Propane leak on a sphere

June 14, 2004

Saint- Hervé [Côtes d'Armor]

France

Leak
LPG depot
Pressurised equipment
Propane
Small branch connection
Corrosion
Organisation

THE INSTALLATIONS IN QUESTION

The site:

The site involved is an LPG storage site having a storage capacity of 2,000m³, which includes a propane sphere. The sphere, dating back to 1974, was last in 2002.

The device at fault:

The lower branch connection of one of the horizontal lines, measuring 1" in diameter (schedule 80; O.D.: 33.4 and I.D.: 24.31 mm) formerly used for connecting a safety level system. Both of these branch connections, not equipped with valves and located approximately 2.50m below the top of the sphere, are made of A-181-1 grade steel (flange) and A-106-B grade steel (branch connection).

THE INCIDENT, ITS BEHAVIOUR, EFFECTS AND CONSEQUENCES

The incident:

The atmospheric conditions were calm on the day of the accident. The sphere contained approximately 630 t of propane. During one of the daily routine inspections of the propane sphere, an operator detected a slight whistling sound, characteristic of a gas micro-leak. There was a leak on the lower horizontal branch connection of the former high level system. The micro-leak (a leak measuring 3 mm long with an equivalent diameter less than 1 mm) could not be easily stopped as there was no valve at that location. On the previous round the day before, no anomaly was recorded.

The effects:

According to the operator's calculations, the quantity of the gas released is estimated as follows:

- Leak rate: 0.0065 kg/sec,
- Distance to LFL: 0.055 m.

These results were evaluated using the PHAST 6.2 tool for a free vertical propane release, oriented downward (product temperature 20 ℃, equivalent diameter ret ained 2 mm).
Considering the leak's flow rate (6.5 g/s, i.e. approximately 23 kg/h for an equivalent diameter of 2 mm) there is no measurable change of level in the sphere. The leak, which was located at approximately 16 m above ground level, did not create a flammable atmosphere at ground level.

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.

Dangerous materials released	■ □ □ □ □ □
Human and social consequences	□ □ □ □ □ □
Environmental consequences	□ □ □ □ □ □
Economic consequences	□ □ □ □ □ □

The parameters that comprise these indices and the corresponding rating method are indicated in the appendix hereto and are available at the following address: www.aria.ecologie.gouv.fr

In the absence of measurable variation in the level in the sphere and information on the duration of the leak, the value of 1 has been attributed to the index 'Dangerous materials released' (parameter Q1).

ORIGIN, CAUSES AND CIRCUMSTANCES OF THE INCIDENT

Following the incident, the operator requested that an expert assessment of the branch connection be conducted by an organisation specialised in metallurgy. The organisation's report concluded that a tube perforation occurred, measuring several mm, in the tube in the zone near the tube/flange junction weld (10 mm away). The perforation measured 3 mm longitudinally and was due to external corrosion associated with point where rainwater collected. The corrosion zone is a 50 mm plate oriented in the tube's longitudinal direction.

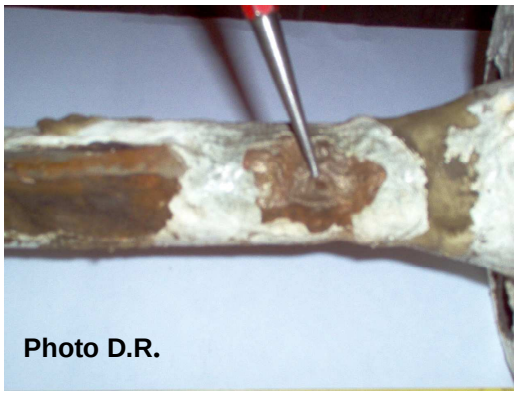
Photo D.R.

Material was lost on the external face of the tube indicating that the corrosion spread from the exterior toward the interior. Corrosion of the same type was observed on the tube's gusset weld although without perforation. The examinations performed show that the corrosion is cavernous and was initiated on the outside of the tube. Its propagation is isotropic in the structure.

No structural or chemical composition anomaly can explain the type of corrosion. The hypothesis by default in this case is that of a rainwater retention point owing to the geometric configuration. A stagnant drop on the "ceiling" triggers a differential aeration mechanism, known as the "Evans drop", resulting in local acidification. This leads to "blistering" of the paint at this point and localised cavernous corrosion of the substrate.

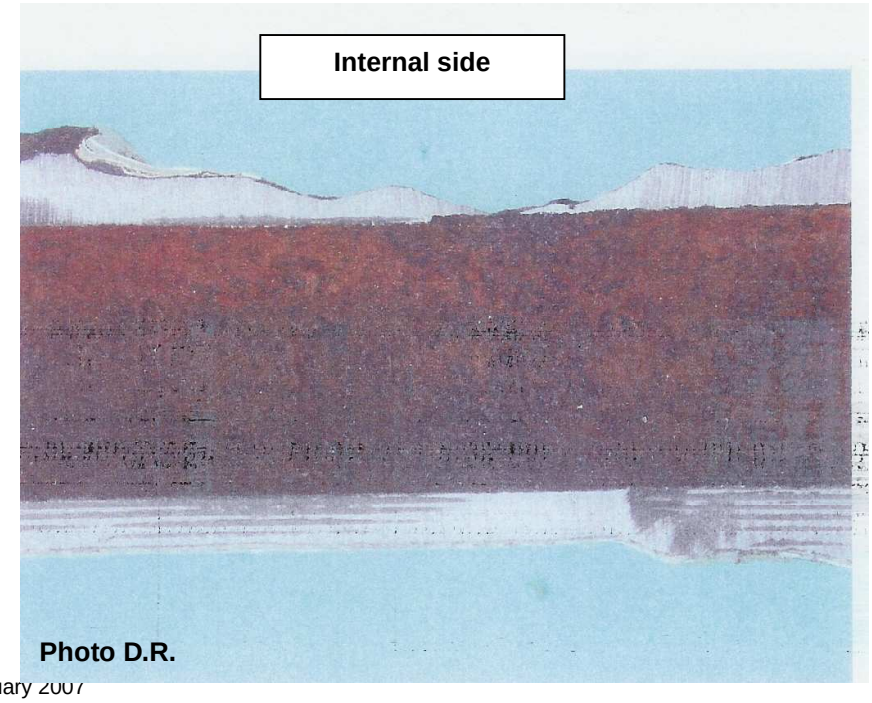

Photo D.R.

The leak occurred 21 months after regulatory hydraulic retesting. At this time, no anomaly was indicated in the inspection and corresponding test report. The sphere had been repainted. No specific information was indicated relative to the verification conditions (visual inspection) of the branch connections for the regulatory examinations.

ACTION TAKEN

The emergency measures taken consisted in ensuring that the leak was stopped using a resin and the installation of reinforcement collars. Two tests were conducted daily on this temporary repair using a foaming product designed for easy leak detection. This poses the problem regarding hostile environment "hot" interventions" (compensated by the fact that the leak was quite limited in volume and being released into the open air). However, appropriate intervention procedures exist for this type of anomaly.

The removal of the 2 tubes then required a series of more complicated operations:

- the sphere was drained, degassed and inerted.
- The operations, conducted by an external company, consisted in shortening the 2 tubes of the former gauging system and installing a welded flange at the end of each. The repair work had to be inspected, as per pressure equipment regulations (see photo opposite: branch connections repaired).

It should be noted that under normal conditions, piping that has become disused may be the cause of serious accidents: removing them improves overall installation safety. In this case, the spheres undergo heat treatments that are difficult to reproduce in situ when the wall of the sphere is directly effected.


Photo D.R.

LESSONS LEARNED

The leak occurred only 21 months after the regulatory pressure equipment inspection. Special attention must be given to small branch connections, in addition to the inspections foreseen by the pressure equipment regulations.

Corrosion perforated a thick section of steel (greater than 4 mm) on an overhead part which went undetected by the standard verifications operations. The phenomenon presented here illustrates their vulnerability. Small branch connections (of small diameter) have the drawback of being difficult to inspect. Adequate preparation of the inspections and tests must thus be foreseen.

While ignition of the product did not occur in this case, this incident illustrates the problem concerning leaks on parts that cannot be shut off (No manual or automatic device to completely control the leak likely to be supplied by the sphere's content).