TECHNICAL BULLETIN

Prepared by WG-6 TB 11/20 – October 2020

Loss of Vacuum on Vacuum Insulated Cryogenic Storage Tanks Due to Inner Vessel or Internal Piping Leak

Background

In the United Kingdom, a 60 000 litre vertical nitrogen tank manufactured in 1997 and equipped with an economiser line suffered a brittle fracture of the outer jacket. Investigations by the United Kingdom's Health and Safety Executive, HSE, found that piping inside the vacuum interspace had developed a fatigue crack that initiated a leak at the economiser tee junction.

It is not known how long the period can be between a through wall crack appearing at the stressed weld and sufficient cryogenic fluid entering the vacuum space to cool the outer jacket to a temperature that would allow brittle failure. Failures are expected to follow a defined pattern for example loss of vacuum, operation of pressure relief device(s), installed to protect outer jacket against increase of pressure in the interspace between inner vessel and outer jacket localised icing of the jacket near to the leak and then brittle failure.

Recognition of a leak within the interspace at a very early stage is expected to give sufficient time for the tank to be made safe.

Risks to consider

Cryogenic liquid storage tanks with these economiser piping assemblies can, under some operating configurations, be subject to repeated and significant differential thermal expansions within piping systems that increase the risk of a hidden failure.

Impingement of cryogenic fluids onto the carbon steel outer jacket of a cryogenic storage tank could lead to brittle fracture and the ejection of fragmented steel. Such ejected fragments could cause life threatening injury to individuals in the vicinity of the tank, and they could also compromise nearby safety critical plant or containment systems such as pipes, tanks or other vessels.

Recommendations[1]

1) Operators and fillers of cryogenic liquid storage tanks shall be given sufficient information and training to allow them to detect a loss of vacuum by observing icing of the jacket and this shall be reported immediately to the owner of the cryogenic tank.

2) The owner of cryogenic liquid storage tanks shall immediately investigate the cause of the vacuum loss.

3) Where a vacuum loss is believed to be associated with an internal pipe failure, for example vapour escaping from the vacuum relief device(s), the cryogenic tank shall be made safe by reducing the inner vessel

[1] Further details can be found in EIGA Doc 224, *Static Vacuum Insulated Cryogenic Vessels Operation and Inspection*

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pressure to atmospheric and emptying all cryogenic liquid in a safe manner. The reduction of pressure is the most significant action to reduce the level of hazard.

4) Owners of cryogenic liquid storage tanks, fitted with an economiser circuit, shall consult the tank manufacturers to consider the operation of the economiser piping within the vacuum space. Tank manufacturers shall consider the piping configuration (flexibility), temperature range (thermal expansion) and tank dimensions to ensure that the operation of the economiser circuit will not result in unacceptable stresses which could initiate a fatigue crack in service. This assessment shall consider the effects of a full constraint of the pipework.

5) Where recommendation (1) cannot be satisfactorily achieved and the assessment in (4) indicates that there is a risk of unacceptably high stresses then the tank owner should consider the use of remote vacuum monitoring with an alarm to indicate vacuum failure.

Additional requirements for cryogenic flammable liquid storage tanks

An additional unique concern for cryogenic flammable liquid storage tanks is the potential for air ingress into the annular space. The cold inner vessel will cryopump air into the annular space it left open after a pressurisation of the interspace (a dislodged lift plate or pump out plug). If in flammable service, there is a potential for an explosive mixture.

Remedial action: Inerting the annular space and the pressure vessel shall be carried out in a timely manner by a person qualified in such a procedure.

To prevent cryopumping a re-closable lift plate shall be installed on new liquid hydrogen cryogenic tanks to avoid air ingress.

NOTE For liquefied natural gas, (LNG) and ethylene the upper flammability limit is much lower and ignition energy is much higher than for hydrogen. Therefore, an explosion resulting from air ingress through a non-re-closable lift plate is unlikely to occur.

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