pressure of the crude oil on the tank bottom, the bottom has ruptured over the length of the gutter. The force of the discharged crude oil was that large that it destroyed a part of the tank foundation and swept away a part of the underground.

Underlying causes

As mentioned before, a gutter was situated in the tank bottom at a distance of 1,5 m from the tank wall. This is just beyond the annular plates on which the tank shell is welded. The first normal bottom plates after the annular plates were cracked during the accident. The gutter has been formed due to settlements in the tank foundation, which at that place consists of compacted sand. The gutter has probably been formed during the first hydrostatic tests on the storage tank. The moment a storage tank is loaded for the first time, the compacted sand settles. In the neighbourhood of the crushed rock annular ring, which consists of coarse rocks, it is difficult to compact the sand bed in an appropriate manner during construction. At the moment the storage tank is loaded for the first time, the sand in that area will be more compacted, but because of the existing holes in de crushed rock annular ring a part of the sand will disappear in the holes between the coarse rocks. Due to these phenomena a gutter is formed in the bottom plates nearby the crushed rock annular ring. Calculations based on a finite element method showed that based on the information about the foundation of the tank in combination with the underground under the tank foundation and the size of the storage tank, the forming of the gutter could be predicted.

The gutter in the bottom plates has not been detected during the internal inspection of the storage tank in 1990-1991, probably because of the used inspection technique and the fact that inspections are performed when the storage tank is unloaded, in which case the elastic deformation can partially hide the gutter in de bottom plates. During the internal inspection in 1990-1991 all the bottom plates were visually inspected on pitting corrosion and ultrasonic thickness measurements of the bottom plates were performed at some places of the tank bottom. These thickness measurements were performed on all bottom plates situated on two perpendicular axes over the whole diameter of the tank (measurement in cross-bandage). The places in the bottom where pitting corrosion was detected have been repaired. The ultrasonic thickness measurements on the bottom plates gave good results for the thickness of the tank bottom.

In the gutter in the bottom of the tank, the present water could not longer flow towards the water sump. This situation of stagnant water in the gutter enabled very fast corrosion in the gutter with the rupture of the tank bottom as the major consequence.

After this incident the bottom plates of all other storage tanks in the terminal have been accurately inspected. All tanks showed the same gutter forming in the bottom plates at 1,5 m from the tank shells. For some storage tanks the length of the gutter was only a few meters long, while other storage tanks showed exactly the same phenomenon as the ruptured tank D2. The visibility of the gutter was different from tank to tank. Ultrasonic thickness measurements in the gutters indicated that locally the thickness of the bottom plates was reduced. In some storage tanks even small perforations in the bottom plates were found, while for storage tank D1 the thickness of the bottom plates in the gutter was never lower than 4 mm.

The inspections on the full tank bottoms of the other storage tanks had to be performed in a very accurate manner. Thickness measurements of the whole tank bottom of storage tank D1 by means of a so called “floor scan” initially did not detect that locally (in a gutter) the thickness of the bottom plates was more reduced. Only after a surveyor made a topographic map of the tank bottom, a small gutter was detected. Ultrasonic thickness measurements indicated that, as mentioned above, in this gutter the thickness of the bottom plates was reduced to 4 mm.

These inspections proved that the leak in the storage tank D3, which happened on the 12th September 2005, had the same causes as the rupture of storage tank D2. In contradiction to storage tank D2, the gutter in tank D3 was much shorter. After some time the leak has stopped, probably because sediment in the crude oil closed the perforated places in the bottom plates.

ACTIONS TAKEN

Emergency measures

The fire brigade of the refinery, the fire brigades of the surrounding communities and civil protection started a massive intervention. Initially the intervention team started to cover the bund with fire fighting foam. Directly a large amount of fire fighting foam, 214 ton, was gathered from the refinery, other (petro)chemical companies, the fire brigade and civil protection to cover the very large bund area with foam. Due to the very strong wind that evening and the largeness of the bund they did not succeeded to cover the whole bund with foam. On the other hand the strong wind was in favour for not achieving an explosive atmosphere above the spill. The crude oil did not ignite. The release of the crude oil caused a lot of odour pollution in the wide surroundings. The rupture of the storage tank got al lot of attention from the national media.

After the major accident all the crude oil stored at the terminal was immediately pumped to the refinery and the contents of the bund was pumped to the storage tanks D10, D11 and D4 by using the existing drain water pump system. Immediately measures were taken to perform all cleaning activities in the storage terminal in a safe manner.

In the afternoon of October 27th, 2005 the major part of the bund was empty. On October 28th, 2005 activities were started to reduce the smell. The smell was effectively reduced by covering the entire bund with sand. Where possible the sand layer was placed by trucks and bulldozers. Between the tanks the sand layer was placed by blowing sand in these areas. This operation lasted for about two weeks.

The stability of all storage tanks was periodically measured. The stability of storage tank D2 on the place where the foundation was blown away, was achieved by hanging the storage tank on 4 large cranes (figure 4).

The intervention was only formally stopped on 18th of November 2005 when the storage terminal was completely free of product.

Figure 4: Major cranes stabilising tank D2

Corrective actions taken by the company

After the major accident the company inspected all other storage tanks in the terminal. These inspections indicated that the gutter forming and the strong internal corrosion of the bottom plates in that gutter, which were the two main causes of the rupture of storage tank D2, were also found in the other storage tanks.

The storage tank D2 had been totally demolished.

The parts of the bottom plates of the other storage tanks of which the thickness and/or the deformation do not fulfil the prescriptions of the standards API 653 shall be repaired. The foundation of the other storage tanks was investigated to control if they still have enough stability (during the accident they were drawn in crude oil) to restart the exploitation of the storage tanks.

Before start-up all crude oil storage tanks shall be coated with a lining to stop the internal corrosion of the bottom plates.

The water at the bottom of the crude oil tanks is drained on a regular basis. After the accident the company decided to analyse the corrosive character of this drain water (by measuring the pH-value of it).

The company also decided to adjust the inspection program of all vertical storage tanks. Between two internal inspections acoustic emission measurements will be performed. Based on the results of these acoustic emission measurements, the next date for the internal inspection shall be adapted if necessary. During the internal inspection of the storage tanks the condition of the bottom of the tank is visually inspected. From the moment there is any doubt about the condition of the bottom plates, ultrasonic thickness measurements will no longer be performed in a cross banded pattern, but the whole bottom of the storage tank will be fully scanned. If a floor scan is performed, 5 additional ultrasonic thickness measurements will be carried out on each bottom plate.

In order to detect leaks in an early stage the company has decided to install a detection with alarm on abnormal level changes on crude oil tanks. Such systems were already available on product tanks in the refinery. Besides these measurements the company is still evaluating to install an on-line oil detection system under the storage tanks.

The company took several measures for cleaning and rehabilitation of the environment. As a result of the soil samples that were taken an area of about 4ha was excavated to a depth varying from 10 cm to 1m. This contaminated soil (including the sand that was used to cover the bund) was removed for further treatment. Several odour catchers were installed around the terminal to prevent possible odour pollution during the cleaning operations. The released crude oil, which was contaminated with 214 tonnes of foam, was recovered from the bund. The polder ditch at the outside of the terminal was cleaned. Several extra gauge wells were installed to establish possible groundwater pollution and to ensure further monitoring of the groundwater quality in the future.

LESSONS LEARNED

Detection of the problem

Just as for each process equipment with risks for major accidents, the phenomena which can lead to a degradation of the containment, in this case the storage tank, should be identified and analysed.

This accident indicates the possible risks as a consequence of the presence of non mixable phases which can settle out. An investigation of the possible presence of such phases should form a part of the identification of possible corrosive phenomena. If necessary chemical analyses should be performed to determine the corrosive behaviour of these phases (chemical composition, pH,…).

This incident further shows that in the bottom of storage tanks gutters can be formed. In those gutters corrosive products can accumulate, what can result in local, uniform corrosion. In the case water and/or other corrosive products can induce corrosion of the tank bottom, it should be investigated if there is also a problem of gutter forming in the bottom.

Gutter forming in the bottom of storage tanks is induced by a combination of the size of the storage tank, the local compressibility of the foundation and a relative elastic underground. The gutters are not always visible by the eye. They can be mapped by performing a topographic investigation. The topographic maps are achieved by a surveyor who measures the bottom of the storage tank with a laser.

The local uniform corrosion which is a consequence of the gutter forming is not easily detected. The local reduction of the thickness of the bottom plate can be overlooked if ultrasonic thickness measurements are only performed on a cross banded pattern. If the risk of local corrosion due to gutter forming in the bottom exists, suitable techniques should be used to investigate the bottom plates. These techniques are described below.

Possible solutions

If local, uniform corrosion induced by gutter forming is a problem, the company should take suitable measures to avoid a loss of containment as a consequence of the corrosion. In the next paragraph some different possible measures are listed according to the place they take in the prevention hierarchy. In function of the specific situation it can be necessary to take multiple measures, if necessary completed with additional measures which are not described here.

1. Avoiding or limiting the presence of corrosive products that can settle out.

2. Avoid that products settle out (mixing the different phases)

   Mixing of the products in the storage tank can avoid or limit that insoluble phases settle out. To achieve good results the effectiveness of the mixing is important.

3. Removing of settled out products

   It has to be assured by a procedure that settled out products are periodically removed. But note that the draining of settled out products does not guarantee that settlements are removed out of gutters in the bottom.

4. Avoiding the formation of gutters in the bottom

   Existing storage tanks can be lifted up and the foundation underneath can be restored. In this case it must be kept in mind that by performing a hydrostatic test it is possible that new settlements can take place. For existing tanks there is also the possibility to analyse the foundation and the underground under the storage tanks in order to gather enough information to perform calculations. These calculations can indicate if the risk of gutter forming exists or not. For new storage tanks a detailed calculations of the foundations can be performed during the design phase to reduce the risk of gutter formation.

5. Lining

   A lining is applied on the tank bottom and the first shell course. A lining which is well attached will largely reduce the corrosion velocity. A badly adjusted lining will still reduce the uniform corrosion but will promote pitting corrosion underneath the lining. A good attachment of a lining depends on a lot of parameters such as moisture, temperature, kind of lining, not stepping on a not fully hardened layer, … To achieve guarantee about the thickness of the lining and the attachment of the lining it is necessary to perform measurements on the thickness of the different layers, to perform a conductivity test and to perform a non porosity test. The code API 652 “Linings of aboveground petroleum storage tank bottoms” describes the advantages and disadvantages of different kind of linings.

6. Planning of internal inspections based on the corrosion velocity

   The intervals between internal inspections have to be defined based on the estimated corrosion velocity. This is a general principle that can be found in the API 653 standard “Tank Inspection, Repair, Alteration and Reconstruction”. Normally the corrosion velocity of the bottom plates is the most important one. In the case of major local corrosion, it will be this higher, local corrosion velocity which is determinative for the inspection interval.

   The internal corrosion velocity can be determined by analysing the settled out products. Based on graphics which indicate the overall corrosion velocity of the construction material as a function of the corrosive character of these residues (e.g. pH-measurement), the corrosion velocity can be estimated. Based on the corrosion velocity it can be determined how long the storage tank can be safely used before a next internal inspection is necessary. Standards API 653 describes what minimum plate thicknesses have to be measured to use a storage tank safely. If it is expected that large differences can occur in the chemical composition and the properties of the residues, these analyses and the calculation of the inspection interval must be periodically repeated. The analysis of the bottom products can be used to trace other corrosion phenomena (e.g. bacteriological corrosion).

7. Adapted internal inspection techniques

   Internal inspections in which case ultrasonic thickness measurements are only performed in a cross banded pattern (just to achieve a general impression of the thickness of the bottom of the storage tank) are not sufficient to trace local, uniform corrosion.

   In order to achieve an entire image of all changes in the thickness of the bottom of a storage tank the bottom must be totally scanned. Floor scans are very useful to measure sudden volume changes in the floor (e.g. pitting corrosion). They can however also be used to trace gradual changes in the thickness of the bottom plates. To guarantee that a floor scan generates accurate information on the state of the entire bottom of the storage tank, certain conditions have to be satisfied.

   It must be checked if the presence of a lining has an influence on the results of the floor scan.

   Before the inspection it must be clearly discussed with the performers in which state the storage tank must be presented to achieve good measurements. In some cases the entire bottom of the storage tank must be sand blasted before measurements can be performed. In this case it is necessary to discuss the criteria for the sand blasting in advance. It is also favourable that the contractor who will perform the floor scan inspects the cleaning conditions of the bottom plates.

The signal that is generated by the floor scanning apparatus can suffer from drift. This phenomenon is not necessarily a problem if the floor scanning is used to detect pitting corrosion. The moment pitting corrosion is detected, the signal changes so much that even with some drift on the signal, the pitting corrosion is detected. The drift on the electric signal has however a much larger impact when floor scanning is used to detect gradual changes in the bottom floor. To solve this problem it is useful to perform a few ultrasonic thickness measurements on each bottom plate. The signal from the floor scanning apparatus can be gauged for each bottom plate in order to achieve accurate measurements on gradual changes in the bottom thickness.

8. Additional external inspection techniques

In addition to the above described internal inspections, intermediate external inspections can be performed in order to gather additional information on the corrosion status of the storage tanks. These inspection techniques, which can be applied when the storage tanks are in duty, are especially useful when there is large uncertainty on the corrosion phenomena and/or on the corrosion velocity.

A first technique uses acoustic emission measurements. Microphones are placed on the shell of the storage tank to receive sound waves coming out of the tank. Each sound wave is stored and the source of the noise is calculated by software. The sounds that can be associated with a general corrosion activity have a very high frequency. The data are processed in order to map the places where corrosion activity is found and to determine the density of the corrosion activity. The technique makes it also possible to determine different grades of corrosion activity, going from grade A (very small) to grade E (high corrosion activity). As a function of the established corrosion activity it can be decided to perform immediately an internal inspection on the storage tank (in case of grade E), to reschedule the next internal inspection to an earlier date or to repeat the acoustic emission measurements after a certain period.

The acoustic emission technique also allows to detect leaks. These leaks are detected at other frequencies than the frequencies at which the general corrosion activity is detected. This technique makes it possible to detect small perforations in the tank bottom.

Another technique to achieve an indication of certain corrosion phenomena is “long range ultrasonics”. This technique admits to achieve a qualitative image of the status of the annular bottom plates (not from the entire tank bottom) by using guided waves.

These external inspection techniques do not gather (quantitative) information about the corrosion velocity and can‘t be used to enlarge the inspection interval that is based on the corrosion velocity.

9. Applying leak detection techniques

Several techniques can be applied to detect a leak in the bottom of a storage tank while the storage tank is in duty.

A possible leak detection technique exists of cables placed in the underground at fixed distances. The conductivity of these cables changes if a product is detected in the underground.

Larger leaks can be detected by looking for abnormal deviations in the fluid level in the storage tank. If a continuous level measurement is installed on the storage tank, it is possible to install an extra alarm in the control program. The alarm is generated when the fluid level decreases when there are no pumping activities out of the storage tank.

Toxic release in a frozen food warehouse

April 23, 2005

Nemours – [Seine-et-Marne] France

Toxic leak
Food industry
Refrigeration / Ammonia tank
Organisation
Training
Work
Emptying

THE INSTALLATIONS IN QUESTION

The company and the administrative context:

The company concerned by this report stores, packages and distributes food products. It operates several hundred frozen food stores.

Located in the Nemours industrial estate near the A6 motorway (Nemours rest stop), the establishment employs 236 people and consists of 2 buildings separated by a public thoroughfare:

- ✓ A "Distribution Platform" built in 1979 and expanded in 1984, which houses a packaging workshop and a cold room using a halogenated refrigerant.
- ✓ A "Storage Logistics Warehouse and Workshop", built in 1987, which houses a laboratory and a cold storage facility coupled to a refrigeration installation operating with ammonia (NH_3); these installations contain a maximum of 2 tons of NH_3.

The public is received in a 360-m^2 store reserved for frozen food products.

The Nemours establishment is governed by a prefectoral order dated October 15, 2003, authorising it to continue operating its installations. This order clearly stipulates the provisions of the Ministerial Order of July 16, 1997 relative to refrigeration installations using ammonia as a refrigerant.

The installations concerned:

The equipment responsible for the accident was a pressure tank, identified as No. 0935. Its rated capacity is 450 kg of NH_3. Its maximum service pressure is 32.5 bar and its operating temperature between -20 ℃ and +50 ℃.

The tank was equipped only with filling and drainage valves and was not equipped with any pressure accessory such as a "pressure gauge" or "safety valve" (see photo).

The tank was rented from a chemical product importer/distributor by the service provider in Nemours. This order did not require that a tank filling procedure be provided. The service provider was however required to attend certain internal training programs held on the distributor's premises.

According to the equipment log, the pressure tank had undergone hydraulic testing less than 5 years ago, in compliance with the provisions of article 13 c (bis) of the order of dated July 23, 1943.

THE ACCIDENT, ITS BEHAVIOUR AND CONSEQUENCES

The accident:

Safety improvement operations on the refrigeration installation were scheduled April 20 to 26, 2005 in order to replace the condenser and the valves on the cold production system in which the NH_3 circulates under pressure.

In order for these operations to take place in the proper conditions, part of the NH_3 had to be emptied from the installation. The operation took place on Friday, April 22nd. Of the 2 tons of fluid in the circuit, 500 kg remained isolated in the "evaporator" portion not concerned by the operations, 1,500 kg of NH_3 at - 18°C being transferred into four 450 kg tanks rented by the subcontractor specialised in maintaining and monitoring refrigeration installations.

Three full tanks and a fourth half empty were then stored outside the warehouse under guard.

One of the tanks burst Saturday, April 23, 2005 at 11.50 am, releasing 450 kg of NH_3. None of the tanks had been handled during their storage period.

The consequences:

A toxic cloud effected roughly one hundred people in the industrial estate, including 21 warehouse employees, and third parties parked in the rest area 200 m from the tanks.

The internal contingency plan was initiated at 12.15 pm.

Significant human and equipment resources were put into action: including roughly one hundred firemen, forty vehicles and 2 helicopters. The rescue services reported 52 victims, 28 of which were hospitalised that evening for analyses, 5 being more seriously effected: 2 *gendarmes*, 1 truck driver in the warehouse and 2 individuals suffering from asthma.

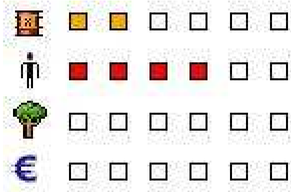
A security perimeter of 150 m was set up, a road was blocked off and lighted sign messages indicating "rest area closed, close car windows and stop fans" were set up on the motorway.

Firemen equipped with PBA diluted the NH_3 fumes with ""peacock tail" fire nozzles, one near the ruptured tank and a second directed toward the road to shield the nearby rest area. In order to maintain a sufficient retaining capacity during the operation, the dilution water collected in a 300-m³ basin were released into the network after its pH had been controlled (8 to 9); 550 m^3 of water was used and released after the pH check. The NH_3 tanks still intact were transferred to the refrigeration unit.

The rest area was reopened at 9.26 pm. The rescue services ended their intervention at around 10 pm. The store resumed its activities Sunday, April 23rd.

European scale of industrial accidents:

By applying the rating rules of the 18 parameters of the scale made official in February 1994 by the Committee of Competent Authorities of the Member States that oversees the application of the ‘SEVESO’ directive, and considering the available information, the accident can be characterised by the following 4 indices.



The parameters that comprise these indices and the corresponding rating method are available at the following address: http://www.aria.ecologie.gouv.fr

The 450 kg of ammonia released into the atmosphere represent 0.23 % of the corresponding Seveso threshold (200 t), or level 2 of the "quantities of dangerous materials released" index according to parameter Q1 (0.1 to 1%).

Three parameters are used to determine the rating of the "human and social consequences" index: H3, H4 and H5.

Parameter H3 is 0, no deaths occurred as a result of the accident.

Parameter H4 is also level 0, no one was seriously injured.

Parameter H5 is level 4, 28 members of the public were effected and hospitalised as a precaution.

As a result, the overall "Human and social consequences" rating is 4.

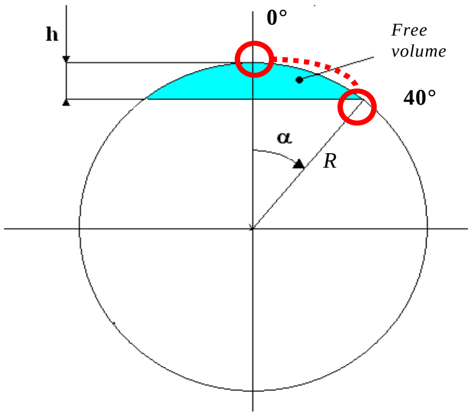
ORIGIN, CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

The rupture of the pressurised tank was the result of abnormally high pressure in the tank as a result of overfilling.

Considering the significant variation in temperature during the storage period of the NH_3 drained from the refrigeration installation, the dilation of the liquid contained in the tank increased the pressure and ruptured the tank.

These "multipurpose" tanks and their filling method may be the cause. These tanks were actually designed to store liquefied gas or liquids. The filling rate is thus able to vary between 85 and nearly 100%.

The coefficient of 85% is obtained by aligning one of the 2 painted marks with 40° angle on the side o f the tank. The operator can thus position the eduction pipe (built into the tank) allowing the NH_3 to discharge before the entire available volume is filled up. The tank's positioning is thus extremely important as shown in the following diagram:



It was noted that, due to the design, the end of this discharge tube is a variable distance from the cylinder wall: It cannot thus fulfil its role with precision.

Next, one must admit that the volumetric method used to transfer product cannot adequately guarantee filling of tanks more than 430 kg. This quantity is very close to the tank's maximum quantity, particularly during filling operations at very low temperatures (-18 ℃).

Furthermore, the procedure provided did not correspond to the tank model used, and thus to the marks indicated on the body of the tank.

Finally, the probability of error was increased by the multitude of various types of position marks (corresponding to various operating modes: filling, transfer, storage or drainage) without documents being provided explaining their meaning, and thus their use.

Furthermore, accidental mixing of incompatible substances cannot be fully excluded between 2 successive uses. In this case, just the presence of water after possible rinsing and insufficient drying is incompatible with the "refrigeration quality" (minimum purity 99.95%) of the anhydrous NH_3 or R 717.

ACTION TAKEN

Administrative and penal actions:

Following this accident, the Prefect required the operator to conduct the following within a period of 2 months:

- complete its danger study with a precise evaluation of the possible consequences of a similar release with a proposal of measures to reduce the consequences of a similar leak
- reinforce its internal contingency plan
- review its procedures concerning its filling operations

Next, within the scope of regional action, the prefect initiated a complementary order outlining organisational and technical provisions intended to reduce the probability of an accident. In compliance with the conclusions of the *Pôle National d'Expertise des Appareils à Pression*, the quantity of NH_3 introduced into the tank must be weighed when the operation is not performed in a confined environment.

Finally, a legal procedure must determine the levels of responsibility of the players involved in the accident.

Technical actions:

The operator, after having considered several provisions designed to reduce the distances of effects in the event of a similar accident, built a dedicated NH_3 storage facility adjoining the machine room, capable of resisting heat flux and equipped with appropriate detection equipment. In case of a similar maintenance operation, the NH_3 tanks shall be placed in this facility. In the event of a leak, the toxic releases shall be automatically directed to the machine room stack via a trap, thus reducing the exposure of personnel, and allowing the toxic plume to be channelled and sufficiently diluted.

From the organisational point of view, the operator reinforced its internal contingency plan and reviewed its maintenance procedures by paying particular attention to greater formalisation of the NH_3 tank filling and draining procedures.

LESSONS LEARNT

This accident highlighted certain procedures for handling liquefied toxic gas which could present significant dangers, and not explicitly outlined by the Ministerial Order of July 16, 1997 or by good practices.

From the equipment point of view, one could question the use of simple "multi-purpose" tanks, not equipped with a safety valve or other pressure or fill limiting device and which is not maintained in a safety position by a metal frame (as the majority of NH_3containers).

From the organisational standpoint, it would appear that this type of handling requires much stricter procedures than those currently in place.

At any rate, this feedback has lead the Ile-de-France DRIRE to propose a additional requirements at the regional level regarding prefectoral orders, requiring that operators comply with a certain number of organisational and technical provisions aiming to reduce the probability of a similar accident, notably by weight a container to ensure the quantity of fluid introduced in the tank as soon as the operation is not performed in a confined environment.

Sudden fracture of a pipeline immediately upstream of an oil terminal

13 December 2004

Nanterre – [Hauts de Seine]

FRANCE

Soil contamination
Pipeline
Gas oil
Dismantling
Safety management systems
Mapping
Successive operators

THE INSTALLATIONS IN QUESTION

Site

The operator was the owner of a 20,500 m^2 stretch of land, on which another company had run a lubricant manufacturing and packaging activity until June 1995 and was subject to the classified facility legislation.

Site clean-up operations under the supervision of the operator were underway since July 2000.

As part of the operations termination procedure, an additional prefectoral decree of 11 June issued within the framework of site rehabilitation set out the objectives of the site clean-up operations.

Further to these operations, the dismantling of the building and the facilities was initiated at the end of the 2004.

An oil depot classified top tier SEVESO facility, another lubricant storage unit, as well as a T22 pipeline terminal with its transport pipes were located inside the industrial area close to the site. The "Paris - Le Havre" pipeline cut across this industrial area and ended at the T22 Terminal. Downstream from this T22 terminal, three distinct pipelines transporting gas oil, domestic fuel and petrol were operating.

This segment of the "Paris - Le Havre" pipeline was constructed in the early 1950s to supply the Nanterre petrochemical complex (lubricant and fuel depot).

THE ACCIDENT, ITS BEHAVIOUR, ITS EFFECTS AND CONSEQUENCES

Accident

As part of the ongoing dismantling of a lubricant depot, a subcontractor disassembled surface pipes, as well as their concrete foundations on **Monday 13 December 2004**. During these operations, the removal of one of the blocks led to severing a segment of underground pipe that neither the site operator nor the subcontractor knew about. In reality, this pipe was one of the three pipes supplying oil products to the Nanterre depot from the T22 terminal of the company operating the pipeline.

The site being dismantled was located just downstream from the terminal of the company operating the pipeline, and at 100 m upstream of the oil depot.

This fracture had no immediate consequence since there were no liquid hydrocarbons being transported at that time. The works contractor considered this pipe to be one of the numerous old decommissioned pipes of the site.

On the morning of December 15 around 11.00 a.m., a gas oil delivery intended for this depot was conveyed through the pipe that had been partially severed 2 days earlier causing an oil spill in the site being dismantled. The construction superintendent of the works company noticed this hydrocarbon spill and promptly informed the oil depot manager. After arriving on site, the oil depot manager ordered an emergency shut down of the transfer. The leak lasted for about 40 minutes.

At 11.55 a.m., the Paris fire department and the police arrived on site to implement the first emergency measures (danger area, pumping, floating boom at the docks, etc.).

Around 2.15 p.m., two specialised companies came to pump the hydrocarbons. At 4.00 p.m. the Paris fire department left the premises.

Consequences

✓ Nearly 370 m^3 of gas oil was spilled on the stretch of land being dismantled. The hydrocarbons seeped into the soil to reach the water table that is 4 meters deep. However, no immediate or medium term pollution was observed in the neighbouring docks of the Seine. Pumping equipment was set up by the various players involved and the operation was coordinated by the fire department right from the afternoon of 15 December on the site being dismantled and in the nearest drainage network. On the evening of 16 December, the pumping equipment helped in recovering 55 m^3 of spillage. About three months following the accident 70% of the products had been recovered.

Photo TOTAL

✓ The supply of oil products (gas oil, domestic fuel and petrol) by the pipeline to the SEVESO oil depot was suspended for about a month until the three 9 inch pipes running from the pipeline terminal to the oil depot were made compliant again.

ORIGIN, CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

The three pipes supplying the depot were installed in 1952 during the construction of the oil terminal. Their diameter was 9 inches and the pipes were directly buried in the ground without an underground warning mesh. During site clean-up and dismantling operations, the external company designated by the site owner was in possession of a work order, an excavation order and had previously sent a formal notification of intent to commence works to the concerned bodies (mainly the neighbouring oil depot, the company operating the pipeline, the Nanterre Town Hall, etc.) in compliance with the regulations in force.

Unfortunately, the existence of these transport pipes was not clearly mentioned in the administrative and technical files drafted on the occasion of the works.

European scale of industrial accidents

By applying the rating rules of the 18 parameters of the scale made official in February 1994 by the Committee of Competent Authorities of the Member States which oversees the application of the 'SEVESO' directive, the accident can be characterised by the following 4 indices, based on the information available.

The parameters that comprise these indices and the corresponding rating method are available at the following address: http://www.aria.ecologie.gouv.fr.

The index concerning the quantity of dangerous materials released is set at level 3 because of the 370 m^3 gas oil spill (parameter Q1 - 312 t rejected i.e. 1.25% of 25,000 t of SEVESO top tier).

Level 1 is attributed to environmental consequences due to the 2,500 m^2 of polluted soil requiring cleaning and excavation of nearly 1,800 tons of polluted soil (parameter Env 13).

The economic consequences rating is set at 4 and includes cost of damaged external material that stands at 550 k Euros for the overhaul of the 3 pipeline segments (parameter € 17); the total cost incurred is 1.5 million euros and that includes site clean-up operation, production losses and material damage.

Lastly, there are no known human and social consequences.

ACTIONS TAKEN

By the classified facilities inspection authority

- On the one hand, an emergency prefectoral order notified on 21 December 2004 required the last operator of the site to:

- ✓ Submit a new hydrocarbon pollution diagnostic study of the site (soil, sub-soil, underground water)
- ✓ Inspect thoroughly the water table on a weekly basis
- ✓ Supervise the site by designating a site guarding company
- ✓ Draw up a detailed inventory of underground pipes before proceeding with any new excavations.

- On the other hand, perform detailed inspections on the safety management systems especially for 2005 on the "pipeline-oil terminal" interface, as well as 2006 on external companies carrying out operations in top tier SEVESO facilities.

By the authority in charge of inspecting pipes

- ✓ An inspection of the three pipes by a competent body in compliance with the guidelines indicated by a professional body in the oil industry to check the pipes for scratches, sinking, tensile stress or unacceptable buckling except in the severed segment
- ✓ Replacement of the severed pipe segment and X-ray inspection of the tie-in welds
- ✓ The technical analysis of the operating mode of the three pipes with a view to re-commission them and the drawing up of a technical and administrative file to prove the facility's compliance with the safely requirements of 1 October 1959 or 21 April 1989 depending on the case.

By the Nanterre Town Hall

- ✓ A motion to appoint an expert at the administrative court.

LESSONS LEARNT

The lesson to be learnt from this incident is more of an organisational kind than a technical one.

The inspection must have observed that the hydrocarbon pipes between the terminals of the operating company and the oil depots were likely to run through private or public property without the owners or the concerned authorities being aware of their existence.

An efficient document management system e.g. plans of facilities at risk is an important criteria when dismantling and excavation operations are carried out on an old site by external companies.

The successive changes of operators in a very old site operated since the 1930s, as well as the transfer of the oil depot between the two operators in 1995 resulted in a loss of information among the various parties in question.

There was a serious lack of communication and information among the various parties involved (land owner, pipeline manager, oil depot operator, external company, etc.).

Apart from the administrative and organisational aspect, the Inspection of Classified Facilities as part of the inspection of safety management systems as of 2005 played an active role in furthering the monitoring capacities of the automatic reception of oil products by pipelines inside oil terminals of top tier SEVESO facilities as well as the interface between the transporter and oil depot.

After this inspection campaign, oil depot operators were asked to improve and reinforce their monitoring capacities right from the filling phase of a tank upon reception of product to detect any leak under pressure.

The following proposals were made to improve the facilities and make them compliant:

On the technical level:

- ✓ Installation of hydrocarbon detectors at the manifold of the transporter terminal.
- ✓ Ensuring air tightness of transfer zones (above-ground transport pipes) and reception zones (transporter terminal manifold).
- ✓ Installation of additional technical equipments such as sound/visual remote alarm in the operating premises of the oil terminal that indicates the start of the tank filling phase.

On the organisational level:

- ✓ Reviewing organisational procedures related to monitoring reception by pipeline during and after working hours with a focus on the critical tank filling phase, e.g. :
    - o Increasing the frequency of inspection rounds.
    - o Continuous monitoring and traceability of tank level readings by technicians or the guarding company.
- ✓ Drawing-up of a formal protocol defining the roles and responsibilities of the transport pipeline and oil terminal operators.

Conclusion

Denis Dumont

Head of the Bureau for Analysis of Industrial Risk and Pollution (BARPI)

After two days of interaction and discussions, our seminar has come to an end and I have the honour of giving the closing address

First of all, may I underline that with this 7th edition bringing together 230 participants, and 23 States and presentations made by 7 countries, our seminar has attained a certain level of maturity. The IMPEL network has truly acquired a full-scale European dimension.

I would like to thank all those who contributed to the success of this event and especially the German, English, Belgian, Italian, Dutch, Swedish and French participants who agreed to make a presentation. The high-quality and pertinence of their speeches were greatly appreciated. Through our publications, these presentations will contribute to the awareness campaigns for all players in the risk prevention sector.

I would also like to thank the Chairpersons of the sessions, as well as all participants, who, by way of their questions, view points and the discussions that naturally followed contributed to furthering our thinking.

May I also thank DRIRE Ile de France, its regional Director Philippe LEDENVIC and his team, in particular Jane SILVERT, Fabienne RAGACHE, Romain LAUNAY and many others who have made endless efforts to welcome us in such excellent conditions.

Last but not the least, I also thank the BARPI staff: Adèle HEUDIER, Christel ROBERT, Marie-José TRUCHOT, Gérard CARTAILLAC and other project managers for having prepared the documents on the resemblances with other accidents in the ARIA database.

The typologies of accidents are rarely new. Accidents tend to draw from human organisational errors to repeat phenomena that are often already well-known.

Without recalling the numerous aspects that contributed to furthering our discussions, I would like to emphasize a few topics:

- Persistence of major hazards
- Aging of industrial facilities
- The importance of the human factor in accident mechanisms
- The special place of work done on facilities these mechanisms

1° THE PERSISTENCE OF MAJOR HAZARDS

Accidentology examined during these two days confirms that the operation of dangerous processes inevitably comes with the probability of a major accident. Even if this risk is brought down to a strict minimum, it can never be totally eliminated. This is due, on the one hand, to the energy and toxicity potentials in the facilities, and on the other, to the limitations in human organisation with regards to our unclear position in the sequence of events triggering the accident and taking effective, timely action.

The crop protection product fire at BEZIERS, the petroleum product fire at BUNCEFIELD, the BLEVE of tank trucks at DAGNEUX and on another scale, the rupture of the ammonia container at NEMOURS have taught us the lesson.

Despite the efforts made in reducing risks, we must always be aware of the quantity of dangerous material in our processes. This is an unavoidable dimension in risk management. From this arises the logical question: does our society need to foresee other major accidents and prepare itself accordingly?

Engineers and technicians must not only have an unfailing sense of determination to reduce the frequency and severity of accidents but also have a sense of modesty when it comes to accepting the limitations of their actions and doing their duty of informing the civil society of the ever present residual risk.

2° AGING OF INDUSTRIAL FACILITIES

The cases concerning the sudden failure of facilities were the highlights of our seminar even though the topic was raised with much restraint in danger surveys due to the low probability of occurrence. Several alarming cases of facility destructions that were not properly supervised and maintained were discussed in our previous seminars.

These cases are not as rare as we would like them to be and affect SEVESO facilities just like others:

Bursting of a petroleum tank at GONFREVILLE in 2004, at KALLO in 2005 and more recently at AMBES last January:

- bursting of a phosphoric acid tank at GRAND-QUEVILLY in 1999,
- corrosion of gas pipes at LA MEDE in 1992,
- as well as cereal silos that collapsed under the weight of the contained matter.

It is advisable to be cautious of aging facilities; time takes its toll on the initial safety margins. Inspection and maintenance programmes directly influence the awareness and restoration of these margins. They help players in positioning themselves in the sequence of events resulting in the collapse of these facilities.

This is undoubtedly a critical aspect in the inspection of old facilities.

3° THE IMPORTANCE OF THE HUMAN FACTOR

Managing safety also implies managing the complexity of processes and the related preventive measures. This calls for appropriate “adaptation” of these measures by managers, operators and possible sub-contractors.

Whether it is the non-compliant execution of plans, or non-observance of operating procedures or guidelines or lack of communication between the involved players, the “human and organisational” factor is omnipresent in the accident chain. This is illustrated by the MARTIGUES, ND GRAVENCHON, SAINTE MARIE de la REUNION and GOTEBORG accidents to name a few.

On this account, the European directive Seveso emphasises the need to rectify basic failures observed on site before they become serious enough to lead to a major accident.

In France, this initiative is stipulated by the order dated 10 May 2000. It is based on a process aiming at constant improvement that consists in

- detecting these basic failures at their origin
- recording and analysing them with a view to optimise the technical and organisational operations and their follow-up in time.

All this tends towards promoting better communication and management in companies and ensuring the on-site application of the SGS regulatory provisions.

4) THE PROBLEM OF WORK DONE ON FACILITIES

Whether it is the un-commissioning of the "chlorine transport pipe" at CHAMPAGNIER, valve replacement on the grease box circuits at ST–AVOLD, assembly of a temperature sensor during the major shutdown at ND GRAVENCHON or dismantling of pipes at NANTERRE, the problem of work done on facilities is very manifest in the accidents examined. It is a recurring weakness in risk prevention.

This problem accounts for 30% of fatal casualties recorded in the ARIA database whereas the work phases are far from representing 30% of the service life of facilities.

The most frequently identified weaknesses include:

- poor prior assessment of risk,
- sharing conclusions of this analysis among managers, operators and sub-contractors,
- organisation and supervision of work site,
- un-commissioning and re-commissioning of facilities
- commissioning of work
- as well as precautions to be taken during re-commissioning

The work done on the facilities constitutes a significant area for SGC inspection.

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I hope that this two-day seminar has provided you with useful guidelines for inspecting facilities and examining danger studies but also spreading general awareness on the realities and limitations of risk prevention

The IMPEL network helps us stay better informed when faced with commonly encountered problems and be more efficient in carrying out our day-to-day jobs. I hope that we will be able to further this exchange without having to wait for our next seminar at the end of 2008. I look forward to welcoming you in large numbers.

I thank you for your attention and the cordial atmosphere enjoyed throughout these two days.

Thanks

List of the persons having contributed by their documentation, their participation and their assistance to the good progress of the seminary and to the elaboration of this document :

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