Preparing for the Hydrogen Economy by Using the Existing Natural Gas System as a Catalyst
Project Contract No.: SES6/CT/2004/502661

The NATURALHY project: The first step of the determination of the existing natural gas network for hydrogen delivery

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NATURALHY is an Integrated Project funded by the European Commission's Sixth Framework Programme (2002-2006) for research, technological development and demonstration (RTD)

Presentation breakdown

Project overview

Safety work

} Onno Florisson

Work on material degradation — Isabelle Alliat

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NATURALHY

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Practical approach of the transition toward hydrogen as an important energy carrier: examination of the existing assets.

Main objective:

To define the conditions under which hydrogen can be added to natural gas in the existing system with acceptable consequences.

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NATURALHY Characteristics

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- 40 partners, including 15 from the gas industry
- Start 01-05-2004, duration 5 years
- Budget 17 M EURO
- Collaborations with other projects and organisations including the US DOE
- Financially supported by the European Commission within the 6th Framework Program
- Recognised by the IPHE

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Hydrogen Addition Impacts on:

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- Combustion properties
- Pipeline material properties
- Additional risks
- Socio-economic and environmental aspects
- Management of gas quality
- System design (compressors, ..)
- Gaseous and energy losses
- Energy capacity
- ……

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Partners Working on Safety

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- Loughborough University (leader safety work)
- Leeds University
- Shell Hydrogen
- CEA
- National Grid
- UK HSE

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Objective of Safety Work

To assess the change in Risk to the public caused by introducing hydrogen into the pipeline network

Risk is Probability of Event x Consequences

So Risk may increase due to:

- Increased consequences – for example: more severe explosion hazard
- Increased probability – failure more likely or ignition more likely

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Scope of Safety Work

- Small and large scale experiments to gather data on consequences
- Assessment of change in failure probability and ignition probability
- Consequence model development and validation
- Risk Assessment of sections of pipeline network with hydrogen/natural gas

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Experiments

Small Scale

- Laminar and turbulent burning velocity

Large Scale

- Gas build-up and explosions in domestic type room and in industrial enclosure
- Vapour Cloud Explosions in congested regions
- High pressure jet fires and pipeline fires

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Gas Build Up in Domestic Room

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10 Large Scale Experiments

- Pressures typical of upstream and downstream of the meter: 20 and 30mbar
- Size of leak from small (2mm) to large (10mm)
- Gas release upwards and upward crossflow ventilation as this is most likely to promote layering
- Varying gas composition: CH4 and 10, 20 and 50% H2 in CH4

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Typical Gas Accumulation

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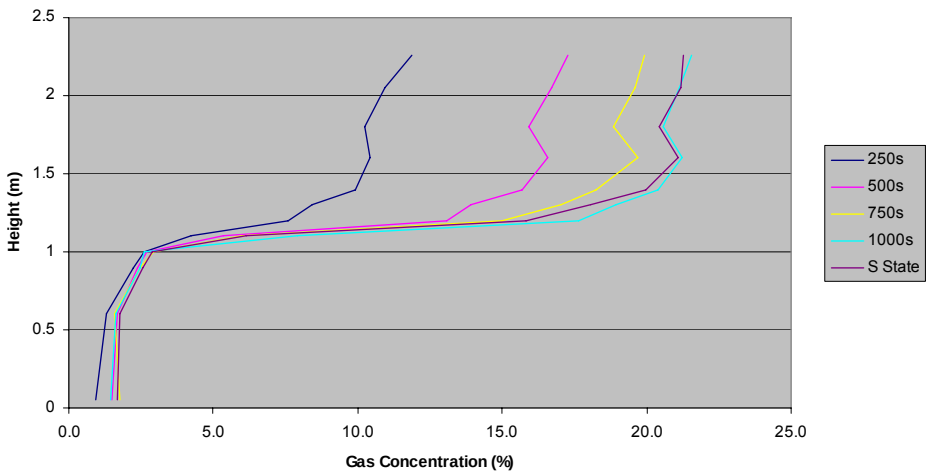
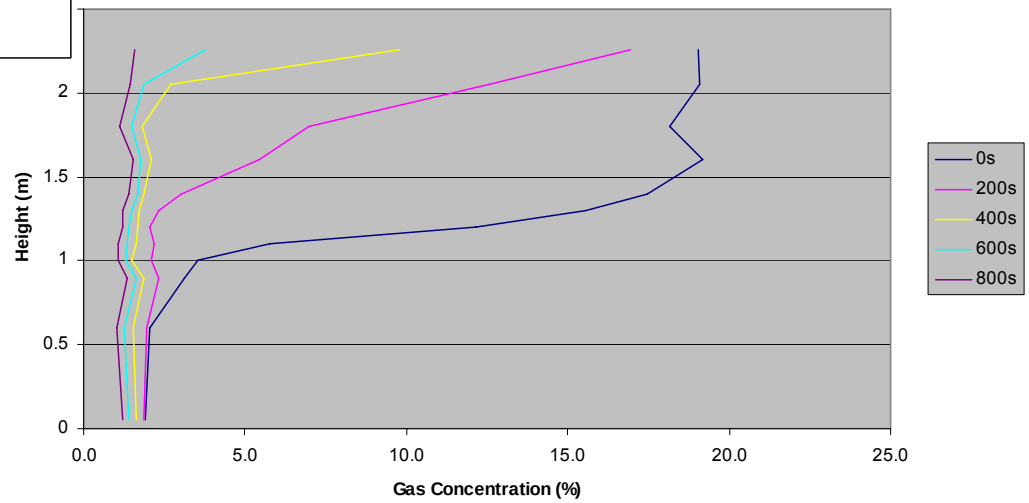
Figure 9.10: DOMEST09 Gas Layer Formation within Enclosure
(times from onset of gas release)



- Layer forms quickly and then increases in concentration

- When gas terminated, ventilation disperses layer

Figure 9.11: DOMEST09 Gas Layer Dispersal within Enclosure
(times from termination of gas release)



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Results

- Still being processed but initial assessment suggests:
  - Similar behaviour for H2/CH4 mixtures as for Methane – that is layered accumulation formed
  - Evidence that the H2/CH4 mixtures result in increased buoyancy induced ventilation which helps lower the concentrations produced
  - No evidence of separation of hydrogen from the gas mixture during gas accumulation

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Some results obtained in the Work Package DURABILITY

Isabelle Alliat / Gaz de France

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OBJECTIVES

How much % of H2 is acceptable in the materials used in Existing Natural Gas Infrastructures (Safety, Damaging)?

- ***Steels for Transmission Pipelines :*** ***H2 effect on defects (mechanical and corrosion) and crack propagation ?***

- ***Polymers for Distribution Network:*** ***H2 permeation in PE pipes ? H2 ageing effect on PE pipes ? Are domestic gas meters reliable, leak with H2 ?***

- ***Materials for Inner grid:*** ***H2 Ageing effect on materials for inner grid ?***

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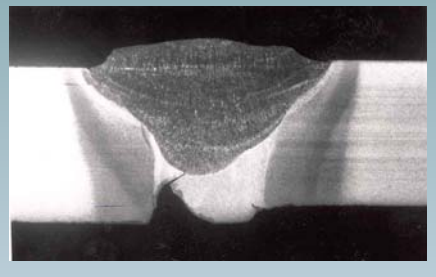
Assess the impact of H2 …

- … on the steels for transmission grids
  - 2 steels are studied ; X52 and X70
  - and the welds

- The crucial point is to determine the mechanical fatigue behaviour of these existing NG pipes
- Others ; burst resistance, fast crack propagation, permeability, adhesion of internal coatings, …

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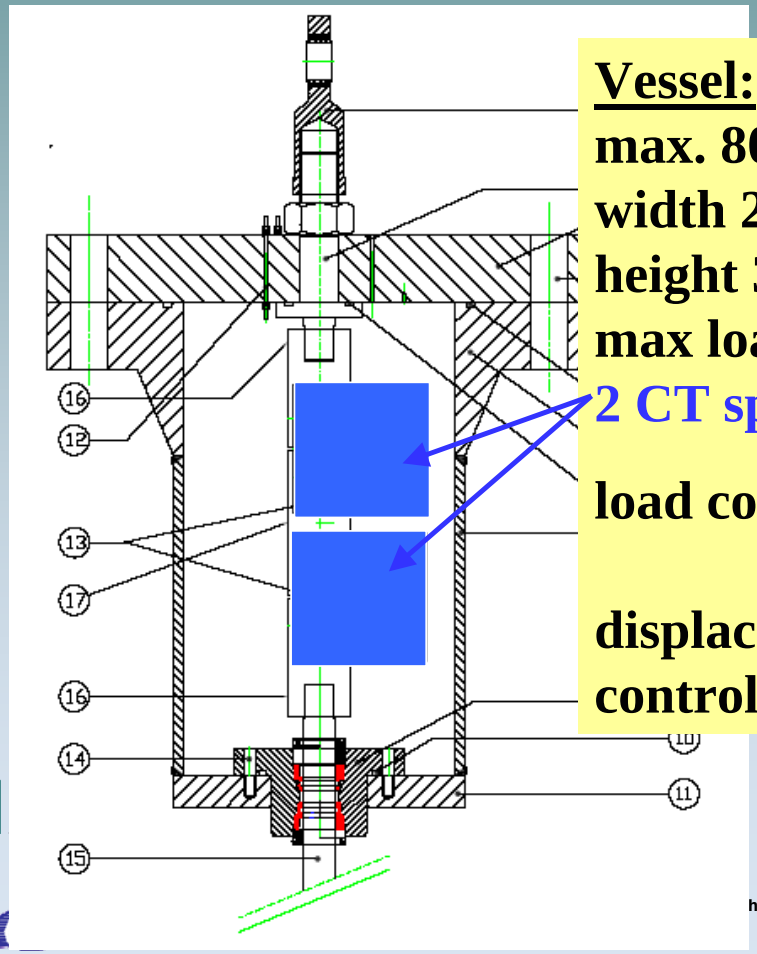
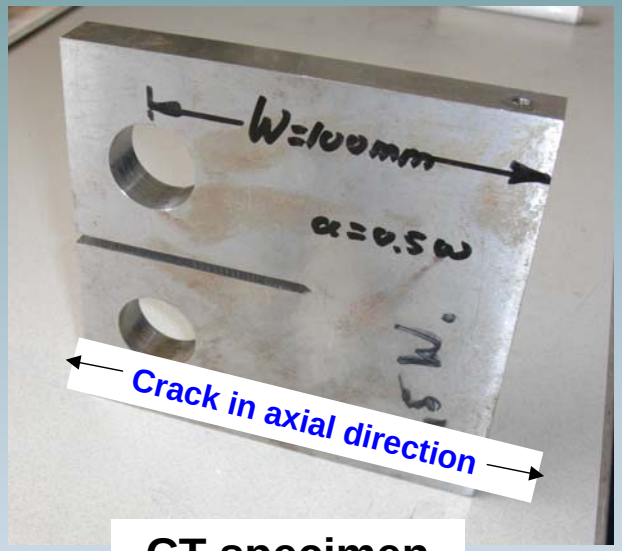
Fatigue tests in gaseous atmosphere

Equipment lay-out and specimen dimensions for fatigue tests in pressurised natural gas / hydrogen blends



Vessel:
max. 80 bar
width 250 mm
height 330 mm
max load 100kN
2 CT specimens

load controlled and displacement controlled



CT specimen

W=100 mm

a=0.5W

Early results on fatigue of the X52

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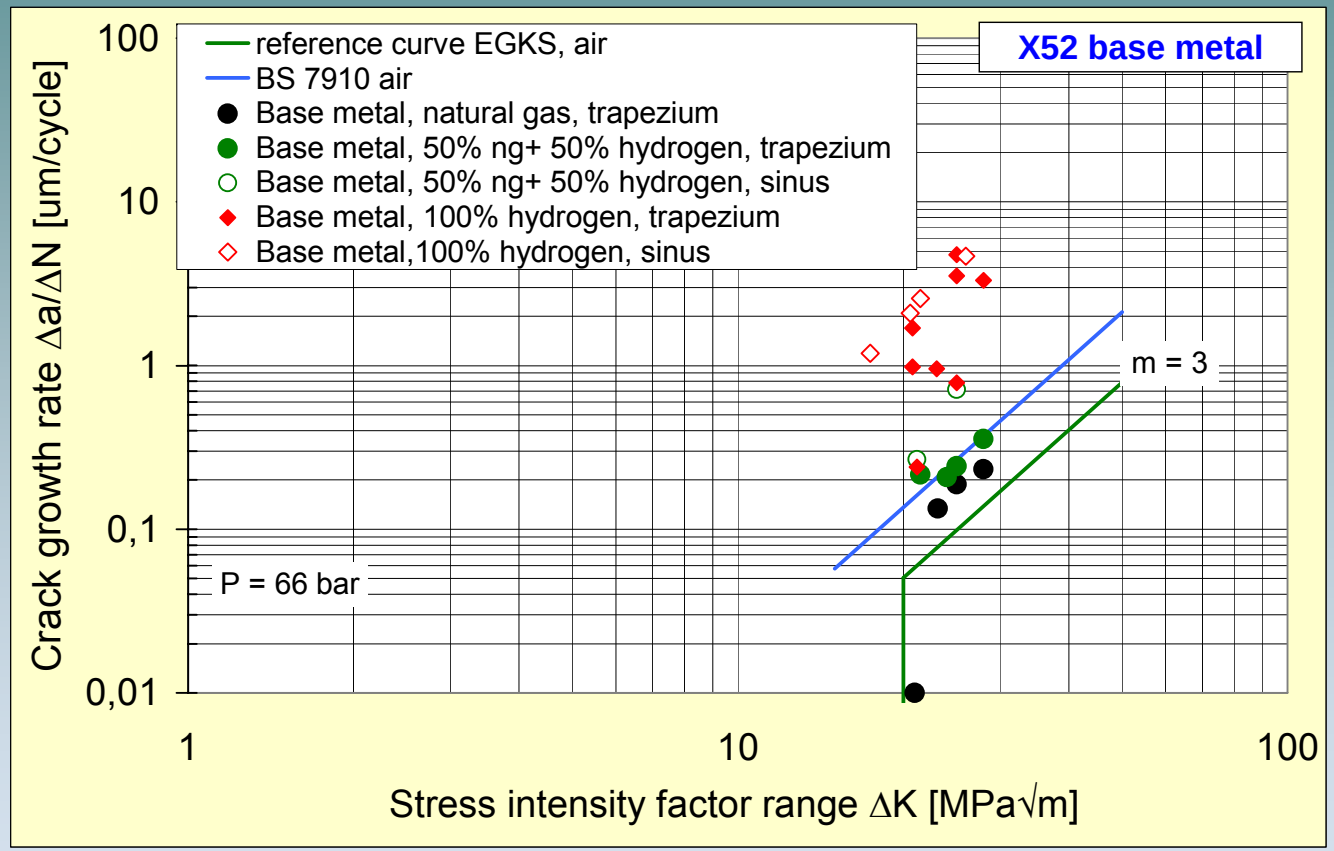
- Mixtures with up to 50% H2 are not critical



- Presence of O2 increase the acceptable % H2

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Assess the impact of H2 …

- … on the polymers for distribution grids
  - 2 polymers are studied ; PE80, PE100, PVC -CPE
  - and the weld by electro-fusion

- The crucial point is to determine the permeability to H2 (safety, metering) and the ageing behaviour of these existing NG pipes
- Others ; mechanical strength, microstructure changes, …

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Assess the H2 permeability of PE

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- Measurements on PE disc samples :
- Results :

Calculated leakages

(due to permeation of gases):

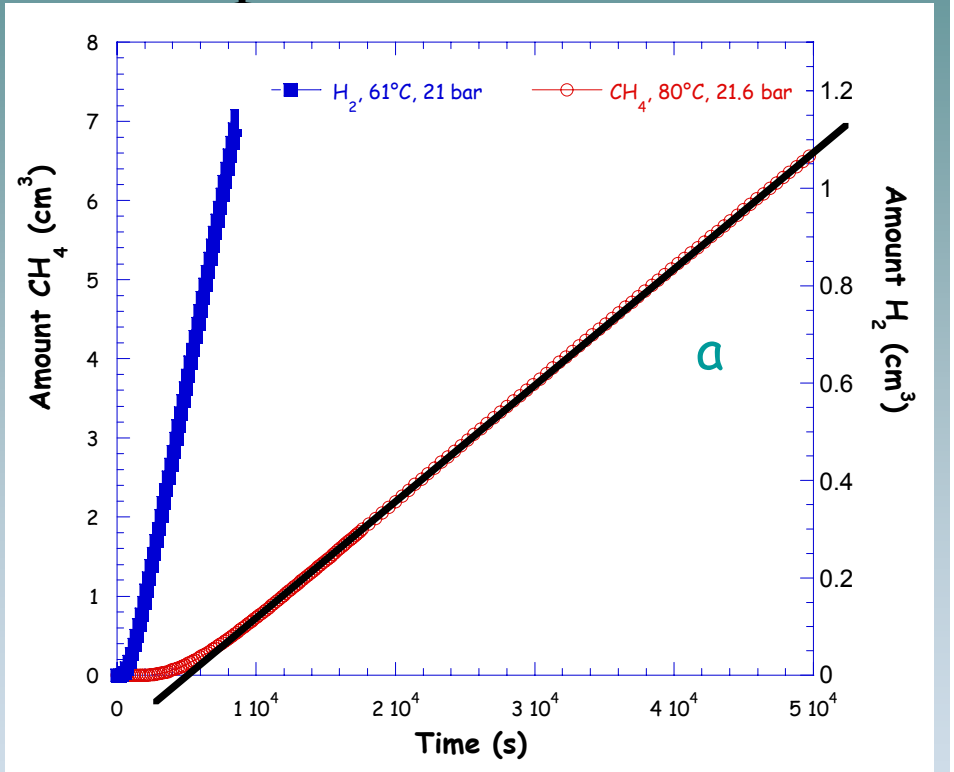
Pipe of PE at 4 bar

Mixture 80% NG + 20% H2 :

= 2,3 liter / km / day of H2

= 1,1 liter / km / day of NG

100% NG => 1,4 liter/km/day



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Actions going on …

- Fatigue behaviour of the X70 steel
- Mechanical tests on girth welds
- Permeability of PE and PVC pipes
- Ageing effect of H2 on PE materials
- Reliability of domestic gas meters

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Thank you for your attention

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