INJECTION OF HYDROGEN INTO HIGH PRESSURE NATURAL GAS GRIDS: INVESTIGATION OF THE IMPACT ON MATERIALS AND EQUIPMENT AT RELEVANT ENVIRONMENT

Vanesa Gil[1,2], Javier Sánchez-Laínez[1], Alberto Cerezo-Alarcón[3], Jorge Aragón[4], Ekain Fernandez[4], Virginia Madina[4], Tobias Weide[5]*, Hans Ramusson[5]

[1] Foundation for the Development of New Hydrogen Technologies in Aragón, Parque Tecnológico Walqa Ctra. N-330A, km. 566, Cuarte, Huesca, Spain
[2] ARAID Foundation, Avda. de Ranillas 1-D, 50018 Zaragoza, Spain
[3] Redexis, C/ Mahonia 2, 28043 Madrid, Spain
[4] Tecnalia, Parque Científico y Tecnológico de Gipuzkoa. Mikeletegi Pasealekua, 2. E-20009 Donostia-San Sebastián (Gipuzkoa), Spain
[5] European Research Institute for Gas and Energy Innovation – ERIG a.i.s.b.l. Rue Belliard 40, 1040, Brussels, Belgium

HIGGS Hydrogen in Gas Grids

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Introduction

- The HIGGS project aims to pave the way to the **decarbonisation of the natural gas grid** and its usage, by **covering the gaps of knowledge** of the impact that **high levels of hydrogen** could have on the gas infrastructure, its components and its management.
- An R&D platform **working at 80 bar** has been developed in HIGGS, **simulating the operational conditions in the grid** when the transported gas changes from bare natural gas to new conditions considering high hydrogen content.
- The most relevant materials, equipment and components present in **transmission gas grids** (i.e. high pressure grids) have been **identified and installed in the R&D platform** to perform empirical tests under hydrogen atmosphere at high pressure.
- The admixture levels consider various hydrogen concentrations, according to the tendencies expected in the market: **20, 30 and 100 %mol H_2**.

The R&D platform

- The R&D platform consists in 1) an **admixture system** that generates and injects the blend for the tests, 2) a **testing platform** where tightness and possible hydrogen embrittlement and further damage on steels, valves and equipment is tested and 3) a gas **separation prototype** for deblending tests (hydrogen recovery).

Figure 1. Testing valves section

Figure 2. Testing equipment section

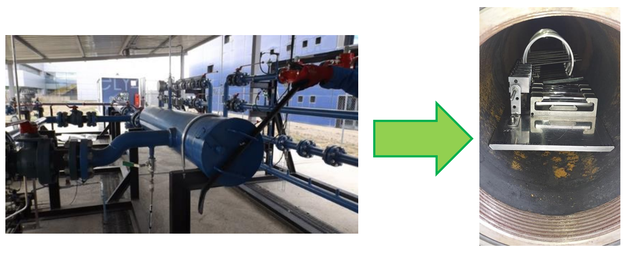

Figure 3. Testing steels section

Figure 4. Whole overview of HIGGS R&D experimental platform

Figure 5. Admixture system

Figure 6. Gas separation membrane prototype

Results of the first experimental campaign (20 %mol H_2 in CH_4)

TIGHTNESS TESTS

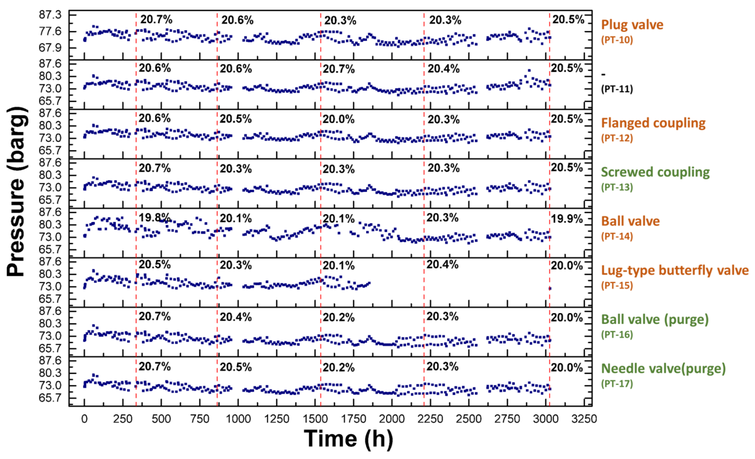

Figure 7. Evolution of pressure (scatter in blue) and hydrogen concentration (lines in red) in each line of the testing valves section

- The lines where the testing valves are allocated are fed with blend at high pressure and closed. The evolution of pressure and hydrogen concentration is monitored.
- Over 3,000 h exposure to the blend at 80 barg.
- Valves of different nature tested. Screwed and flanged couplings considered.
- No critical hydrogen losses detected.

HYDROGEN EMBRITTLEMENT

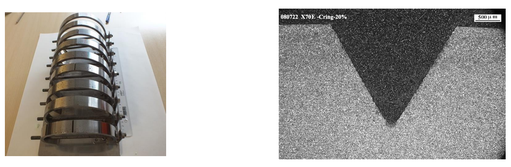

Figure 8. Tests on C-ring specimens (ISO 7539-5, ASTM G38 standards)

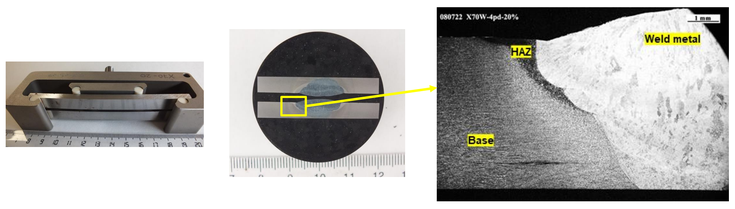

Figure 9. Tests on 4pb specimens (ISO 7539-2, ASTM G39 standards)

Figure 10. Tests on CT-WOL specimens (ASME B31.12, ISO 1114-4 standards)

- Exposure of carbon steels API 5L Gr X42, X52, X60 and X70 to the blend at 80 barg (>3,000h).
- Metallographic sectioning confirms the absence of new cracks or crack propagation after the test

GAS SEPARATION TESTS

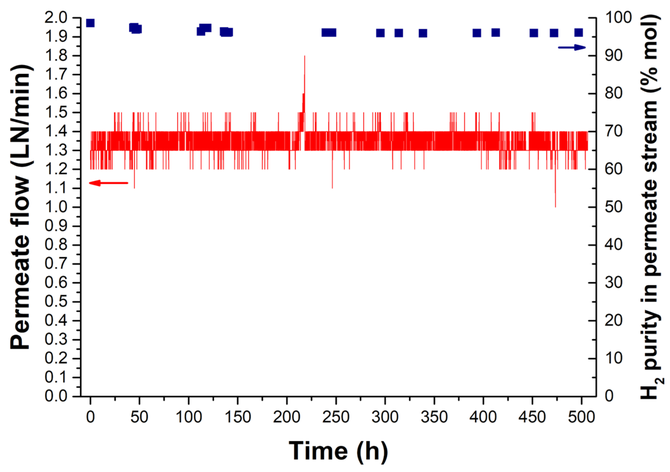

Figure 11. Gas separation performance of the membrane separation prototype.

- Gas separation test using Pd-based membranes.
- A 10.4 LN/min flow (blend) at 80 barg is fed to the prototype for 500 h and the H_2/CH_4 admixture is deblended.
- The permeate flow (recovered hydrogen) and its content in hydrogen is monitored.
- Good gas separation performance with an average permeate flow of 1.35 LN/min and a hydrogen purity > 96%mol.

Conclusions

- The different valves are tight to hydrogen under the tested conditions and may be compatible with this new gas quality in the grid.
- No hydrogen embrittlement or further damage detected on any steel quality after exposure to hydrogen for more than 3,000 h.
- Stable gas separation performance of the membranes during operation, with an acceptable hydrogen recovery rate and gas quality.

Acknowledgements

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Clean Hydrogen Partnership