MICE hydrogen system

CM41

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Review

- Requested by ISIS – held on 15/16th January
- *"To review the installation and operational methodology of the MICE LH2 system for its compliance with all relevant safety frameworks"*
- Chaired by John Thomason, head of ISIS accelerator division
- Panel composed of:
  - ISIS technical experts
  - John Dowell (Birmingham Uni)
  - Jon Gulley (CERN)
  - David Findlay (previous LH2 working group chair)
  - Matt Dickson (RAL SHE group representative)
- Talks given by Steve Watson, Andy Nichols, Phil Warburton and Wing Lau

Outcomes

- Panel generally happy with the LH2 team, approach and basic safety philosophy
- Recommendations (paraphrased) as follows:
  - Consider interaction of LH2 system with rest of MICE in risk assessments
  - Proposal to remove the hydride bed is supported
  - Calculations of absorber failure modes should be revisited and updated to give confidence in ability of windows to survive pressure excursions
  - Further physical testing of the windows, as suggested by Wing Lau, is supported
  - A maintenance plan for the LH2 system (and other MICE systems) should be developed
  - Consult as to whether a third (mini) HAZOP is desirable considering the system changes since the last review
  - Explicitly define the necessary experience and training required for a system operator
  - Revisit emergency procedures
  - Safety approval will follow a similar pattern to the R&D tests i.e. via the working group

Hydrogen storage

- Question has often been asked, why use a hydride bed at all?
  - Original reasoning was to keep the system closed during repeated operation
  - Minimises the number of manual handling operations with H2 bottles
  - Only requires hydrogen venting during emergency scenario and bed purge

- R&D tests suggested that bed capacity was insufficient to last more than 2 or 3 fills without needing topped up
- Risk that bed capacity has degraded over 8 years
- Significant hydrogen is vented during each cycle due to remnant pressure in the buffer tank
- Empty procedure takes considerable time to commence, due to thermal mass of hydride bed
- Glycol pipework generated large amounts of condensation during absorption cycle, leading to pools of water inside the gas panel
- Work list to re-commission hydride bed after R&D tests considerable

Hydrogen storage

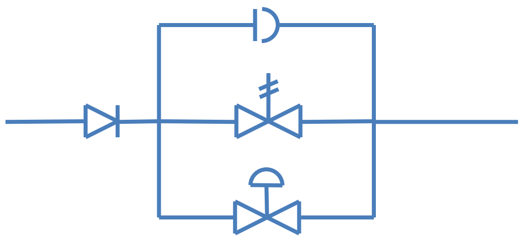
- Proposal made to liquefy directly from a bottle source
  - Manifolded bottle pack stored outside the hall in a protective enclosure
  - Jacketed, all-welded pipework routed along existing helium pipe run to gas panel
- No other hardware required to accommodate this
- Possible requirement for flow meters / pneumatic valves in charging line
- Control sequences do not require substantial reworking
- Main disadvantage is the venting of hydrogen during a standard empty sequence

Relief circuit repair

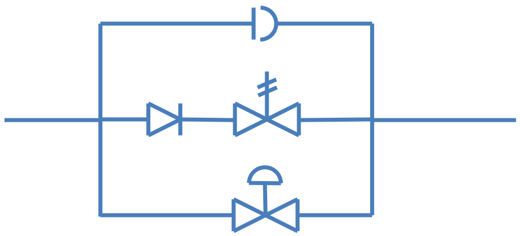
- During leak testing of R&D tests, the insulating vacuum would not go lower than 10^{-4} mbar
- Due to leaks in both relief valve and burst disk – became apparent that both components were duplicates of versions on the pressure-side of the system and not vacuum-compatible
- Leak was successfully arrested using a check valve upstream of the whole circuit
  - Not good practise!

Relief circuit repair

- First proposal was to remove the relief valve entirely and replace the burst disk assembly with a vacuum-compatible one
  - May have caused an unacceptable increase in line impedance during catastrophic boil-off scenario
- Current proposal:
  - Discovered that burst disk assembly can be made leak-tight through retrofit of seals (were graphite spiral gaskets, now aluminium KF-style seals)
  - A leak-arresting check valve will be placed upstream of the relief valve only



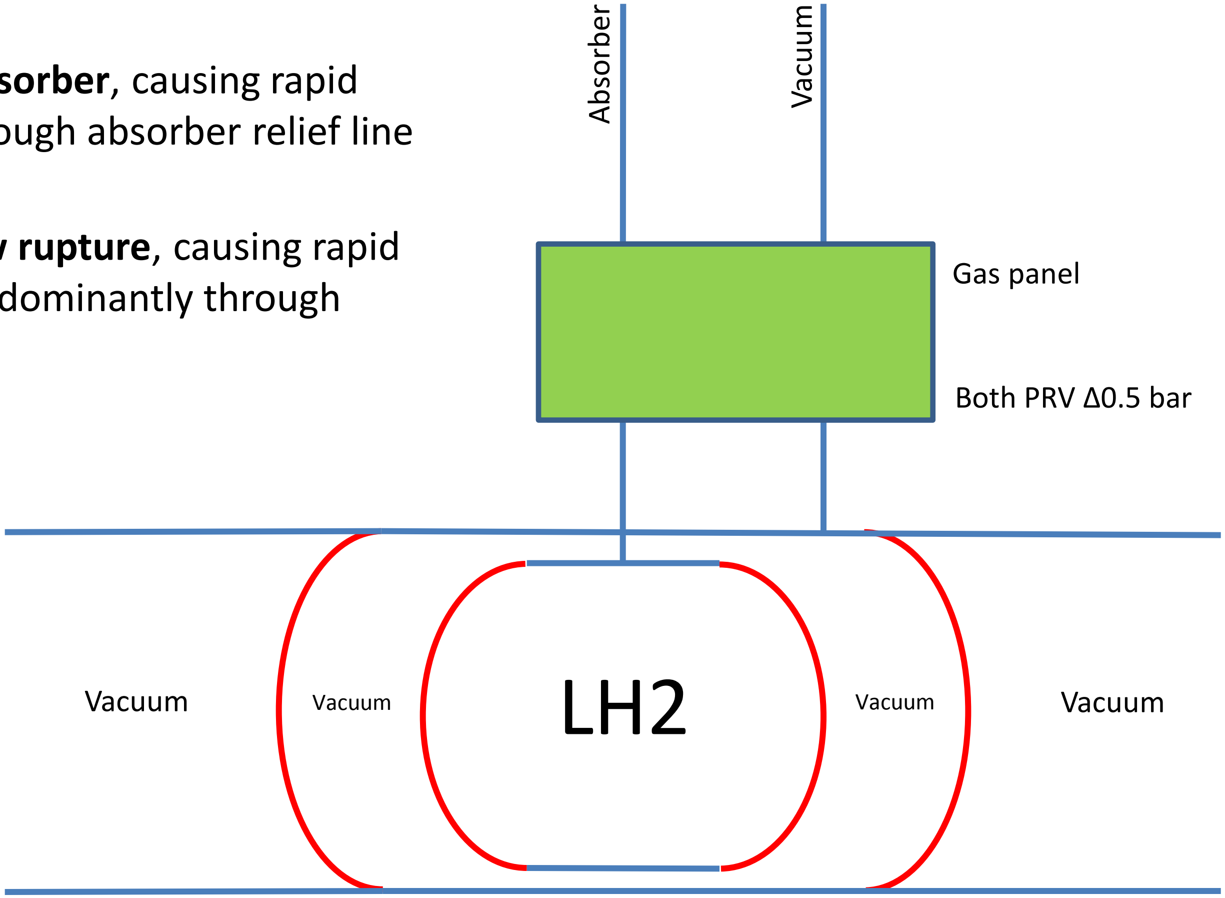
Old



New

Relief circuit calculations

- Two failure scenarios
  - **Heat load into absorber**, causing rapid boiling of LH2 through absorber relief line
  - **Absorber window rupture**, causing rapid boiling of LH2 predominantly through vacuum relief line

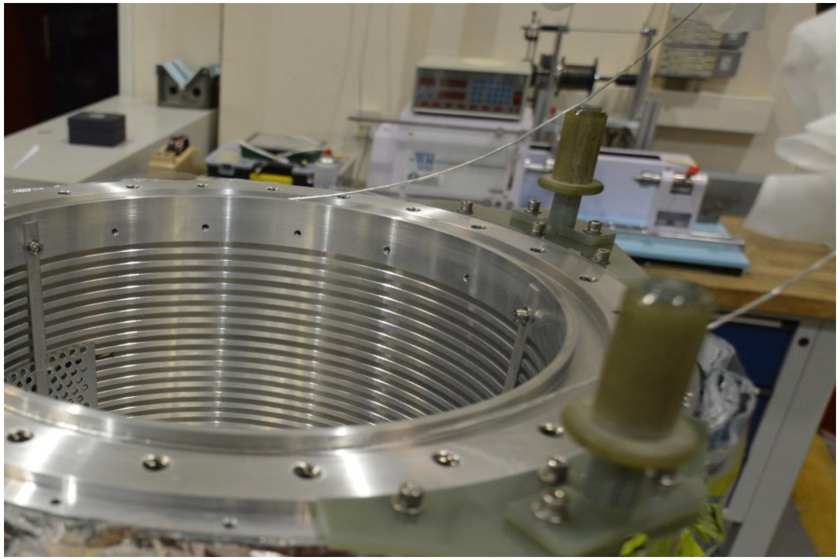


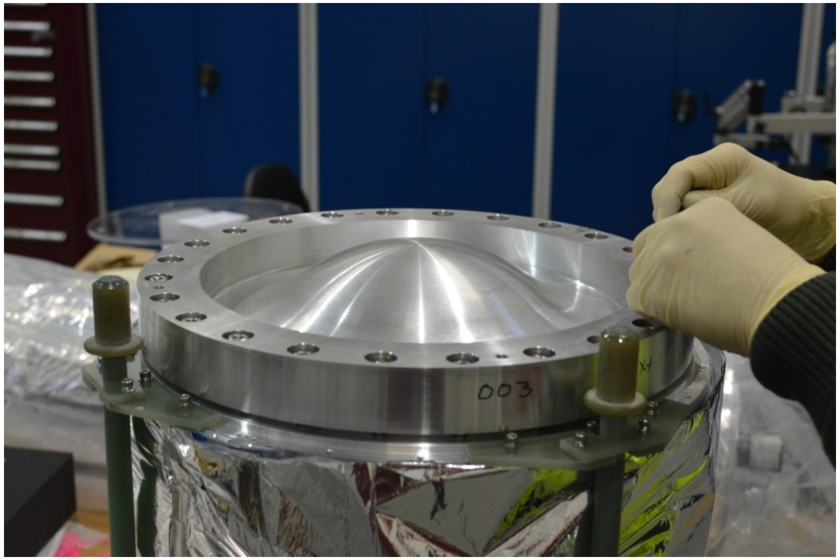
Relief circuit calculations

- Problem is that there are discontinuities in the ‘story’ from Mike Green’s original design studies to the physical system as it exists now
- Review has requested that we calculate the system pressure rises for catastrophic scenarios using the as-built system parameters – very complicated calculation!
- Approach:
  - S Watson/J Cobb/T Bradshaw will review the heat flux assumptions and write a MICE note either defending the original numbers or proposing new ones
  - S Harrison of ISIS (head of instrument design) will calculate the subsequent pressure drop along the pipe. This is recognition of the difficulty of the problem and his extensive prior experience of similar scenarios.
- Potential action in event of unacceptable conclusions:
  - Increase AFC to gas panel line from 1” to 4”
  - Make use of 6” vacuum line as parallel relief line, sacrificing the turbo pump

Absorber progress

- Absorber assembly
  - Window – absorber indium seals made
  - 2 MLI blankets applied to vessel – another 2 will be added post-proof test
  - **QUESTION – how much MLI is acceptable over the windows?**





Window testing

- Review accepted that existing testing and FEA has all be done to a high quality
- However…
  - As-assembled system needs to be proof tested to design pressure x 1.1 x 1.25
  - Suggested that spare safety windows undergo burst and buckling tests to further validate FEA
- This may be problematic due to insufficient numbers of acceptable spare windows. However, working group has indicated that the suggestion is not a show-stopper if we cannot fulfil it.