Dangerous Goods Safety Significant Incident Report No. 01-16 and Petroleum Safety Significant Incident Report No. 01/2016

Hydrogen-fired boiler explosion

Summary of incident

At a chemical manufacturing plant that produces hydrogen gas and other substances, a potential restriction in the feed line to a hydrogen-fired boiler was identified.

Specialist contractors were engaged to check for flow restrictions in the boiler feed line. The boiler was shut down and the feed line purged with nitrogen. After checking for residual hydrogen, the line was isolated prior to examination.

After completing the line examination, de-isolation commenced and hydrogen was introduced into the line.

Soon after the last isolation valve was opened, there was an explosion in the combustion chamber of the boiler, which ruptured its shell at the designed failure point.

The boiler and adjacent cooling tower pipework sustained significant damage but, fortunately, no one was injured.

Left: Safety shut-off valves forming part of the burner management system. Right: Damage to boiler

Direct factors

- At the time of the boiler explosion, the burner management system, which allows the safe control of the combustion process, was apparently not operating.
- Two safety valves in the hydrogen feed line, which forms part of the burner management system, had been manually overridden. These valves remained open during feed line checks and up to the explosion, despite other line isolations being in place.

Contributory factors

- Contractor management was inadequate. The operator placed too much reliance on the contractor's expertise.
- There was no formal handover from maintenance to operations.

- The critical importance of the burner management system was not fully recognised.
- There was no risk assessment or documented process regarding the manual opening of the two safety valves that formed part of the burner management system.
- The job safety analysis (JSA) used by the contractor was generic.
- The permit issuer did not examine the JSA prepared by the contractor.
- The section of the work permit requiring the permit issuer to state if the equipment was available for use had not been completed prior to the introduction of hydrogen into the system.
- The permit issuer had not received formal training in the plant and equipment covered by the permit.

Actions required

This incident highlights the importance of ensuring that appropriate controls are in place to manage the risks posed by dangerous goods such as hydrogen. The following actions will assist in managing risks and meeting legislative requirements.

Note: The source of ignition of the hydrogen-air mixture was not established. Regardless, in the absence of suitable safety controls, ignition sources in the presence of fuel-air mixtures pose a significant explosion risk.

Engineering controls

- Where engineered safety-critical controls have been installed, there should be robust systems to safely manage the bypassing or modification of such controls.

Work permits and handover

- The permit issuer and holders need to adequately understand the plant and equipment covered by a permit.
- Handover documentation should be confirmed as complete before recommissioning plant and equipment.
- A formal start-up procedure or checklist will facilitate the safe recommissioning of plant and equipment.

Risk management

- Permit issuers should review any associated risk assessments, including those prepared by third parties. In particular, risk assessments need to adequately address hazards.

Training

- Anyone who may be involved with safety-critical controls need to be suitably trained and understand the importance of these controls to the safe operation of the plant and equipment.

Leadership and responsibilities

- Statutory safety obligations exist under the *Dangerous Goods Safety Act 2004* and associated regulations and need to be understood by facility operators, contractors and other relevant personnel before engaging in activities involving dangerous goods.
- Clear leadership and accountability need to be exercised, with assigned responsibilities being understood and discharged.

Further information

- United Kingdom Health and Safety Executive (UK HSE), http://www.hse.gov.uk/pubns/books/hsg250.htm

  Guidance on permit-to-work systems – A guide for the petroleum, chemical and allied industries

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