RESEARCH AND CONSULTANCY FROM HSE

ELVHYS WP4.2 Unignited LH2 Pressure Peaking Phenomena

ELVHYS Workshop 05/12/2025

Disclaimer

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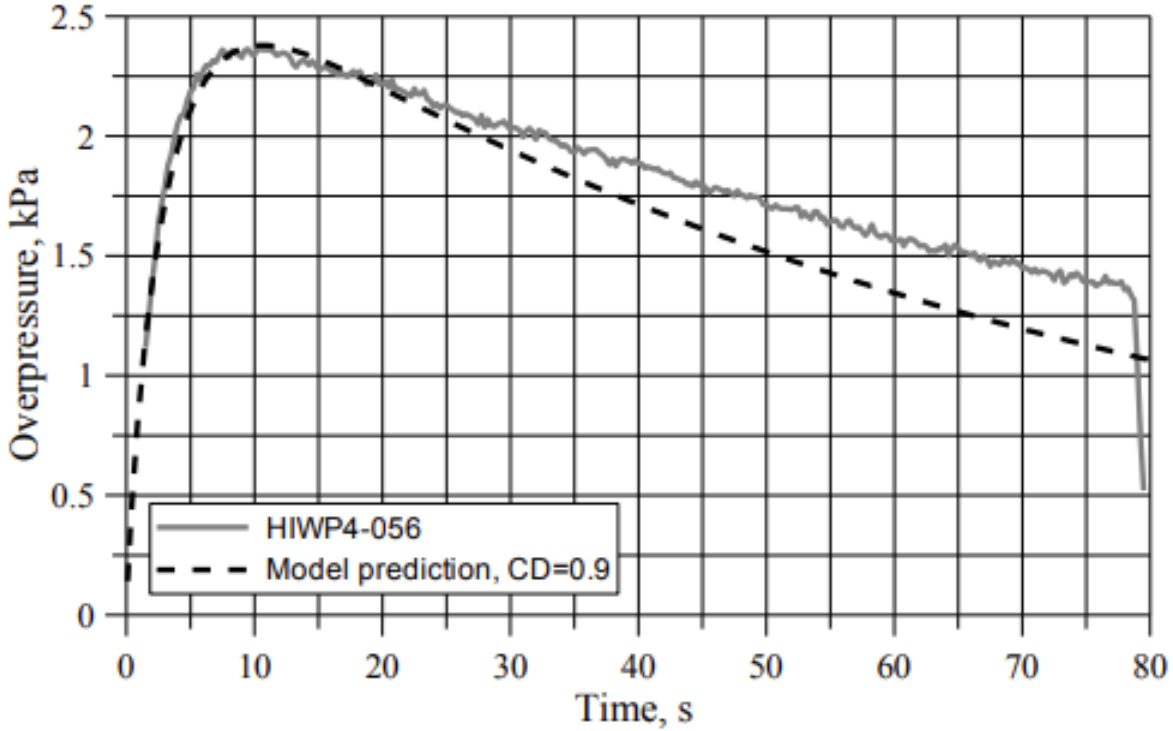
Its contents, including any opinions and/or conclusions expressed or recommendations made, do not supersede current HSE policy or guidance.

Background

- Unignited releases of buoyant gas (helium and hydrogen) into vented enclosures can cause overpressures many times higher than the steady state pressure
- First predicted by models of indoor gaseous hydrogen releases and shown through experiments in 1 m^3 and 14.9 m^3 chambers.

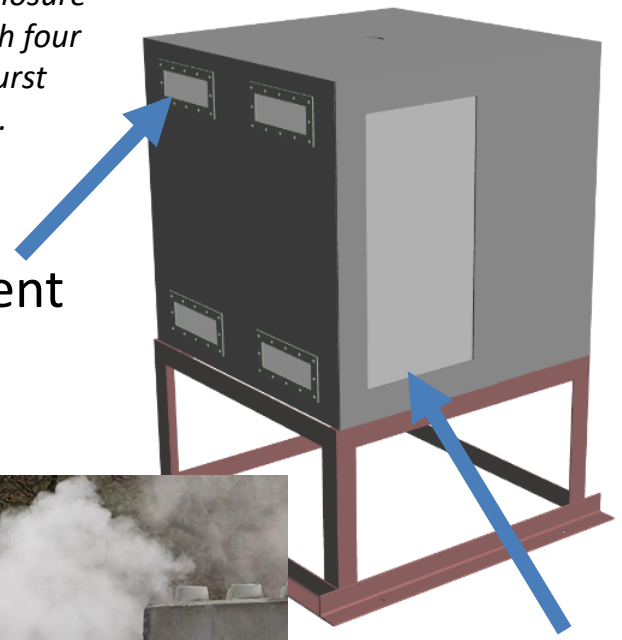


Pressure peaking test (1.086 g/s gaseous hydrogen leak in a 1 m^3 enclosure with 16.5 mm diameter vent). Grey line shows experimental overpressure, black dashed line shows the modelled overpressure. (Shentsov, Kuznetsov and Molkov, 2015)

Methodology

- LH2 released into 1m^3 enclosure through 1” ID pipe (approximately 180 g/s, 330 kPa)
- Enclosure had four passive vents to which vent flanges were attached
  - To reduce vent area, vent flanges were swapped for blank flanges
- Enclosure instrumented with pressure and temperature sensors

CAD model of 1 m^3 enclosure showing enclosure with four passive vents and burst panel on a frame.



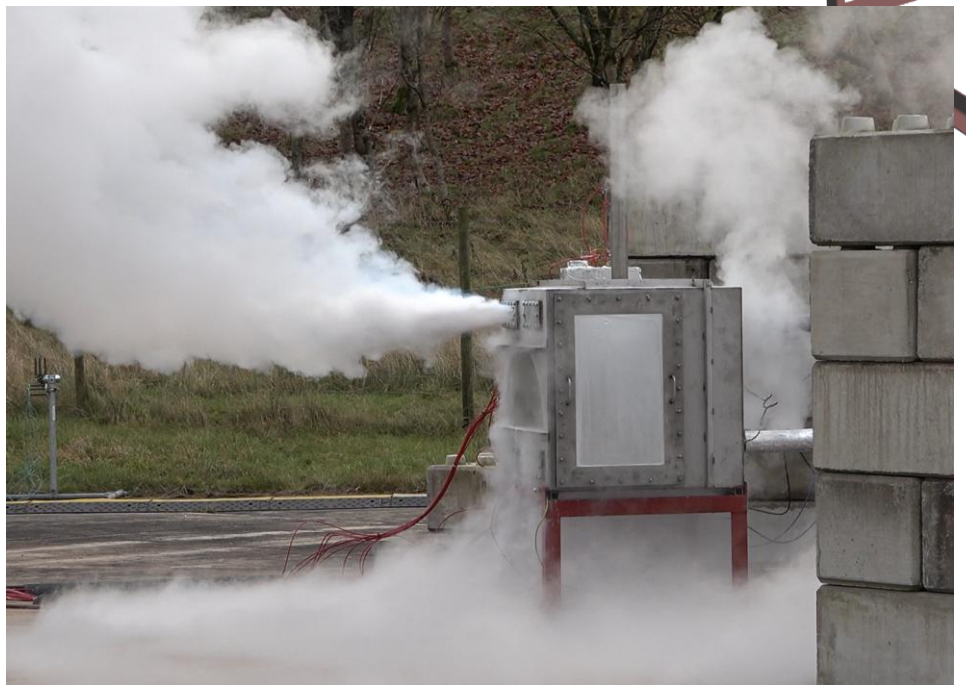


Image of LH2 pressure peaking test 3 with one open vent

Results

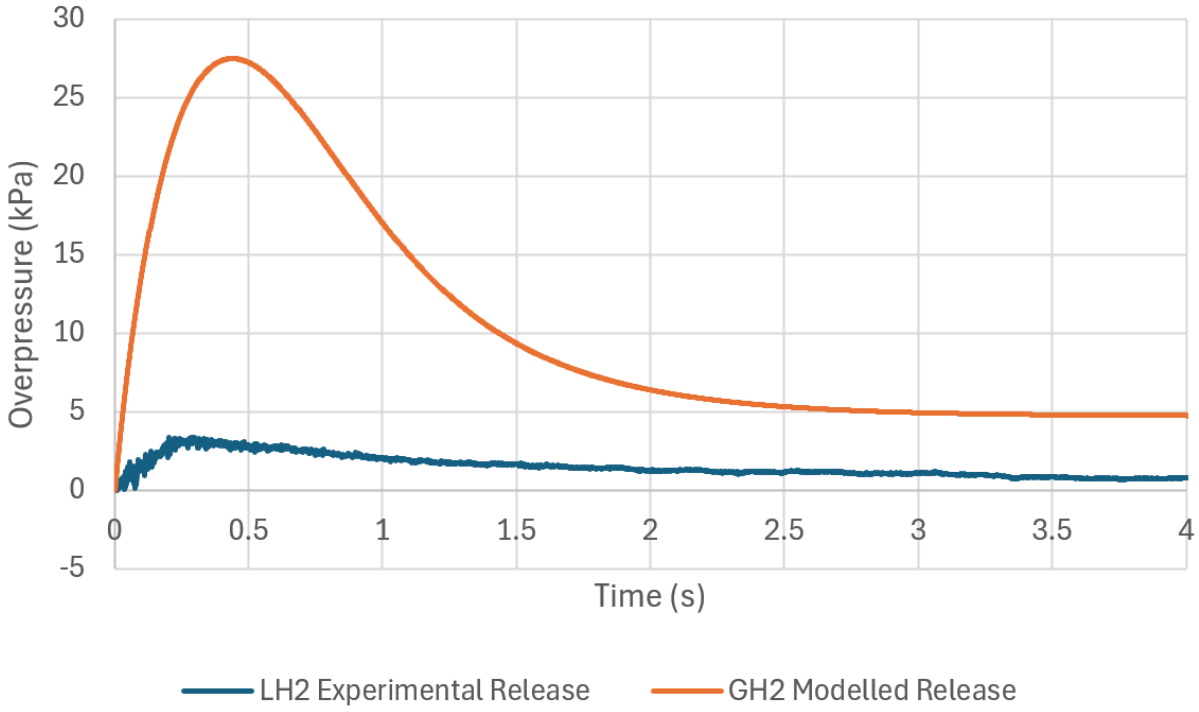
- Pressure peaking did occur for all tests, with peak overpressure increasing as vent area decreased
- Test 3 initial peak follows GH2 pressure peaking
  - Change in gradient after 4 seconds
  - LH2 specific behaviour

Test no.	Vent area (m^2)	Peak overpressure (kPa)	Time to peak overpressure (s)
1	0.0416	0.55	0.15
2	0.0208	1.20	0.20
3	0.0104	3.3	0.33

Graphs of enclosure over pressure for tests 1, 2 and 3

Comparison with GH2 Pressure Peaking

- GH2 pressure peaking modelled using *Pressure peaking phenomenon for unignited releases* tool created by Ulster University.
- Modelled GH2 release of 180 g/s achieves much higher maximum overpressure (27.6 kPa).
  - Steady state overpressure is also significantly higher (4.6 kPa)
- Increased density of cryogenic hydrogen is likely the largest contributor to reduced peak overpressure
- Time to peak pressure is similar
  - High impulse overpressure, acts on structures quasi-statically



Graph of enclosure overpressure for LH2 experimental release (test 3) and GH2 modelled release using Ulster University pressure peaking model

Experimental Conclusions

- Pressure peaking can occur of LH2 releases into vented enclosures
  - As expected, peak pressure increases as vent area decreases
  - Step-change in gradient after initial peak may be due to LH2 specific behaviour
- LH2 experimental results are compared to modelled GH2 releases of the same mass flow rate
  - Peak overpressure of LH2 experimental release is 8.3 times lower than GH2 modelled release
- Experimental data available on NTNU Dataverse