ESRA Norge
Norsk forening for risiko- og pålitelighetsanalyse

Velkommen til årsmøtewebinar

Erfaringer fra Hydrogeneksplosjonen i Sandvika juni 2019

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Tekna – Teknisk-naturvitenskapelig forening

Fueling Station Incident

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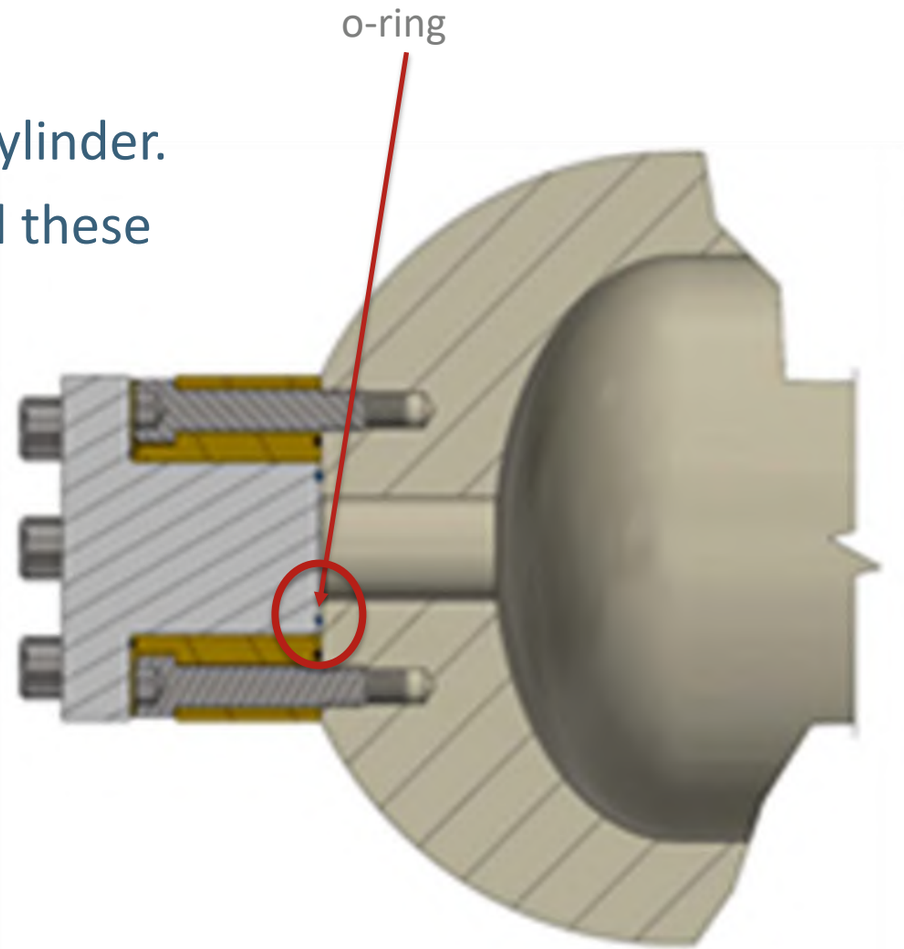
Incident

- In the late afternoon of 10 June 2019, a leakage and subsequent explosion occurred at the Hydrogen Fueling Station located in Sandvika near Oslo, Norway.
- The explosion was followed by several fires within the facility.
- Gexcon was called to investigate the root cause of the incident and to propose mitigating measures for implementation in existing and future facilities.

Root cause identified

- Under-torqued bolts in the plug assembly at the end of the cylinder.
- Significant effort was made to explore other possibilities, and these mechanisms were ruled out.
- The leakage started small and developed over time, possibly due to the following mechanism;
  - Insufficient bolt torque
  - Insufficient compression of o-ring
  - Motion of o-ring under pressure cycles
  - Friction/wear
  - Initial, small damage to o-ring
  - Developed to complete failure of o-ring



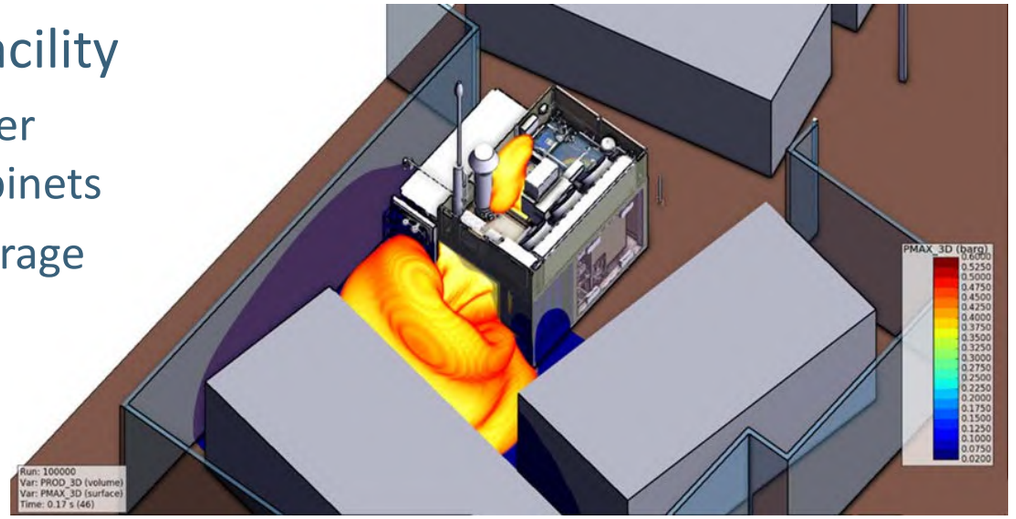
Possible ignition mechanisms

- Several possible mechanisms for ignition were investigated. The mechanisms comprised
  - Spontaneous ignition due to thermodynamic effects (literature search conducted)
  - Agitation of particulate matter (gravel)
  - Exposure to non-ATEX mechanical equipment (e.g. drive belt)
  - Exposure to non-ATEX electrical equipment (e.g. cooling fans, pumps, electrical cabinet)

- All of the above mechanisms would have had potential to ignite the leakage.
- Due to extensive fire damage, there was no hard evidence to support a decisive conclusion, but it was deemed that auto-ignition is a likely mechanism.

Explosion

- Gas from the leakage dispersed to several parts of the facility
  - Via cable trenches to adjacent modules, such as the electrolyser and auxiliary module, containing switchboards and control cabinets
  - Into compressor module located adjacent to high-pressure storage
  - Free dispersion in air



- Upon ignition, the hydrogen cloud exploded
  - In free air, causing pressure waves affecting traffic on nearby roadway and minor damage to neighbouring building.
  - This explosion also caused flexing of the perimeter wall, causing architectural elements on the external face of the wall to be thrown off.
  - Internal to the compressor module, causing extensive damage. The image is a view of a simulation used to determine the likely amount of hydrogen involved in the explosion within the module.

Ensuing fires

- Subsequent to the explosion, several fires occurred
  - Internal to the high-pressure storage, the initial leakage continued as a fire
  - Evidence indicates the explosion caused a new leakage in the high-pressure storage, resulting in a jet fire directed towards the mobile storage container, eventually causing the inner lining of the composite tanks to melt and the stored hydrogen to permeate the composite material and burn off. The burning polyester is the source of the smoke seen in the picture
  - The vent system for the high-pressure storage was destroyed by the internal explosion in the compressor module. When pressure relief valves opened, the hydrogen was fed into a fire internal to the compressor module rather than to the vent mast

Learning points

- Documented and verified mechanical completion
- Wide use of ATEX rated equipment throughout the facility
- Smart control system algorithms to detect developing failures
- Redesign vent system to reduce vulnerability
- Fire partitions are effective. Should be applied between different storages to prevent escalation
- Fail close valves in the facility had aluminium actuator housings which melted in the fires. Steel housings should be used for improved fire resistance
- Use hard surfaces (e.g. concrete) under all pressurised equipment
- Fill cable trenches with sand or other aggregate to prevent gas migration and possible escalation of incidents
- Improve explosion relief in the compressor module
- Consider to pre-install fire water headers (dry sprinklers) so that responders can connect to single coupling to provide water cooling to all parts of facility in the event of a fire

Q & A

Thank you for your attention

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