Rupture of an oxygen pipeline
13 June 2010
Richemont (Moselle)
France

Chemical engineering manufacture
Oxygen
THM/pipeline
Clean break
Corrosion

THE FACILITIES INVOLVED

The site :

The site is a top-tier Seveso classified air liquefaction plant subject to Prefecture approval, in accordance with the French regulations regarding classified facilities It is located in Richemont and is operating several high-risk installations, including :

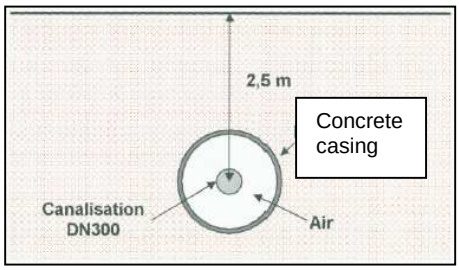
- a cryogenic production unit
- a splitter (diffusion column)
- storage units for argon, nitrogen and oxygen.

The company also owns a 600-km pipeline network for transporting chemical products within the Lorraine Region (forming a 1,600-km pipeline coverage nationally). The infrastructure is used to supply nitrogen (a gas critical to industrial safety) to many local industriesas well as hydrogen and oxygen, two other raw materials vital to industry.

The pipelines have been declared in the prefectural order under a private law regime and no declaration of public interest was required.

The unit involved :

The accident involved the underground gaseous oxygen pipeline, labelled "O_2 Richemont-Gandrange", operating under 40 bar of pressure and buried for 36 years within the site boundary at a depth of 2.5 m.



The pipe, with a nominal diameter of 300 mm (DN 300), is made of E24-4 steel (nominal thickness 4.9 mm / minimum thickness of 4.3 mm / maximum service pressure of 44 bar), featuring a spiral weld, coal tar pitch lining and cathodic protection (-1.4 V).

The pipeline was not internally inspected (e.g. by using an instrumented scraper), so as to maintain the highest purity of the transported industrial gases.

THE ACCIDENT, ITS CHRONOLOGY, EFFECTS AND CONSEQUENCES

The accident :

On 13 June 2010, the pipeline burst around 1:30 pm on the plant's premises at the boundary with public property, where the pipe pass in a concrete pipe underneath the railway that serviced the plant.

The site's internal emergency plan was activated within an hour after the break ; fire-fighting crews and the local gendarmerie were dispatched to the scene. The pipeline was safely isolated by shutting off a valve; by 2:30 pm, an O2 concentration of 26% was recorded 5 m from the isolated pipeline section. The operator duly informed the facility's clients and issued a press release at 6 pm.

Around 2 pm, the DREAL Office on call was informed of the break by the Prefecture, and the classified facilities inspectorate went on site.

Consequences of this accident :

The material damagesincluded :

- The oxygen pipeline, "rolled out" in a strip over 1 m, was immersed in water.
- A crater was formed (diameter: 7 m, depth: 3 m). The TNT equivalent was evaluated by the operator at 0.14 kg.
- Pieces of the railway, along with sludge and fragments of pavement and concrete, were projected some 50 m (1-kg debris found 60 m away and 15-kg pieces blasted 30 m).
- A concrete wall located a few metres from the pipeline was partially destroyed.
- The fence was twisted and damaged.
- No fire outbreak was detected on the tube structure, although the onset of combustion was observed on a 220/24 V transformer installed in an electrical utility room 3 or 4 m from the break.

DREAL - Lorraine

DREAL - Lorraine

The production unit was not affected by the incident.

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*' directive on handling hazardous substances, and in light of information available, this accident can be characterised by the four following indices :

Two parameters were used to determine the ultimate rating of the "Hazardous materials released" index :

- The quantity of O_2 released during the accident, in recognition that this combustive substance is listed in the *Seveso* Directive with a threshold of 200 tonnes. The quantity was evaluated at 180 000 m^3 or 257 tonnes, i.e. 13 % of the threshold, making the corresponding Q1 parameter equal to 4 ;
- The TNT equivalent of the explosion, assessed by the plant operator at 0.14 kg, places parameter Q2 at level 1.

The index relative to the release of hazardous substances was therefore set at 4.

Since the accident led to no human casualties, the index relative to human and social consequences was scored a "0".
Given that no environmental impact was recorded, the index relative to environmental consequences also received a "0" rating.
The economic consequences was evaluated at 1,05 M€, the index relative to the economic consequences equalled 2.

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

THE ORIGIN, CAUSES AND CIRCUMSTANCES SURROUNDING THIS ACCIDENT

The causes and circumstances related to this accident were only partially understood. Nonetheless, given that no works were being performed on the line and the absence of any impact from lightning, these two common causes could quickly be eliminated, as could structural fatigue, since all pipeline use reports and recordings would appear to dismiss any cyclical phenomenon like a pressure surge.


DREAL Lorraine

Corrosion seems to be the most likely source of this pipeline break. The metallurgical appraisal found the presence of generalised corrosion over a section where a casing crossed the alignment at the point of the accident, making it plausible to conclude that several factors acting in unison were the underlying cause :

- presence of an electrolyte (water), which moreover had a high chloride content
- delamination of the pipeline's anticorrosion lining
- defective cathodic protection
- an over-oxygenated atmosphere.

ACTIONS TAKEN

Another unlined O_2 pipeline together with a N_2 pipeline lined in concrete were also passing underneath the rail track, adjacent to the damaged infrastructure.

The nitrogen pipeline was supplying safety systems at several sites in the Lorraine region. Although it might have been damaged (by fragments or vibrations) inducing arisk of bursting later on, it could not be shut off without forcing the closure of downstream client installations.

The classified installations inspectorate, which received a comprehensive report on the accident (including the internal emergency plan) along with a technical file on the damaged pipeline, requested a number of follow-up measures, namely : introduction of a safety perimeter around the oxygen pipeline ; decrease in N_2 pressure ; and installation of a local monitoring camera.

A prefectural order, issued under the "pipeline legislation", confirmed these measures and furthermore requested expert appraisals on :

- geotechnical issues related to pipeline installation
- the metallurgical condition of the damaged tube and the origin of its break (emphasis on corrosion)
- delamination of the lining, as highlighted by the previous appraisal (results yet to be released).

In order to assess the generic vs. exceptional nature of this event the facility operator implemented a programme to verify all pipelines originating from Richemont displaying similar characteristics throughout the network.

LESSONS LEARNT

The initial expert reports pointed to a number of items, including : installation defects, soil/embankment quality, and differential settlement of poor-quality subsoil layers caused by the railway. Such phenomena should have been visible on the surface yet went unreported, according to the expert, who favoured the hypothesis of corrosion made worse by extended immersion due to the shallow (-2.2 m), fluctuating water table (fed by the Moselle River). The presence of sulphate-reducing bacteria or chlorides could explain the craters on the tubes' external surface.

The investigation also revealed defaults on the pipe form : most of the pipe was slightly flattened, except of thicker a section of pipeline 5 m from the break which had been formerly replaced and which presented different deformation. However, none of the observed mechanical deformation seemed to have an impact on the mechanical strength of the pipes.

The final metallurgical expert's report cited a combination of several factors : defective seal on the shaft, shifting water table level in the shaft creating medium discontinuities for the electrolyte as well as diminished cathodic protection, local deterioration of the lining with delamination of the coal tar pitch. The water reaching the coal tar pitch/steel interface, plus the onset of corrosion penetrating the pipeline and a micro leak of O_2, all helped accelerate this phenomenon.

Above the new segment of pipeline, concrete slabs were installed to distribute the load. The specifications issued in the geotechnical expert appraisal commissioned by DREAL were respected when burying the line.

The monitoring and maintenance plan was updated in order to take this feedback into account.

The other critical pieces of feedback worth noting consist of :

- Activation of the internal emergency plan (upper-tier *Seveso* site), and not the external emergency plan (as should have been the case with regards to the pipeline regulation), since the accident occurred on transport infrastructure at the boundary of plant premises, as opposed to an "plant pipe"; these boundaries need to be indicated in the safety reports, i.e. the degree of pipeline coverage in the internal emergency plan.
- The safety studies on installation techniques and local hydrogeology/geotechnics need to be complemented to better comprehend the "water table fluctuation" hazard and, more generally, all geotechnical aspects.
- The distances at which damage appear after such a "clean break": crater, wall, projections. Beyond having to verify the operator's safety report data, the zones encompassing significant lethal effects, sub-lethal effects and irreversible effects for this category of pipeline should be reviewed.
- Not including third-party works or landslides, corrosion can be the trigger event of a total pipeline break.

DREAL Lorraine