PROTECTING PEOPLE AND PLACES FOR 50 YEARS HSE

HSE research on hydrogen safety

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UK-HyRes workshop “Bringing hydrogen to the market”, 12-13 March 2025

Introduction to the Health and Safety Executive

- HSE is the regulator for workplace health and safety in Great Britain
- Includes onshore/offshore pipelines, chemical/oil/gas infrastructure, offshore platforms etc.
- Activities: evidence gathering, policy development, consultation, regulation, incident investigation, enforcement
- In 2022-23, HSE investigated over 230 fatal and 5,500 non-fatal incidents
- 2,700 total staff (FTE): £262M annual budget, 66% from Government

- HSE Science and Research Centre, Buxton, UK
- 400 staff, 550-acre test site
- Scientific support to HSE and other Government departments
- “Shared research” or joint-industry projects co-funded by HSE
- Bespoke consultancy on a commercial basis

HSE's Strategic Objectives 2022-2032

Protecting people and places

- Reduce work-related ill health, with a specific focus on mental health and stress
- Increase and maintain trust to ensure people feel safe where they live, where they work and, in their environment
- Enable industry to innovate safely to prevent major incidents, supporting the move towards net zero
- Maintain Great Britain's record as one of the safest countries to work in
- Ensure HSE is a great place to work, and we attract and retain exceptional people

https://www.hse.gov.uk/aboutus/the-hse-strategy.htm

HSE's Areas of Research Interest

Contents

https://www.hse.gov.uk/research/content/hse-areas-of-research-interest.pdf

https://ari.org.uk/ https://int.octopus.ac/

HSE's Areas of Research Interest

Question 1: How can it be ensured that GB's evolving industrial landscape and the built environment doesn't lead to a higher likelihood of major health and safety incidents?

- What are the significant hazards and risks associated with the deployment and scale-up of new and emerging technologies for Net Zero, such as Carbon Capture Usage and Storage (CCUS) and hydrogen?

- How HSE ensures that dutyholders in new industries such as CCUS, hydrogen, alternative liquid fuels and energy storage, design with safety and health considerations in mind?

- What are the appropriate controls and mitigations that need to be built into new carbon capture infrastructure?

- How do operational fusion power plants compare in risk profile to more traditional industrial installations?

- How can the integrity and safety of industrial assets be ensured across their lifecycle?

https://www.hse.gov.uk/research/content/hse-areas-of-research-interest.pdf

HSE hydrogen safety research

Examples of HSE publications on hydrogen safety

- RR1133 – Maintaining the integrity of process plant susceptible to high temperature hydrogen attack. Part 1: analysis of non-destructive testing techniques
- RR1134 – Maintaining the integrity of process plant susceptible to high temperature hydrogen attack. Part 2: factors affecting carbon steels
- RR1169 – Hydrogen in the natural gas distribution network: Preliminary analysis of gas release and dispersion behaviour
- RR715 – Installation permitting guidance for hydrogen and fuel cell stationary applications: UK version
- RR1047 – Injecting hydrogen into the gas network – a literature search
- RR769 – Hazards of liquid hydrogen: position paper
- RR985 – Modelling of liquid hydrogen spills
- RR986 – Releases of unignited liquid hydrogen
- RR987 – Ignited releases of liquid hydrogen
- RR1159 – Hydrogen research priorities workshop
- RR615 – Spontaneous ignition of hydrogen: Literature review

https://www.hse.gov.uk/research/rrhtm/index.htm

Recent and ongoing HSE hydrogen safety research projects

- Hydrogen safety training courses
- Liquid hydrogen safety guidebook
- Land, sea and port integration (hydrogen highway)
- Hydrogen burner experiments for food production
- Hydrogen compatibility of components in the gas network
- Hydrogen blends in the gas network
- Zero emissions for sustainable transport
- Aircraft liquid hydrogen container lab tests
- Gaseous hydrogen aircraft fuel sub-system testing
- Cold hydrogen combustion tests for aircraft applications

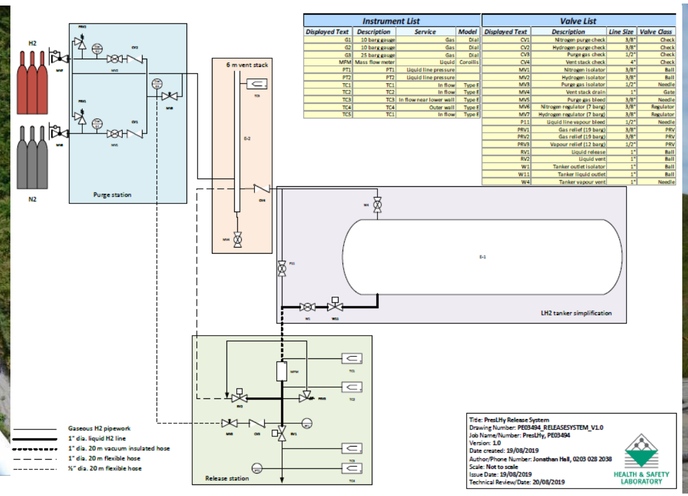
Externally funded

- Hydrogen heating programme
- MultHyFuel safety of hydrogen at refuelling stations
- ELVHYS liquid hydrogen in transfer operations for mobile applications
- High-pressure hydrogen jets in enclosed spaces
- Hydrogen risk assessment models for land-use planning assessments (both fixed sites and pipelines)
- Facility for materials testing in hydrogen atmospheres
- Review of hydrogen leakage in isolated vessels and pipes

Internally funded by HSE
Shared research (part-funded by HSE) or DESNZ funded

Example of previous HSE research project: PreslHy

- Pre-normative research on the safe use of liquid (cryogenic) hydrogen as an energy carrier.
- 3-year test programme (release & mixing, ignition and combustion) in 2018 – 2020
- Experiments on source term characterisation, near- and far-field dispersion, fire-fighting measures, explosion overpressures, electrostatic charging and condensed phase assessment
- Flows ranged from 1-5 barg at source with flow rates up to 300 g/s in 1” pipework
- EU FCH JU 2.0 co-funded research and innovation activity (Project ID 779613), €1.9m budget



Instrument List

Displayed Text	Description	Service	Model
G1	10 barg gauge	Gas	Druc
G2	10 barg gauge	Gas	Druc
G3	25 barg gauge	Gas	Druc
MFM	Mass flow meter	Liquid	Coriolis
PT1	PT1	Liquid line pressure	-
PT2	PT2	Liquid line pressure	-
TC1	TC1	In flow	Type E
TC2	TC2	In flow	Type E
TC3	TC3	In flow near lower wall	Type E
TC4	TC4	Outer wall	Type E
TC5	TC5	In flow	Type E

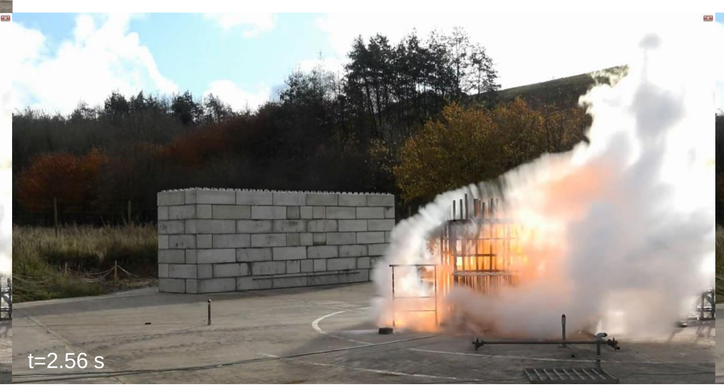
Valve List

Displayed Text	Description	Line Size	Valve Class
CV1	Nitrogen purge check	3/8"	Check
CV2	Hydrogen purge check	3/8"	Check
CV3	Purge gas check	1/2"	Check
CV4	Vent stack check	4"	Check
MV1	Nitrogen isolator	3/8"	Ball
MV2	Hydrogen isolator	3/8"	Ball
MV3	Purge gas isolator	1/2"	Needle
MV4	Vent stack drain	1"	Gate
MV5	Purge gas bleed	3/8"	Needle
MV6	Nitrogen regulator (7 barg)	3/8"	Regulator
MV7	Hydrogen regulator (7 barg)	3/8"	Regulator
P11	Liquid line vapour bleed	1/2"	Needle
PRV1	Gas relief (19 barg)	3/8"	PRV
PRV2	Gas relief (19 barg)	3/8"	PRV
PRV3	Vapour relief (12 barg)	1/2"	PRV
RV1	Liquid release	1"	Ball
RV2	Liquid vent	1"	Ball
W1	Tanker outlet isolator	1"	Ball
W11	Tanker liquid outlet	1"	Ball
W4	Tanker vapour vent	1"	Needle

Title: PresLHy Release System
Drawing Number: P003494_RELEASESYSTEM_V1.0
Job Name/Number: PresLHy, P003494
Version: 1.0
Date created: 19/08/2019
Author/Phone Number: Jonathan Hall, 0203 028 2038
Scale: Not to scale
Issue Date: 19/08/2019
Technical Review/Date: 20/08/2019
HEALTH & SAFETY LABORATORY

Example of previous HSE research project: PreslHy

HSE explosion tests in congested volume



Example of previous HSE research project: HyTunnel

Pre-normative research for safety of hydrogen driven vehicles and transport through tunnels and similar confined spaces

Aims

- Analyse effectiveness of conventional safety measures for hydrogen incidents
- Develop explosion and fire prevention and mitigation strategies
- Produce experimental data to validate CFD and FE models for consequence analysis
- Develop correlations for quantitative risk assessment
- Harmonise recommendations for intervention strategies and tactics for first responders
- Provide recommendations for inherently safer use of hydrogen vehicles underground

https://hytunnel.net/

- 13 European partners
- Budget: € 2.5m
- Duration: 2019 – 2022

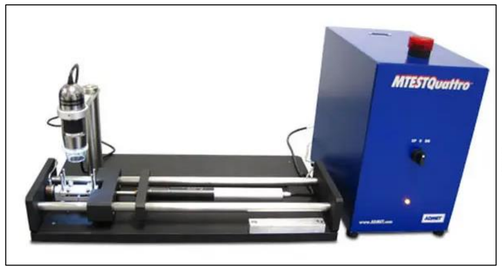
Co-funded by the European Union

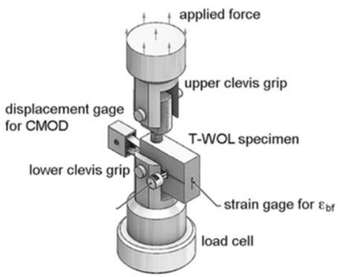
Grant agreement: 826193

Example of previous HSE research project: HyTunnel

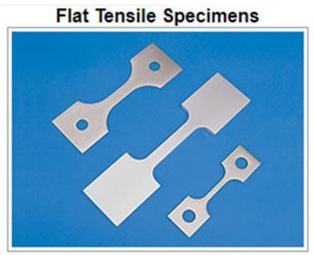
Example of ongoing HSE research project

- HSE is investing in a new hydrogen materials testing facility at its Science and Research Centre in Buxton
- Aim to conduct long-term exposure tests of materials (~years) in gaseous hydrogen up to 10 bar
- Testing methods:
  - In-situ micro tensile testing
  - Ex-situ tensile testing
  - Ex-situ impact testing
- Testing of metals, polymers and elastomers
- Four vessels acquired; setup ongoing
- Due to be operational in 2025





https://www.admet.com/products/micro-testers/expert-4000/



Future topics of interest to HSE

- Assess leaks from liquid hydrogen bayonet connections
- Assess immediate/delayed ignition and consequences of cold BLEVE of liquid hydrogen tanks
- Condensed-phase explosions associated with oxygen enrichment from liquid hydrogen releases
- Review current guidance on different substrates around LH_2 bulk storage tanks, e.g., gravel
- Further analysis of two-phase flow in pipes transporting liquid hydrogen (PreslHy experiments)
- Hazardous area classification for hydrogen
  - Zone of “negligible extent” criteria, appropriate hole sizes for area classification, selection of hydrogen lower flammable limit value (4% or 8% v/v ?), buoyancy-induced ventilation in enclosures (produced by hydrogen cloud)
- Hydrogen vent stack dispersion experiments and analysis
- Air ingress into depressurized hydrogen systems through leak paths: possible experiments
- Review of safety issues relating to sub-COMAH (< 5 tonne) hydrogen installations
- Lessons learnt from operational experience of hydrogen equipment and hydrogen incidents

Other hydrogen research gap analyses

- Aerospace Technology Institute
  - Hydrogen Capability Network https://www.ati.org.uk/hydrogen/
- US Federal Aviation Authority
  - Hydrogen-Fueled Aircraft Safety and Certification Roadmap, December 2024 https://www.faa.gov/aircraft/air_cert/step/disciplines/propulsion_systems/hydrogen-fueled_aircraft_roadmap
- Energy Institute
  - Findings from “hydrogen five-year plan” workshop held at DNV Spadeadam on 16 October 2024
- HySafe
  - Research priorities workshops https://hysafe.info/activities/research-priorities-workshops/
  - International Conference on Hydrogen Safety https://hysafe.info/ichs2025/
- EU Clean Hydrogen Partnership
  - https://www.clean-hydrogen.europa.eu

Thank you

Any questions?

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