Hydrogen safety research:

Gas transmission, distribution and storage

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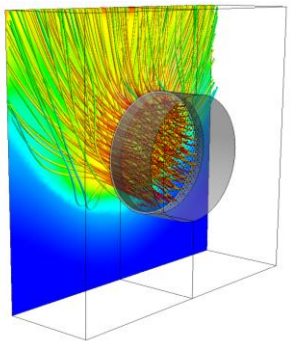
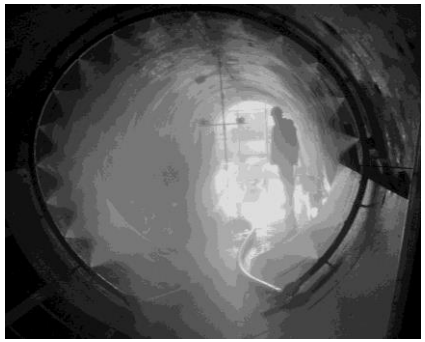
Outline

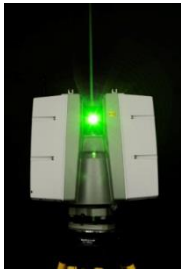
- Introduction to HSE Science & Research Centre
- Previous hydrogen research projects
- Gas transmission projects
  - NTS and LTS
- Gas distribution and use projects
  - H21, HyDeploy, H100, Hy4Heat
- Bulk storage
  - PreslHy
- Issues where further confidence is needed

HSE Science & Research Centre

- Multi-disciplinary laboratory:
  - Fire and process safety
  - Computational modelling
  - Exposure control
  - Toxicology etc.
- Approx. 400 staff
- 550 acre test site
- Fire galleries and burn hall
- Impact track
- Anechoic chamber
- Thermal test chamber

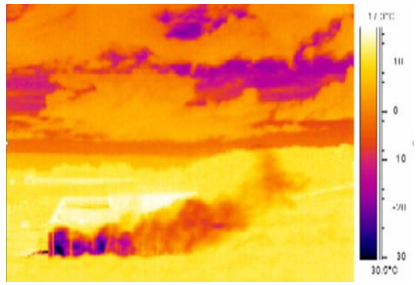






Hydrogen Safety Research Projects

- Indoor hydrogen leaks, vented deflagrations, hydrogen fires in confined spaces (HyIndoor)
- Hydrogen refuelling stations (HyApproval)
- Stationary hydrogen and fuel cell applications (HyPER, H2FC)
- Hydrogen release, dispersion, fire and explosion model evaluation (Susana)
- Fire testing on composite hydrogen cylinders (FireComp)
- Flame-out and re-ignition of hydrogen-powered gas turbines (ETI High Hydrogen)
- High-pressure hydrogen releases in tunnels (HyTunnel)



Gas Transmission

National Transmission System (NTS) 70 – 100 bar

- Aim: assess impact of hydrogen blends and up to 100% H_2 on NTS pipeline network and AGIs
- Scope: degradation of materials, current standards and operating procedures, fitness-for-service criteria

Local Transmission System (LTS) < 70 bar

- Aim: Assess scientific and regulatory feasibility of repurposing the LTS for storage and transport of hydrogen, blended-hydrogen and CO_2 gas
- Scope: gas specification, materials, standards, design and operation, risk assessment, permissioning
- Feasibility study on a selected pipeline section

Gas Distribution and Use

HyDeploy – 20% hydrogen and natural gas blend (https://hydeploy.co.uk/)

H21 NIC – 100% Hydrogen, network repurposing (https://www.h21.green/)

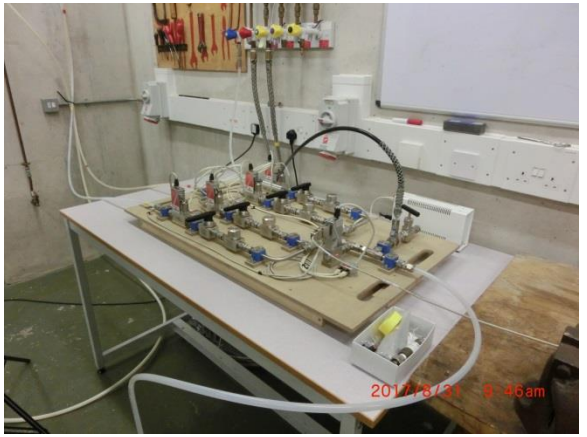
H100 – 100% Hydrogen, new PE network (https://www.sgn.co.uk/about-us/future-of-gas/hydrogen/hydrogen-100)

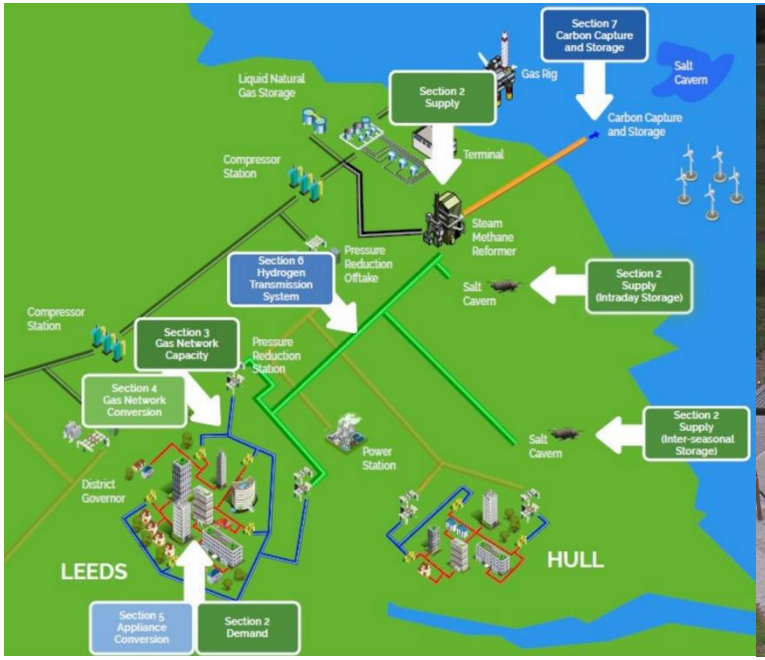
Hy4Heat – 100% Hydrogen, gas quality, appliances, metering (https://www.hy4heat.info/)

- Project Objective:
  - To demonstrate for the first time that a blend of hydrogen and natural gas can be distributed and utilised safely & efficiently in the UK distribution network without disruptive changes for consumers
- HSE scope of scientific work
  - Feed into Quantitative Risk Assessment (QRA) to demonstrate relative risk
  - Feed into procedural assessment to evidence continued safe operation of the network

Scope of Scientific Work

- Materials assessment
- Appliance testing
- Fire and explosion risk
- Procedures and gas detection





RIIO NIC
NETWORK INNOVATION COMPETITION

H21 Scope of Scientific Work

- Leakage tests on recovered assets
- Gas migration through soil
- Dispersion and accumulation
- Ignition
- Fires
- Explosion severity
- QRA

H100 Scientific Work

Point source of nitrogen gas at a depth of 650mm – no cavity - Flow rate 544 l/min

Gas on


30s


60s


120s


180s

Point source of hydrogen gas at a depth of 650mm – no cavity - Flow rate 881 l/min


Gas on


18s (=30 x 544/881)


37s (=60 x 544/881)


74s (=120 x 544/881)

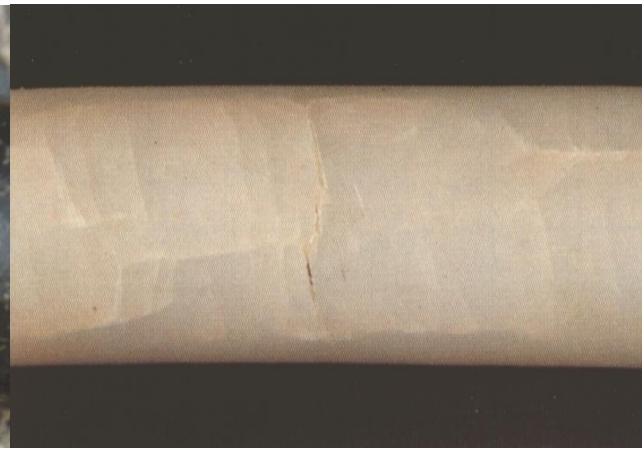

112s (=180 x 544/881)

H100 PE Materials

- Pipe testing

Stage 1 – Ductile Rupture

Stage 2 – Slow Crack Growth



Stage 3 – Oxidation >400 years

Bulk Storage

- **P**renormative **Re**search for **S**afe Use of **L**iquid **Hy**drogen
- EU project: Jan 2018 – Dec 2020
- Review state-of-the-art and knowledge gaps
- Experiments on release, ignition, combustion
- Develop models, correlations, risk assessment toolkits
- Guidelines for safe design and operation
- http://preslhy.eu

Further Confidence Needed?

- Gas transmission
  - Engineering Critical Assessments for pipelines changing from NG to hydrogen service and impact on required inspection capabilities
  - Evaluation of repair techniques, e.g. preheat requirements for steels previously exposed to hydrogen service, hydrogen tightness of clamps and sleeves
  - Evaluation of potential beneficial effects of trace elements (e.g. oxygen) on pipeline fatigue properties and fracture toughness
  - Permissioning (potential for improved crack growth models and failure rate models)

Further Confidence Needed?

- Gas distribution
  - Safety of operational procedures, e.g. ignition hazards, purging, detection, training
  - Investigation of materials issues on assets in the existing network (e.g. high tensile steel springs in valves, cast iron pipelines) and engineering critical assessments to inform the way forward
  - Safety of infrastructure, e.g. gas accumulation and explosion relief of governor kiosks
  - Gas tracking, accumulation, ignition, explosion, lethality
  - Operation of components (e.g. regulators, meters) at higher flowrates (filters, noise issues, controls etc.)
  - Background leakage modelling: effect of backfill on leakage rates across the network

Note: Many of the above issues are already being considered in ongoing and proposed projects, e.g. HyDeploy2, H21 Phase 2

Thank you

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