

Rupture of a phosphoric acid storage tank

23rd April 1999

Rouen (Seine Maritime)

France

Acids
Storage
Corrosion
Ageing
Organisation / Procedures
Inspections / Equipment
verification
Maintenance

THE FACILITIES INVOLVED

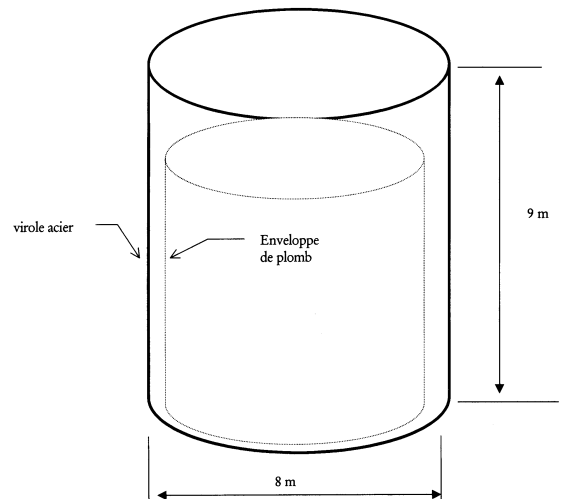
The site:

The factory is divided into 2 parts. The facility was used within a special context : it was scheduled for shut-down in the short term; the workshops were to be transferred to the other part of the factory, where fertilisers are manufactured.

The involved unit:

The unit is a 450 m³ overhead phosphoric acid storage tank used to run a production series lasting 3 to 4 weeks per year. At the time of the accident, the tank had just been placed back into service and contained approximately 350 m³ of product,

The tank was made of a steel casing lined with lead sheeting to ensure a hermetic seal in relation to the structural casing. This tank, measuring 9 meters high by 8 meters in diameter, was correctly dimensioned to contain phosphoric acid at atmospheric pressure. The retaining basin consisted of a slab (thickness: 15cm) and retaining walls (thickness: 15cm at the base, 10cm at the top). The entire structure was made of reinforced concrete. The mechanical resistance at the slab-wall intersection was ensured by two metal brackets made of 10mm steel round stock placed every 20 centimetres.



THE ACCIDENT, ITS CHRONOLOGY, EFFECTS AND CONSEQUENCES

The accident:

On that friday afternoon, the casing of the tank suddenly ripped. The violent release of the acid caused the concrete retaining basin to rupture. Traces left of an adjoining wall show that the wave was several meters high. Most of the acid spread over the ground and in the bulk fertilizer warehouses.

Upon discovering the accident, the plant watchman immediately closed off the wastewater system with a guillotine valve designed for this purpose. The manager on duty informed the regulated facility inspectorate by fax.

The pumped liquid was being stored for recycling in the acid-resistant tanks located within the phosphoric acid shops of the fertiliser production plant. The entire amount of natural phosphate deliberately spread on the floor in order to absorb the acid was stored onsite and will be subsequently used as an input material in the production areas at the other part of the plant devoted to complex fertilisers.

The wastewater network remained isolated for several days following the accident, then was flushed into the zone affected by the spread off product prior to the restart of the installation.

Consequences of the accident:

Since the accident occurred on a Friday evening, it caused no victims.

By having closed the slice valve, the accident did not generate any surface water pollution; however, higher phosphate content was observed in both the soil and groundwater. The responsibility of monitoring phosphorus concentration in the groundwater was assigned to the site operator.

The European scale of industrial accidents

By applying the rating rules applicable to the 18 parameters of the scale officially adopted in February 1994 by the Member States' Competent Authority Committee for implementing the 'SEVESO II' directive on handling hazardous substances, and in light of the information available, this accident can be characterised by the four following indices:

Dangerous materials released		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Human and social consequences		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Environmental consequences		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Economic consequences		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

The parameters composing these indices and their corresponding rating protocol are available from the following Website: <http://www.aria.developpement-durable.gouv.fr>

The overall "Hazardous materials released" index was scored a "0", given that phosphoric acid is not a substance within the scope of the SEVESO Directive.

No human consequences arose, meaning that the "Human and social consequences" index was rated a "0".

Since the materials involved in the accident were recovered and treated onsite and moreover no quantitative information was provided on the level of soil and groundwater pollution, the "Environmental consequences" index could not be scored.

Lastly, with no information available on the economic consequences of this accident, the corresponding index was not scored either.

THE ORIGIN, CAUSES AND CIRCUMSTANCES SURROUNDING THE ACCIDENT

For the follow-up of its units, the company operates an inspection department and a maintenance department. The inspection department had checked the tank in anticipation of its return to service after 8 months of inactivity and reported a lack of material on the first ring of the structural casing. The department recommended that a thorough inspection be conducted to determine the zone of the internal casing which was at the origin of a probable acid leak and to conduct a series of thickness measurements on the external casing in order to determine the extent of the corroded area. In order to ensure a seal, the maintenance department decided to add an internal casing made of 6mm-thick polyester sheeting reinforced with an anti-acid skin. On the exterior, the lack of material was compensated by the installation of a metal plate banded onto the tank by two slings. These repairs were subjected to a water resistance test for 24 hours. The tank was placed back into service two days later and the first production operations were launched in the afternoon prior to the accident.

The post-accident assessment revealed the following defects :

- √ On the 5 rings which make up the cylinder:

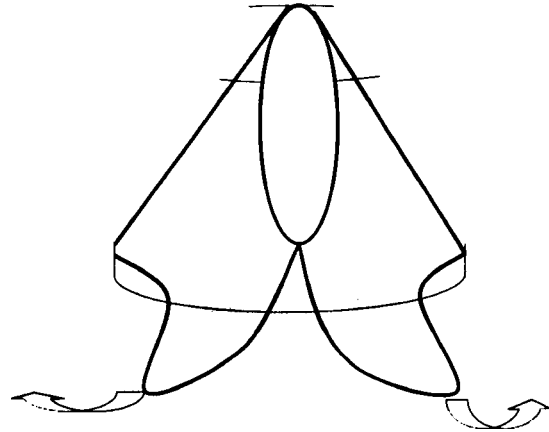
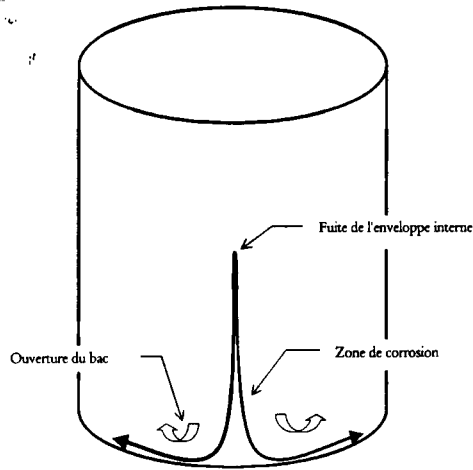
Lack of metal on the generatrix of the lower ring of the structural casing, significant thickness loss on the following three rings along the same generatrix, and a rip in the structural casing along this generatrix.

- √ On the tank floor:

Significant corrosion was noted at the foundation skirt junction level; a symmetrical opening of the foundation skirt junction in relation to the cylinder's corroded generatrix.

There was a failure in the seal which initially occurred on the internal casing at the level of the 4th ring of the structural casing. As both casings were not bonded, the acid leak was routed vertically causing the corrosion along a generatrix and then along the foundation skirt junction. The repair carried out by the maintenance department did not correct the weak point between rings 2 and 4 of the cylinder.

Furthermore, the pressure exerted by the acid is far greater than that exerted by the water during the resistance test (1,640 kg/m³ for phosphoric acid). The rupture occurred suddenly and the wave effect created pressure on the retaining walls must be greater than the hydrostatic pressure. In addition, defects were discovered in the concrete reinforcement: the reinforcement bars were not correctly attached.



Destroyed reservoir (Source DRIRE)

ACTIONS TAKEN

An emergency action order was initiated which called for the suspension of all site activities. On the one hand, it requested an analysis of the causes and consequences of the accident and ordered, on the other hand, the definition of an inspection plan for all of the tanks and associated retaining basins located on the site.

The damaged tank was not returned to service. As the storage requirements for phosphoric acid were limited to 3-4 weeks, the operator wanted to use another tank normally used to stock sulphuric acid.

The nature of the internal casing of this tank allowed a product change to take place without risk. Furthermore, this tank would contain only the quantity of phosphoric acid strictly required, or 45m³. A certain number of verifications were performed on the replacement tank: inspection of the tank by the inspection department, hydraulic test with water filled to the maximum level, rework of the seal on the retaining basin, external signage on the tank in relation to its new contents. Production operations were resumed in late July 1999. The site was totally shut down in late December 1999 and is disassembled from year 2000.

LESSONS LEARNT

The special context in which the plant was operating (last production series) did not incite the operator to rigorously apply the establishment's operating procedures. The measures recommended by the inspection department should have been carried out prior to a joint definition of the repair program.

The accidents occurred due to hasty repairs which were performed without respect for the existing instructions. As the accident occurred on a Friday evening, there were no victims. The consequences on the environment were limited owing to the guillotine valve on the wastewater network and the spreading of natural phosphate on the ground to absorb the spent acid.