Hydrogen distribution in The Netherlands

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Various report on (re)use of network for distribution of sustainable gasses
Main Message of “Futureproof Gas Networks”

- “Existing networks are suitable for the distribution of sustainable gases. The most important conclusion from this research is that the existing gas network can be used with appropriate measures to distribute sustainable gases such as (100%) hydrogen and biomethane.”

- “Costs of network modifications estimated at a maximum of 700 million Euros. The future use of new gases in the built environment still has various uncertainties. The costs for the network modifications depend on which parts of the current gas network remain necessary.”
Aspects, on which findings were based

- Material compatibility
  - Plastics
  - Metals
- Leakage and permeation
- End use (equipment)  
  Not discussed in this presentation
- Measuring and billing
- Safety and work procedures
Focus on

- **PE**  PE 80, PE 100
- **PVC**  not covered in this presentation
- **POM**  not covered in this presentation
- **Rubber**  NBR, SBR
Compatibility of plastic materials

- Potential degradation processes:
  - Physical degradation: bloating, weakening
  - Chemical degradation: chain break

- Checking:
  - Exposure to relevant (severe) conditions
  - Observing which degradation occurs
  - Measurement of essential properties
Examined aspects of PE

- Material aspects – test methods
  - Mechanical short and long term behaviour – tensile test, constant load test.
  - Chemical degradation – OIT.
  - Physical degradation – Mass increase (bloating), Viscosity/ Melt flow rate.
Results – Mechanical Strength (1)

DGC-survey 10 years @ 100% hydrogen

- Tensile strength test: strain at rupture
- After 3 years of exposure: No change in PE 100 and PE 80
Constant load: large measurement spread (as expected for these tests)

- No change in PE 100 and PE 80
Results – Chemical degradation

- Oxidation Induction Time: measuring effects on stabilizing compounds
- No changes for PE 80 and PE 100

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**PE80 pipes first exposed to 20 year of CH4**

- OIT200 C-inside
- OIT200 C-middle
- OIT210 C-inside
- OIT210 C-middle
- No nat gas exp-OIT200-Inside
- No nat gas exp-OIT200-middle
- No nat gas exp-OIT210-Inside
- No nat gas exp-OIT210-middle

**PE100-type I pipes not previously exposed to CH4**

- OIT200 C-inside
- OIT200 C-middle
- OIT210 C-inside
- OIT210 C-middle
Results – Physical Degradation

- Viscosity: measured differences due to production date and the measurement uncertainty
- No change in PE 80 and PE 100
Examined Aspects NBR / SBR

- ISO/TR 7620 “Rubber materials – Chemical resistance”
  - Both SBR and NBR are recognized as compatible with hydrogen.

- “American National Renewable Energy Laboratory”
  - Both SBR and NBR are well compatible with hydrogen.
Compatibility of Metallic Materials

Potential degradation processes:
- Corrosion
- Hydrogen embrittlement
- Fatigue

Checking:
- Exposure to relevant (severe) conditions
- Observing which degradation occurs
- Measurement of essential properties

- Very minor, acceptable difference between strength as exposed to air vs exposed to $H_2$
- Hydrogen embrittlement will not occur at conditions in the distribution grid. Verified by NATURALHY experiments.

<table>
<thead>
<tr>
<th>Type of steel</th>
<th>Mechanical characteristic</th>
<th>Air</th>
<th>69 bar $H_2$</th>
<th>Difference [%]</th>
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</thead>
<tbody>
<tr>
<td>A106 gr. B</td>
<td>Yield stress [MPa]</td>
<td>462</td>
<td>503</td>
<td>8,9</td>
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<td></td>
<td>Tensile strenght [MPa]</td>
<td>559</td>
<td>576</td>
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<td>Elongation at fracture [%]</td>
<td>14</td>
<td>11</td>
<td>-21,4</td>
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<td>X42</td>
<td>Yield stress [MPa]</td>
<td>366</td>
<td>331</td>
<td>-9,6</td>
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<td>Tensile strenght [MPa]</td>
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<td>483</td>
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<td>20</td>
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<td></td>
<td>Elongation at fracture [%]</td>
<td>20</td>
<td>20</td>
<td>0,0</td>
</tr>
</tbody>
</table>
Scenario’s tested conform BS 7910:

- 66.2 bar
- 10%, 15% en 20% pressure sweep
- 1 fluctuation a day: 14,600 fluctuations over 40 years.
- Crack growth velocity of $\leq 0.01 \, \mu m$ per fluctuation is acceptable
Results – Copper and Aluminium

- 4 years exposure to 20% H₂ (Ameland)
  - No corrosion observed
  - Corrosion requires water to proceed
- Brass junction fitted on copper pipe:
  - No corrosion observed (no stress corrosion)
Conclusions materials

- Not all materials have been tested with 100% H$_2$ representing lifetime expose.
- So far no showstoppers have been found or are expected.
  - All published research show no degradation of plastics and rubbers due to exposure to hydrogen.
  - All published research show no significant degradation of metals due to exposure to hydrogen for conditions found in the distribution grid.
Leakage (leaks and permeation)

- Turbulent outflow volume (‘large’ leaks):
  - Inverse proportional to square root of density: $\text{volH}_2$ is $3 \times \text{volCH}_4$

- Laminar outflow volume (‘small’ leaks):
  - Inverse proportional to kin. viscosity: $\text{volH}_2$ is $1.3 \times \text{volCH}_4$

- Permeation:
  - Measurements: $\text{volH}_2$ is $\approx 3 \times \text{volCH}_4$
Gas Metering

- For same energy consumption, flow is 3x higher
  - Bellow meter (displacement meter): size increase, space not always available
  - Ultrasonic flow meter: is compact, needs adjustment of electronics/software
Billing

- Accurate billing with variable H\textsubscript{2}-mixtures is problematic.
- Issue is argument in favor of regional distribution of 100% H\textsubscript{2}, as opposed to distribution of H\textsubscript{2}/NG-mixtures.
Safety (1)

- Ignition energy H2 is 0.019 mJ:
  - Higher probability of ignition than NG
  - Risk mitigating measures needed for 3th party damage?
- Laminar flame velocity is 4 m/s
  - More pressure build up when ignited than with NG
- Lower density than NG, higher diffusion than NG:
  - More dispersion => (probably) less flammable volume (more experiments and careful monitoring advised)
- No danger of CO poisoning (eliminating the largest risk of indoor gas installations in NL)
Safety (2)

- Odorization:
  - Similar to NG
  - Switch to sulphur-free odorant to be considered
Recommendations for the Dutch DSO’s.

1. To validate and elaborate findings from this report in practice, and to develop "best practices“.
2. To investigate the implications of measuring and billing sustainable gases.
3. To organize drafting appropriate (international) norms and standards throughout the entire chain from production to use.
4. To set up training courses and to set up campaigns for public awareness.
Current H2 Initiatives on Distribution

- Delft Green Village
- Hoogeveen
- Rozenburg
- Stad aan 't Haringvliet

You are here!
Case study: Stad aan ‘t Haringvliet

Green Hydrogen Economy South-Holland Covenant:

..., ...

“a plan is now being developed to provide the Stad aan ‘t Haringvliet with 100% hydrogen. The conversion is to be completed in 2025 and will be carried out under the direction of the regional grid operator Stedin.”

Goeree-Overflakkee to be “hydrogen island”.
H2 from Rotterdam harbor (option).
Windturbines + other sust.
Electrolizer.

ECN, H2platform, Samenwerkingsverband Smart Water, TNO, TU Delft, VNO-NCW West

+ 19 project partners

Egatec 2019 H2 distribution in NL

8 November 2019
Stad aan ‘t Haringvliet

- 1200 inhabitants
- 800 houses (some older)
- 600 connection
- 15 km 100 mbar pipeline
Natural Gas Infrastructure

40 bar Gasunie pipeline

8 bar and 2 bar local ‘backbone’
Reconstruction Phase

2 main phases:
180 + 342 conn.

Daily progress:
- Ca 20 houses a day
- 2 workers 4 hr each house

Total 30 working days
Daily Activities (per section)

In advance (now ongoing): general acceptance, guarantee for reliability

1. Preparation: Intake with house owner & temporary pipelines.
2. Isolation of section.
3. Replacement of gas meter.
4. Replacement of appliance(s).
5. Purging and refill of section.
6. Testing and recommissioning service lines and installation.
7. End of day check.
After Care

- Under discussion:
  - Additional in-house inspection.
  - Helpdesk & information/complaint service.
  - Intensified leak survey (until proven superfluous).
  - …
Status.

Discussion ongoing:
- Adaption and interpretation of existing standards and regulations.
- DSO Stedin: to guarantee reliability and safety during transition and after.
- Certification of gas metering: to be incorporated in delivery contracts.
- Billing and H2-price setting: to be discussed (similar to district heating contracts?).
- Transition costs:
  - Compensation for existing appliance
  - Compensation for inconveniences
  - Opt-out options for individual house owners?
Conclusion

- Hydrogen options are being taken seriously in NL and studied in depth on distribution scale.
- Long term perspective for 100% H2 (probably not blending).
- Current gas distribution network is suitable for H2 (and blending, and biomethane).
- Pilot studies ongoing in NL.
- Demo projects ongoing and in start up phase.