Significant incident summary No. 02/25

Shear coupling failure enabled ammonia release

Summary of incident

In August 2024, while loading ammonia into a rail tank wagon at a manufacturing site, a shear coupling on the loadout arm failed to an unsafe mode. Two out of three bolts failed and wedged the coupling open, which resulted in a loss of containment (LOC) of compressed liquefied ammonia that formed an ammonia vapour cloud.

A proximity sensor adjacent to the shear coupling was not actuated. Consequently, release of the toxic gas continued until gas detection activated a safety instrumented system (SIS) shutdown of the ammonia supply.

As the first responder, the operator escalated their risk by entering the rapidly forming toxic vapour cloud without respiratory protection, increasing their exposure potential to an acutely hazardous atmosphere.

Shear or breakaway couplings are emergency release protective systems

The bulk transfer of dangerous goods fluids should have safe systems in place that can reliably 'fail-to-safe' when forces outside the standard operating conditions are exerted upon the loading circuit.

Transfer interfaces in Western Australia relying upon emergency release couplings include:

- marine loading arms for export of fuels and liquefied gases
- terminal gantries for road tanker and rail tank wagon filling
- distribution networks for LPG and LNG transfer to power utilities, mine site power stations and commercial storage tanks.

Shear couplings are designed to interrupt the flow of fluids and seal each side of the pipework or loading hose and as such, they provide a risk reduction to operational workers by limiting the dangerous goods released.

An inherent safety in design (ISD) feature relies on an energised spring-loaded piston assembly that slams shut upon shearing of the connecting bolts across the juncture. In major hazard facilities, these features are often incorporated into shutdown interlocks either via gas detection, proximity sensor, or actuated solenoid circuits.

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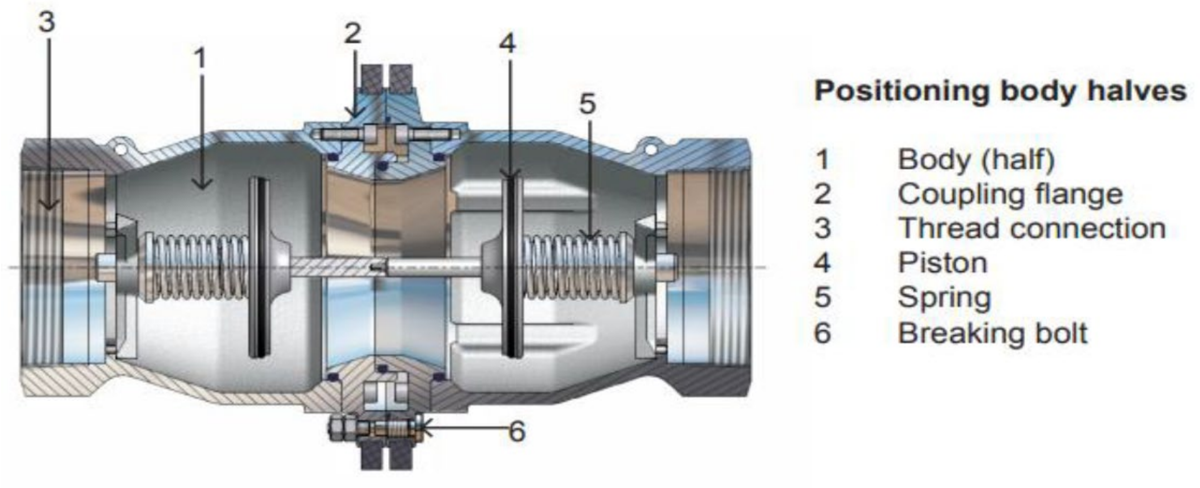

Shear Coupling assembly

Investigation findings

- Shear coupling failure to unsafe state: several instances over recent years where coupling bolts had failed post-loading had not triggered a review of the coupling's integrity status.
- Loading arm remained in service: recent concerns over the allowable flexure of loading arm assemblage had not resulted in its removal from ammonia loading of rail tank wagons.
- Respiratory protection choice of first responders: donning of self-contained breathing apparatus was not conducted as operators perceived the shear coupling was functioning as intended with an expected minor release.

Key corrective actions by site operator

- Adopted enhanced emergency release coupling design.
- Inclusion of shear coupling into preventative maintenance program.
- Response to LOC:
  - learning objectives embedded in training
  - repetition of response practice.

Industry learnings

This incident had a high potential for serious harm considering the operating conditions for transferring liquefied ammonia gas (toxic and corrosive hazards) to rail tank wagons. Failure of the proximity switch to activate an SIS designed closure of flow and initial operator response were causes for concern.

Failure of shear coupling that was a critical control preventing ammonia LOC:

- Mechanism of shear coupling failure rendered the proximity switch ineffective.
- Ensure the failure modes for safety critical equipment are interrogated to avoid a scenario that negates the detecting element initiating a protective shutdown.

Shear coupling design – fit-for-purpose and maintenance:

- A large range of shear couplings are offered by original equipment manufacturers (OEMs), ranging from dry-break couplings in fuel loading gantries to emergency release couplings for marine loading arms.
- Review the mechanisms of release and closure of the shear coupling in transfer system to ensure it provides the level of reliability and risk reduction sought.
- Align preventative maintenance practices with OEM recommendations to provide a high level of mechanical rigour periodically to support the frequent visual field assessments.

Operator initial response to LOC:

- Workers may potentially respond to a major incident based on procedures relating to common minor incidents (normalisation of risk) therefore increasing exposure risks.
- Ensure there is an adequate level of training relating to major incidents and practice emergency response for those scenarios.
- Empower adequate first response to major incidents by ensuring consultation between operational workers, work health and safety coordinators and process safety leaders to develop effective and more easily remembered key principles for response. For example:
  - protect your own health and safety
  - communicate for help
  - decide whether circumstance dictates to seek refuge whilst awaiting assistance
  - wear appropriate personal protective equipment, which may include higher protective factors such as breathing apparatus
  - attend to the incident in alignment with developed training principles and prioritise your safety.

Further information

Department of Energy, Mines, Industry Regulation and Safety

- *How to manage work health and safety risks: Code of practice*
- *Managing risks of hazardous chemicals in the workplace: Code of practice*
- *Managing risks of plant in the workplace: Code of practice*
- *Risk assessment and management including operational risk assessment: Guide*
- *Human factors: Integrating human factors into bowtie analyses of major accident events: Information sheet*