BESPOKE RESEARCH AND CONSULTANCY FROM HSE

Hydrogen in the gas network and area classification

Simon Gant, Fluid Dynamics Team

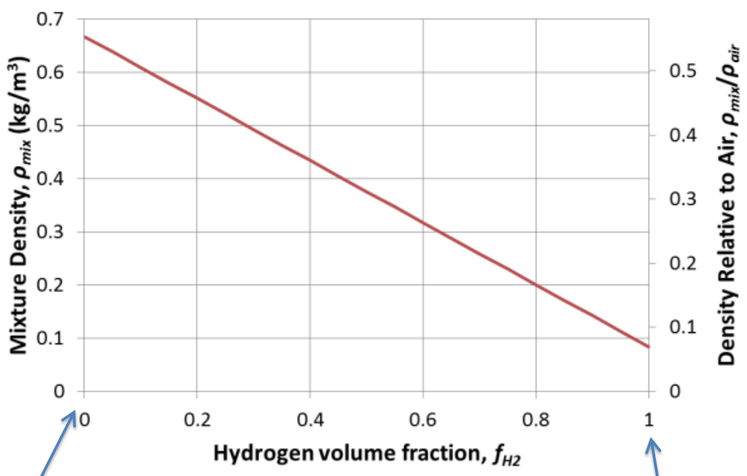
Bespoke research and consultancy - using our scientific expertise and regulatory insight to address health and safety risks

Outline

- Brief review of gas properties
- HSE input to ongoing hydrogen projects:
  - HyDeploy
  - H100
  - H21
  - LTS Futures
- Gas leak rates and jet/plume dispersion
- Update of IGEM/SR/25 area classification standard

Gas Properties

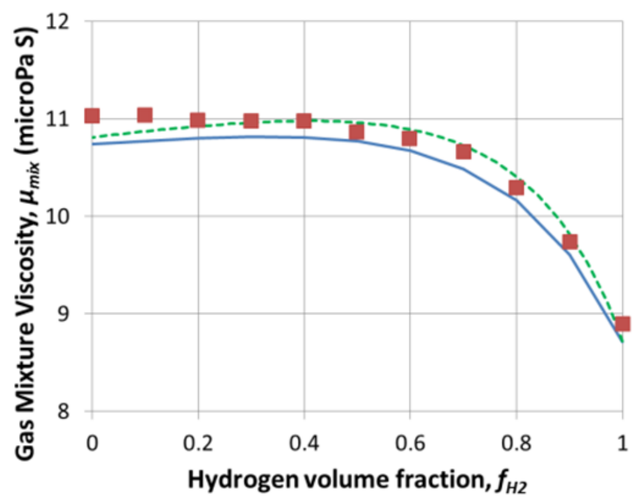
Density



100% methane

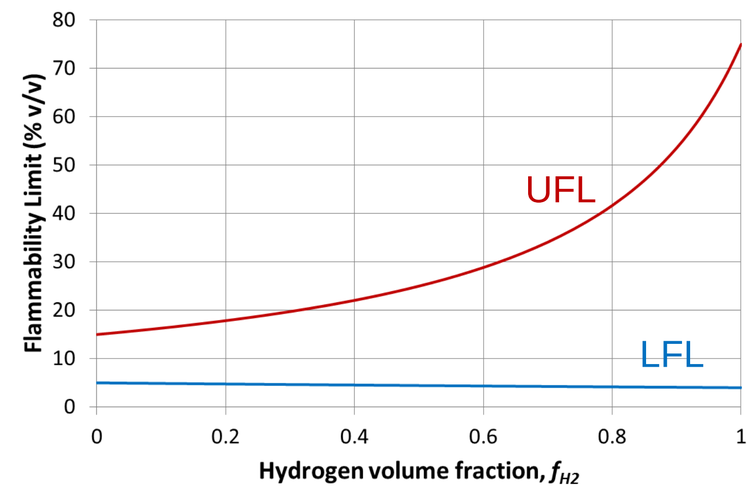
100% hydrogen

Viscosity



GasVLe model predictions
https://www.dnvgl.com/services/gasvle-8331
Davidson (1993) model predictions
https://stacks.cdc.gov/view/cdc/10045/cdc_10045_DS1.pdf
Kobayashi *et al*. (2007) viscosity measurements
https://doi.org/10.1299/jtst.2.236

Flammability Limits



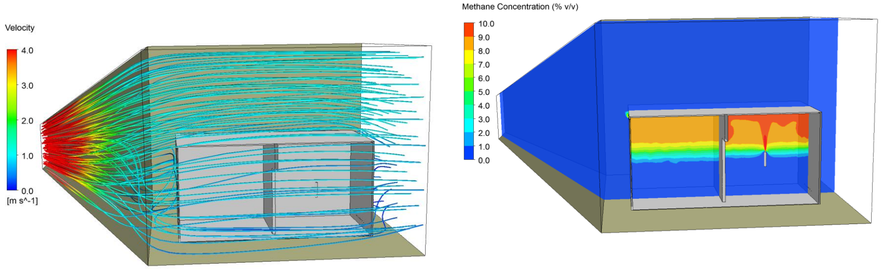
LFL_{CH4} = 5.0 % v/v; LFL_{H2} = 4.0 % v/v

UFL_{CH4} = 15 % v/v; UFL_{H2} = 75 % v/v

Coward, H.F. and Jones, G.W. (1952) Limits of flammability of gases and vapors, US Bureau of Mines Bulletin 503
https://apps.dtic.mil/dtic/tr/fulltext/u2/701575.pdf

HyDeploy

- Scope: 20% hydrogen in the existing gas distribution network
- Review of gas incidents
- Review of gas industry procedures and application to hydrogen blends
- Analysis of appliance behaviour (including carbon monoxide production)
- Effect of hydrogen on materials
- Gas leakage rates and gas accumulation in buildings
- Consequences of ignition
- Analysis to feed into Quantified Risk Assessment (QRA)
- Analysis of multi-occupancy buildings

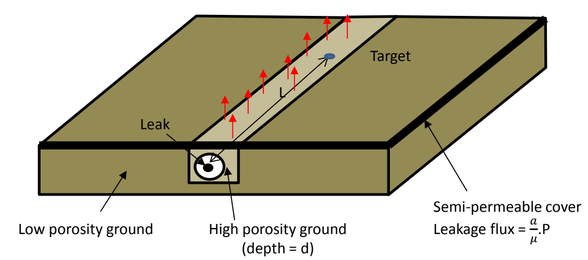


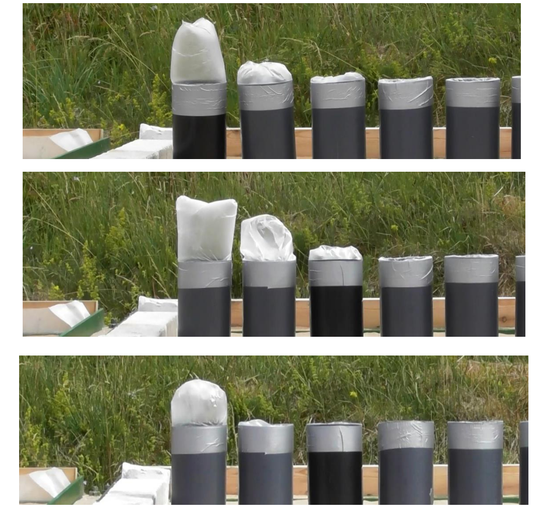
https://www.hydeploy.co.uk

Isaac *et al*. (2021) *Evidence base utilised to justify a hydrogen blend gas network safety case*, International Conference on Hydrogen Safety, 21-24 Sept 2021. http://www.ichs2021.com/

H100

- Scope: 100% hydrogen in a new polyethylene (PE) gas distribution network
- HSE analysis of below-ground gas leak behaviour
  - Leak in a porous ground, e.g. sand, soil
  - Leak that is mainly vented to open air through porous ground but for which a proportion tracks along a crack or service into a building
  - Leak under an impermeable and semipermeable cover
- Experiments
  - Nitrogen, natural gas and hydrogen
  - Effect of water content in soil
- Mathematical modelling
  - Darcy's law + method images for sources/sinks
- Information used by ERM to develop QRA





Gas flows released near edge of impermeable layer

https://www.sgn.co.uk/about-us/future-of-gas/hydrogen/hydrogen-100

H21

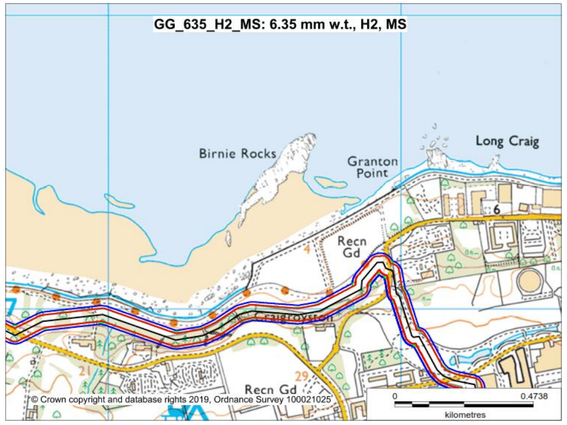
- Scope: 100% hydrogen in the existing gas distribution network (LP, IP, MP tiers up to 7 bar)
- New facility for hydrogen leakage testing of gas network assets (H21 Phase 1A)
- HSE peer review of DNV experiments and analysis used to develop QRA
- Review of gas industry procedures for 100% hydrogen
- Analysis of DNV pipeline purging tests currently ongoing

http://www.h21.green/

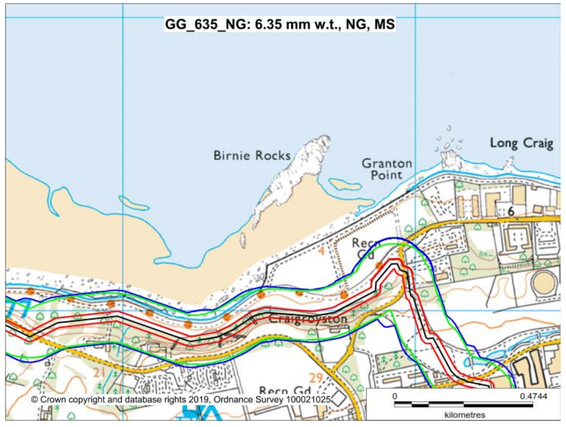
Garrison & Gant (2021) *An investigation into the change in leakage when switching from natural gas to hydrogen in the UK gas distribution network*, International Conference on Hydrogen Safety, 21-24 Sept 2021. http://www.ichs2021.com/

LTS Futures

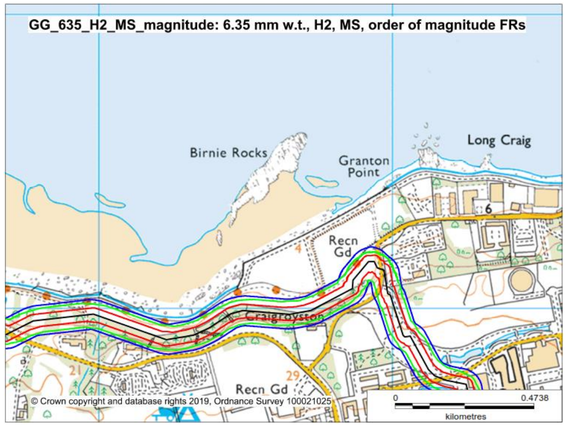
- Scope: repurposing the Local Transmission System (LTS) for hydrogen transport
- Review characteristics of the LTS
- Review relevant standards and safety regulations
- Pipeline risk assessment
- Fitness for service evaluation
- Case study of Granton-Grangemouth pipeline



Hydrogen
(NG failure rates)



Natural gas

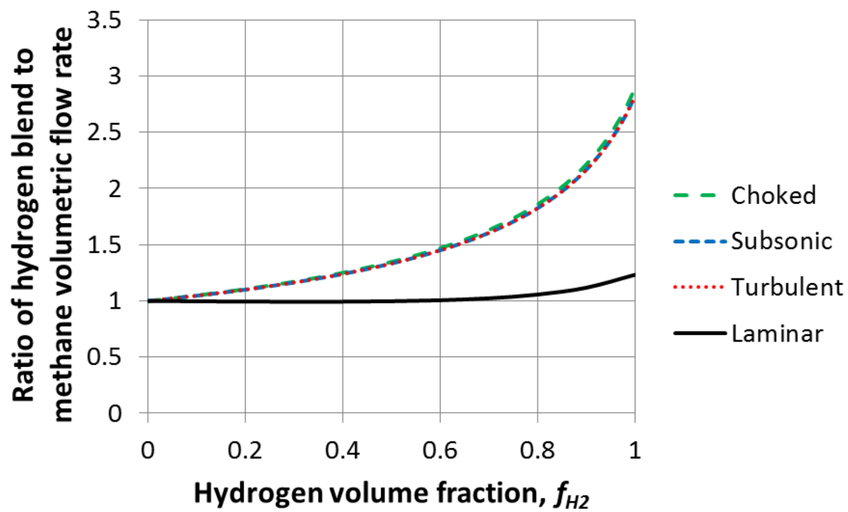


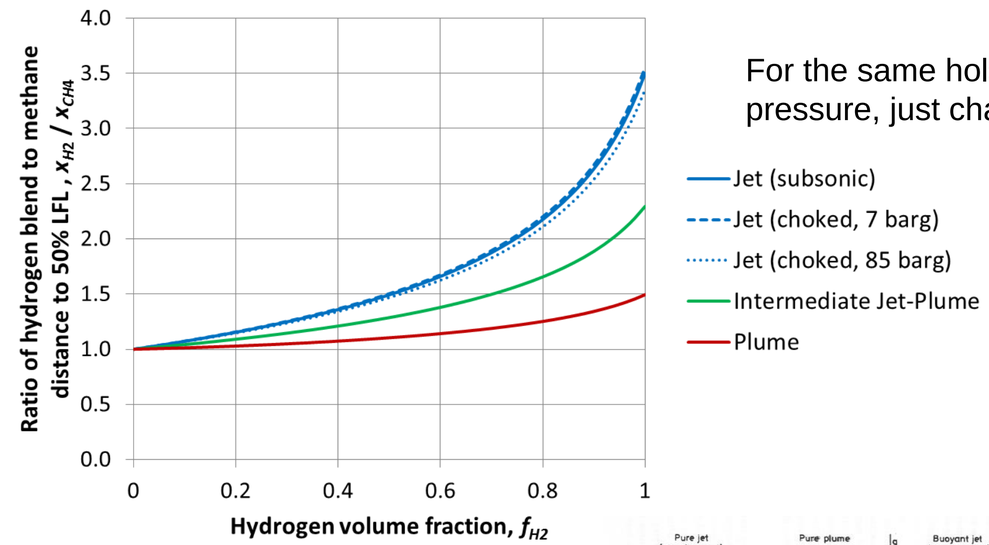
Hydrogen
(x10 NG failure rates)

Bannister *et al*. (2021) *Approaches and methods to demonstrate repurposing of the UK's Local Transmission System (LTS) for transporting hydrogen,* International Conference on Hydrogen Safety, 21-24 Sept 2021. http://www.ichs2021.com/

Gas Leak Rates and Dispersion

- Scope: effect of hydrogen on leak rates, jet/plume dispersion and gas accumulation



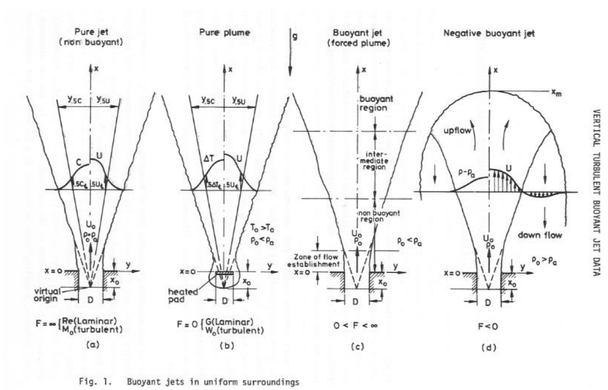


For the same hole size and pressure, just changing the gas

Comparisons also made to Quadvent model:
https://www.hsl.gov.uk/publications-and-products/quadvent-2

Gant *et al*. (2021) *Preliminary analysis of gas release and dispersion behaviour relevant to the use of hydrogen in the natural gas distribution network*, Fire and Blast Information Group webinar, 23 June 2021.
https://www.fabig.com/publications-and-videos/online-lectures-webinars/

HSE Research Report RR1169



From Chen & Rodi (1982) *Vertical turbulent buoyant jets*, Pergamon Press, ISBN 0-08-024772-5

IGEM/SR/25

- UK gas industry standard on area classification of natural gas installations
- Defines extents of zones where EX-rated protective equipment must be used
- Gas group: Natural Gas (IIA), 20% hydrogen blend, (IIA), 100% hydrogen (IIC)*
- Scope of work: producing a hydrogen-specific supplement to the standard to extend applicability of IGEM/SR/25 to both 20% hydrogen blend and 100% hydrogen
- HSE & DNV review of suitability of existing calculation methods for hydrogen
- HSE peer review of hydrogen zoning distances produced by DNV
- Completion of technical work anticipated by end of September 2021
- Timeline allows for IGEM and industry consultation with preparation of a final draft supplement by end of November 2021
- Work is also underway to update Energy Institute EI15 guidance for hydrogen

https://www.igem.org.uk/technical-services/technical-standards-enquiries/

https://www.igem.org.uk/technical-services/technical-gas-standards/safety/

* BS EN 60079-20-1 Explosive atmospheres Part 20-1: Material characteristics for gas and vapour classification — Test methods and data

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