



WHEN TRUST MATTERS

Quantification of the Risks Associated with a Hydrogen Gas Distribution Network

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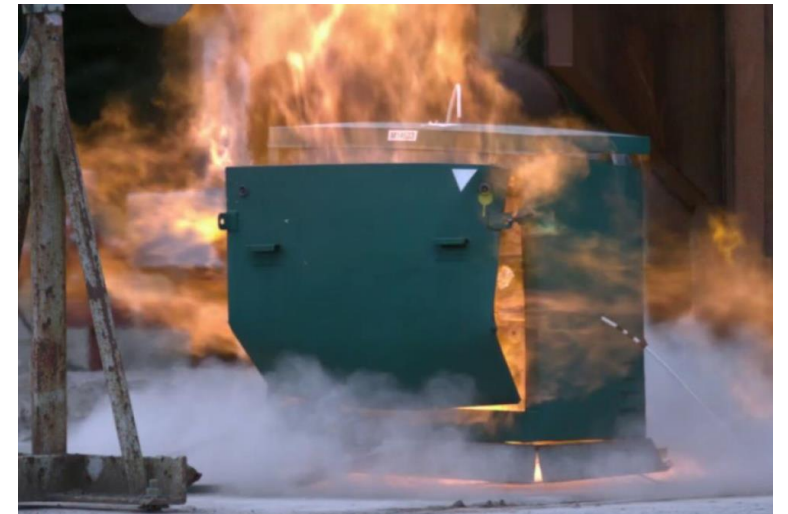
Introduction

- This work has been conducted by DNV as part of the UK Gas Distribution Networks and Ofgem National Innovation Competition funded H21 project.
- Authors of accompanying paper:
 - Michael Acton, Ann Halford, and Andrew Phillips (DNV)
 - Russ Oxley and Dan Evans (Northern Gas Networks)
- Thank you to
 - Northern Gas Networks
 - HSE Science Division
 - DNV's Spadeadam Testing and Research Centre



H21 Project, Phase 1

- Phase 1A – Background testing
 - Carried out by HSE Science Division
 - Investigation of the leakage rate of distribution network assets
 - Included experimental testing of methane and hydrogen
- Phase 1B – Consequence testing
 - Carried out by DNV
 - Included large experimental programme at our Spadeadam test facility
 - Development of a QRA model, which is the focus of this presentation
 - QRA divided into Parts A to E



Phase 1B Experimental Programme

- ‘Small’ releases underground
 - Investigate outflow and migration through the ground
- ‘Large’ releases
 - Investigate ground breaking and fire severity
- Ignition potential tests
 - Domestic appliances and common equipment
- Explosion tests in a variety of enclosures
 - Meter box, kiosks etc.
- Operational safety tests and demonstrations



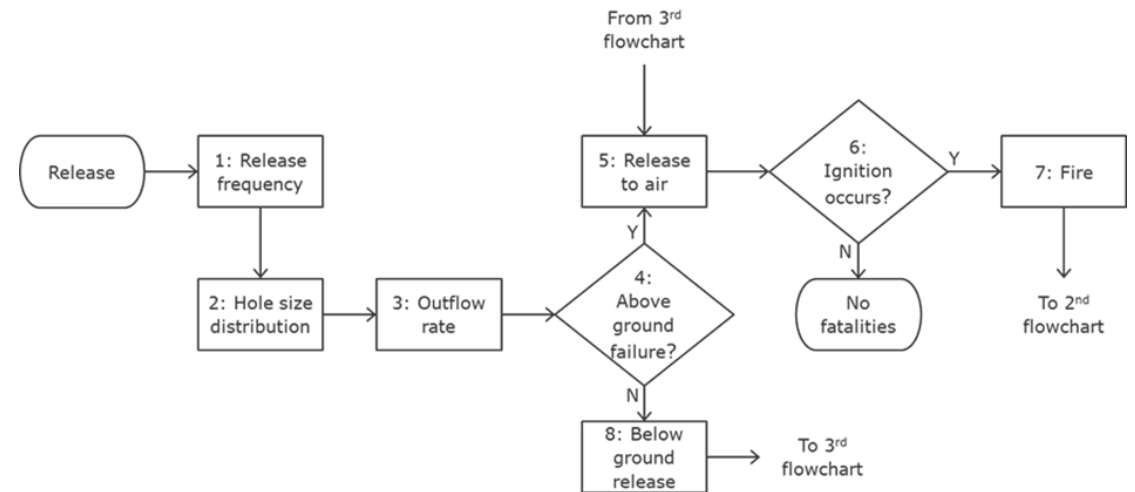
Part A: Information Gathering

- Literature review
 - Publicly available reports
 - Conference and journal papers
 - DNV's previous work
 - Information from other projects
 - Asset data from Northern Gas Networks
- Ensured that
 - Existing information was reused where relevant
 - Distributions of pipe sizes, pressures, materials etc. were realistic



Parts B and C: Preliminary QRA Model

- Development of first version of CONIFER
 - Natural gas model adapted to account for basic hydrogen properties
 - Simple assumptions where behaviour unknown
- Preliminary risk calculations
 - Identify gaps in the model
 - Identify areas for improvement
 - Identify the events that drive the risk predictions
 - Produce preliminary risk predictions
 - Help guide the experimental programme



Part D: Refinements to QRA Model

- Updates to CONIFER based on
 - Spadeadam test programme
 - Further model development
 - Incorporation of additional information
- Major changes include
 - Outflow methodology (both gases)
 - Fire model developed for hydrogen
 - Buoyancy included in gas accumulation calculations
 - Ignition probability model updated
 - Vulnerability model updated for explosions



Part D: Refinements to QRA Model

- Same for natural gas and hydrogen
 - Pipe operating pressures
 - Pipe failure frequencies
 - Hole size distributions
 - Building damage from thermal radiation exposure
 - Vulnerability of people to thermal radiation
 - Ability of people to detect gas ingress
 - Response of people to gas detection
 - Vulnerability of people to overpressure
 - Building types and locations
 - Occupancy patterns of people
- Differences between natural gas and hydrogen
 - Outflow rate
 - Ignition probability
 - Fire severity
 - Gas movement through soil
 - Gas accumulation in buildings
 - Explosion severity

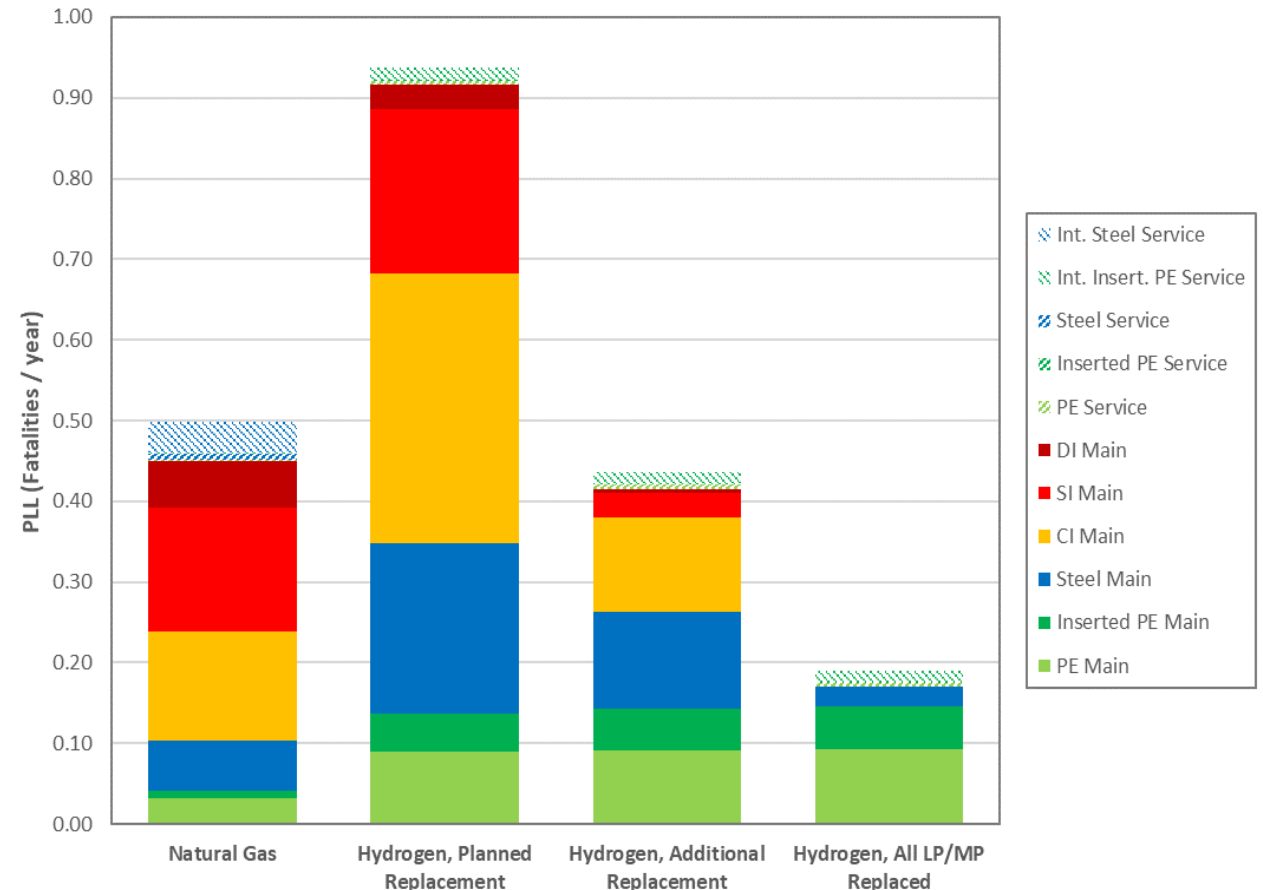
Part E: Results for the GB Networks

- Risk comparison for natural gas and hydrogen networks
- Many combinations of main and building considered
 - 6 main materials (PE and metallic)
 - 8 main diameters (63 to 630 mm)
 - 8 operating pressures (30 mbar to 7 bar)
 - 3 service materials
 - 4 service diameters (15 to 32 mm)
 - 23 building proximity distance (3 to 150 metres)
 - 16 types of houses
 - 4 different occupancy patterns



Part E: Results for the GB Networks

- 2020 natural gas
- 2032 hydrogen
- Hydrogen with additional replacement
 - LP mains with 8" < d < 18" reduced to 10% of population
 - For other LP and MP mains, additional 20% replacement
- Hydrogen with all LP/MP metallic mains replaced



Part E: Results for the GB Networks

- Mitigation measures considered
 - Move internal meters to outdoor locations
 - Reducing operating pressures (likely not practical)
 - Protection against interference damage
 - Excess flow valves on services (not at the meter)
- Other mitigation measures identified
 - More relevant to releases downstream of ECV
 - To be evaluated in Phase 2

H21 Phase 2

- Inclusion of releases downstream of the ECV
 - Incorporating work by Hy4Heat
 - Releases from the meter, pipework and appliances
- Model developments
 - Hydrogen explosion model
 - Hole size distributions
 - Benchmarking against historical data
 - Overpressure effects outside buildings



Conclusions

- The differences between natural gas and hydrogen are understood
- A hydrogen network can pose a lower risk than the 2020 natural gas network
 - Mitigation measures will be required
 - Replacement of metallic mains and services has a significant safety benefit
 - Other mitigation options are available
- Inclusion of releases inside buildings will give a more complete comparison of risks

Thank you for your attention.
Please feel free to contact me.

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