

Fire and explosion of ammonia synthesis gas

1st June 2006

Billingham

United Kingdom

Ammonia
Joints
Piping
Valve
Organisation/Maintenance

THE FACILITIES INVOLVED

The site:

The plant primarily produces ammonium nitrate-based fertilizers; part of this process entails synthesising ammonia. The particular unit is located within the Billingham industrial complex, a site that falls under jurisdiction of the *SEVESO* directive for hazardous installations. The closest residences lie at a distance of 500 m from the scene of the accident.

The involved unit:

The unit involved in this accident was the ammonia synthesis column.

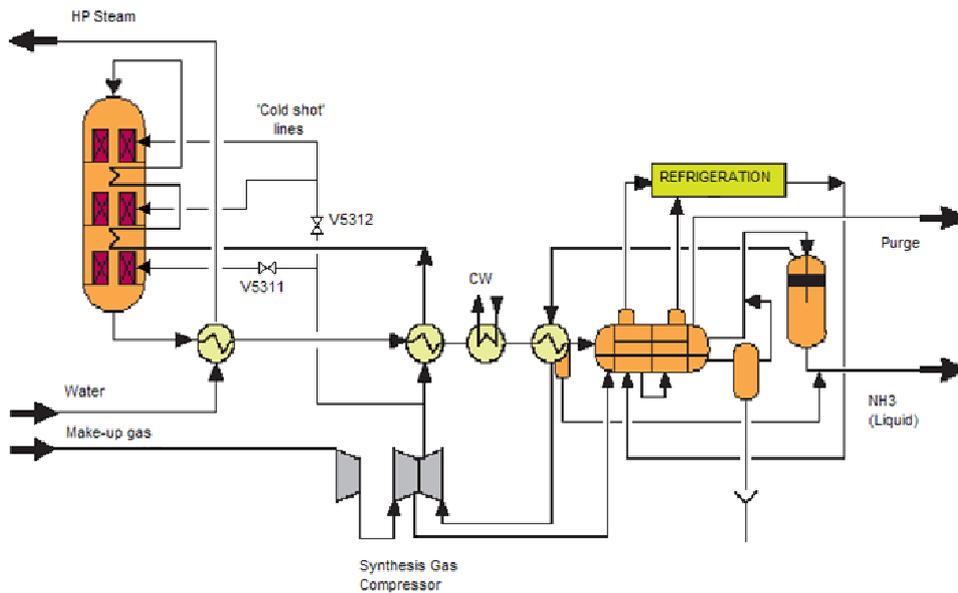


Figure 1 - Ammonia Synthesis

THE ACCIDENT, ITS CHRONOLOGY, EFFECTS AND CONSEQUENCES

The accident:

Around midnight on the night of Wednesday June 1st, 2008, an extremely flammable leak of a so-called "synthesis gas", containing primarily hydrogen, occurred on valve V5312 within the ammonia synthesis column.

The gas, released at a pressure of 220 bar and a temperature of 120°C, ignited spontaneously, forming two flame cones directed along the pipe connected to the valve. The pipe could not resist the heat from these flames; and under such internal pressure, it burst in freeing its contents, which in turn exploded. The quantity of gas released during the accident was estimated at 1.45 tonnes. The gas continued to burn for more than two hours, given the quantities found at the site when the fire broke out.

The consequences of this accident however remained confined to the zone adjacent to the valve.



The accident happened during a period of limited activity, with just one team of four technicians and a supervisor present in the unit. When the fire was detected, two technicians left the control room to isolate the valve. The pipe actually burst while they were still performing this operation. The pressure surge generated by the explosion was strong enough to knock one of them to the ground and send debris flying, a piece of which struck and slightly injured the other technician.

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 the information available, this accident can be characterised by the four following indices:

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

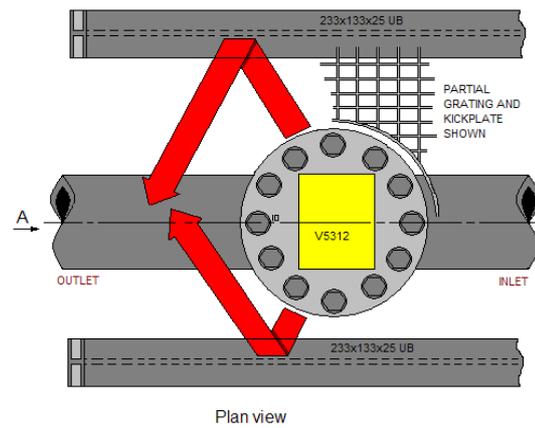
A level of 3 assigned to the "Hazardous materials released" index characterises the resulting gas discharge; 1.45 tonnes of synthesis gas were freed and since hydrogen represents 75% of the gas composition, this incident was the equivalent of losing approximately 1.2 tonnes of hydrogen, i.e. a tier in excess of 2% of the Seveso cap for extremely flammable gasses and liquids.

The number of slightly injured personnel explains the level 1 rating reached by the index relative to human and social consequences (parameter H5: 2 slight injuries).

The company estimated the economic consequences of the accident to be as follows: 6-week production loss, and the works required to restore the damaged unit to operability - in the vicinity of £2 million, i.e. approx. €3.3 million.

THE ORIGIN, CAUSES AND CIRCUMSTANCES SURROUNDING THE ACCIDENT

This accident was caused by a gas leak on the joint between the body and cap of a shut-off valve [V5312] on a pipe transporting synthesis gas. The valve, in the open position, was operating at full flow. The seal between the two parts, held together by 12 bolts, was applied to a metal-on-metal contact. Inspection of the valve indicated that gas had leaked in two spots prior to ignition, meaning that two distinct flames were produced.



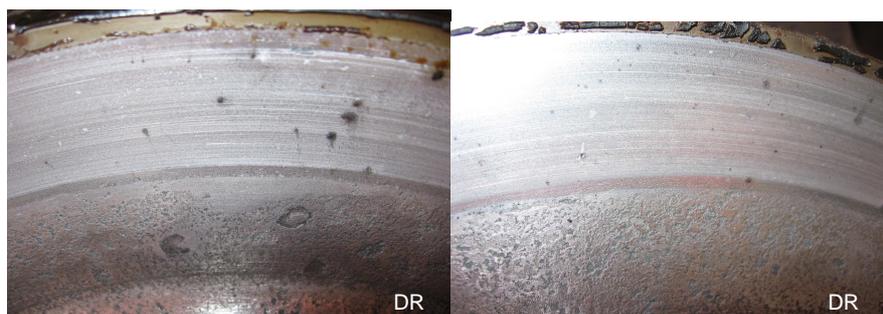
Given the layout of the structure's metal frame, one of the flames actually "ricocheted" off the side and reached the pipe on the outflow side of the valve, causing it to heat for some ten to fifteen minutes, before bursting open over a full metre and releasing gas at a pressure of 150 bar.



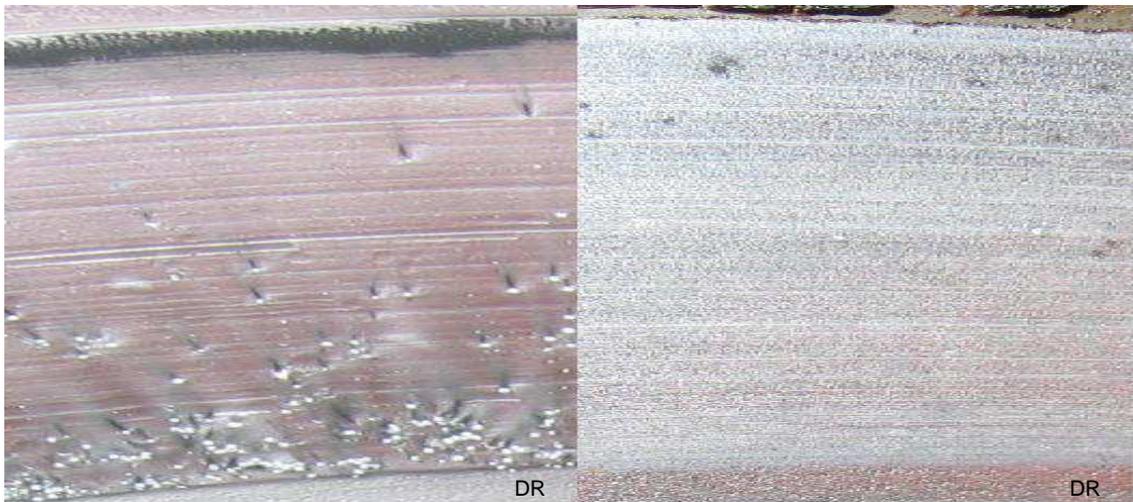
The valve had been operational since 1975. In October 2002, as part of a maintenance procedure, the cap [upper part of the valve] separated from the body [lower part] and reached some of the valve's internal parts. This procedure was performed by a subcontractor.

Several anomalies were observed:

- inadequate clamping of nuts, the subcontracted firm did not follow any pre-established set of procedures or specifications in conducting this operation;
- a metallurgical examination of the valve seal surfaces revealed a degraded surface condition: a sizeable lateral surface groove, presence of particles (though below manufacturer's standards). Also noteworthy was that the particles were apparently of a shape and composition analogous to those of shot blasting material used to clean metal surfaces.



A comparison of seal surfaces on the valve that caused the accident with those of an identically-designed valve clearly highlights the particles responsible for surface defects: the surface roughness of this deficient valve was twice that of a similar valve (see photos below).



The investigation carried out by the HSE unit exposed the following:

- The operator did not consider the valve to be a critical element for plant safety.
- The subcontractor selection process seems to have been based on price criteria rather than the level of competence and experience demonstrated in maintaining this type of valve.
- The operator provided no technical information concerning the valve to the subcontractor.
- The subcontractor was uninformed of valve characteristics and did not keep any kind of log for monitoring the operations already completed.
- The operator did not inspect work performed on the valve.
- The particles detected on seal surfaces were similar to materials used when shot-blasting metal surfaces. Their origin remains unknown but were undoubtedly deposited prior to the maintenance work of 2002.
- No log was kept regarding the amount of torque applied to the joint fastening bolts. It is therefore impossible to determine whether the valve had been lifted with the right clamping force.

ACTIONS TAKEN

The conclusions of this investigation were discussed with the operator and subcontractor assigned the valve repair job. Corrective measures were laid out with the objective of improving plant procedures.

LESSONS LEARNT

Maintenance work at installations generates specific risks that need to be analysed in order to define the best-suited means of prevention. Such an analysis proves even more essential given that maintenance operations are most often outsourced to subcontractors. The operator must pay careful attention to the choice of contracted parties by ensuring that they have the requisite level of competence, training and qualifications to successfully undertake the planned works.

A risk management effort on the part of the site operator is necessary and implies the following: preliminary risk analysis, qualification procedure for all subcontracted entities, preparation of the maintenance intervention (detailed description of works to be performed, equipment specifications, documentation, procedural information, etc.), traceability of the works undertaken, and acceptance conditions by the operator.

A similar accident occurred in GONFREVILLE-L'ORCHER on April 24, 2006: During start-up of the ammonia production unit at a chemical plant, a synthesis gas leak ignited on a flange immediately adjacent to the synthesis reactor. The tightening torques used to bolt this flange were found to be the cause of the accident (ARIA 32174*).

*: A summary of this accident is available at: www.aria.developpement-durable.gouv.fr