Lessons learned solving pilot valve instability issues on LNG storage tanks

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LNG Summit Houston 23/24 Feb 2017
Applications for Cryogenic Tanks

LNG Terminal Bulk Storage Tank with a set of P/V valves
Pilot-operated Valves on LNG-Tanks
Where are the problems?

- Pilot operated pressure relief valves installed on cryogenic storage tanks may become unstable as a result of inaccurate plant design or sudden construction changes on site.

- Pilot operated valves which are forced to become unstable may not provide sufficient relief capacity resulting in overpressure and imposing safety risks to the facility.

- It is known that relief valve instability is a dynamic problem which requires an understanding and coupling of the pressure source (e.g. LNG storage tank), the inlet line, the pilot operated pressure relief valve and the discharge line.
Some reasons for instability and lessons learned

• It is quite obvious that the 3 % rule – known from pressure safety valves - is not sufficient to guarantee POV stability.

• POV instability is a dynamics problem which requires an understanding and coupling of the dynamics of the following components:

  1- Inlet Line
  2- Discharge Line
  3- Pressure Source or Vessel/Equipment
  4- Pilot-Operated Valve - POV
Lessons learned for 1 and 2

Since the 80th PROTEGO® delivered a lot of Pilot valves around the world
Lessons learned for 1 and 2

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Results:
• Common guidance on how to design the piping seems to be missing or is not applied in all cases
• Inlet pressure loss seem to be neglected in some cases
• Built up pressure in the discharge line is not allways considered
To high inlet pressure loss:
Chattering, hammering, results in flow reduction and can destroy the valve

To high built up pressure in the vent line:
Pumping, Flow reduction but lower risk of destroying the valve

Lessons learned for 1 and 2
Example LNG Plant:

• The installed 12“ PROTEGO-devices PM/S 300/350 experienced extrem instabilities.

• The valve pallet was hammering on the seat and destroyed the Aluminum valve pallet.

• When opening the discharge line we could see that the valve pallet did not reach full lift, which can result in a reduced relief capacity.
Problem-analysis (chattering)

- Chattering resulted from to high inlet pressure losses. For safety relief valve everyone is familiar with the 3% rule.
- When calculating the inlet pressure losses we received results up 20%-30% of the set pressure
- This high inlet pressure loss exceeded the blow down by far.
- In addition the customer used a sensing line directly at the valve body and not an installation at the tank. In that case higher flow reduces the static pressure and the valve acts extremely unstable. The static pressure fell below the crack pressure of the magnetic valve.
Solution: Increase blow down of the pilot valve
Important remarks for sizing

- The tank is insulated but your discharge pipeline may not be.
- In the discharge line the cryogenic gas warms up due to heat input from environment.
- Consider the density changes along the line when calculating the pressure losses and the tank relief loads.
- Build up your own or use a commercial package with a reliable thermo-fluid dynamic model.
- Consider the internal piping within the tank.
The pressure relief system is designed for (e.g.):

- **Liquid LNG input**
- **Thermal outbreathing**
- **Liquid Displacement and Flashing by filling**
- **Roll over**
- **Recirculation from a submerged pump**

This design results in very high relief loads and that means large valves with very high capacities

But what is your testing procedure before start up?
Example: Nitrogen evaporation procedure

- The tank is just filled with a small amount of liquid nitrogen, which then evaporates
- Relative to the design case the evaporation rate is very small
- This results in chattering of the valve due to massive oversizing
- If this start up/test procedure is used the valve potentially runs into instability issues through rapidly relieving and closing

But how can we solve this during start up and assure that the valves works even though the valve is operated within a zone that causes instability?
Testing to extreme condition and forcing the valve to operate instable is a must for understanding the valve behavior.
Instability Problem: Valve chattering heavily
Instability Solution: Valve with dampening system
Lesson learned

Challenge:
• Start up with small vaporizing quantities can result in valve instability

Solution:
• Dampening systems which prevent valve instability
Cryogenic Test showing chattering effect and the performance of the damping system
Cryogenic test

Tests according to ISO 21013-4
„Cryogenic vessels – Pilot operated pressure relief devices – Part 4: Pressure-relief accessories for cryogenic service“.
PROTEGO PM/HF with Fiel-Test-Connection and Test-Kit
Oxygen-Cleanliness-Workshop

Washing machines

Oil-free test bench

UV-light Tent for Visual Inspection

Ultra-sonic bath for small pieces
Vacuum-Breaker for Cryogenic Application

Propylene Storage Tank
Vacuum Breaker installed on Cryogenic Storage Tanks need to be very tight against leaking!

- Vacuum breaker are exposed to relatively high over-pressure due to the operating pressure of the storage tank which works as a closing force to the valve pallet.
Why Does Quality Product Result in Vapor Saving?

Competitors soft sealing with FEP-foil
Competitors valve leaks due to exposure to sun radiation – Visible through IR-camera
PROTEGO has improved vacuum breakers with setting at -2,5 mbar / - 1“ WC, metallic sealing and highest possible capacity.
Thank you for your attention

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