Material Testing and Recommendations for H_2 Components under Fatigue
(GA 303422)

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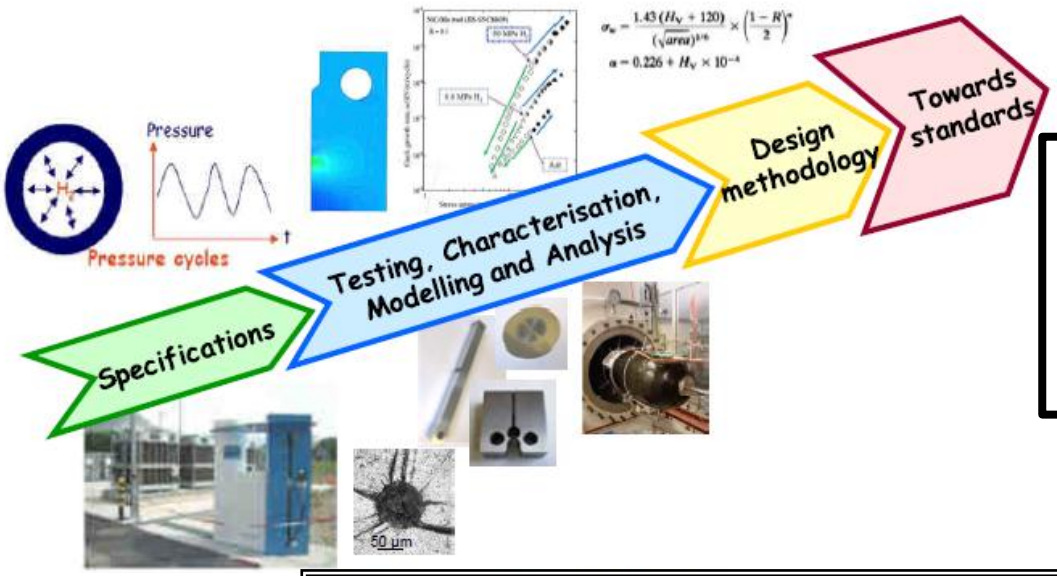
PROJECT OVERVIEW

- **Material Testing and Recommendations for H_2 Components under fatigue**
- SP1-JTI-FCH.2011.2.8 Pre-normative research on design and testing requirements for metallic components exposed to H_2 enhanced fatigue

- October 1, 2012 to September 30, 2015
- Budget: Total budget 2,492,937€
  FCH JU contribution 1,296,279€

- Stage of implementation: 66%

PROJECT OVERVIEW



- No international standards to ensure fitness for service of pressure vessels subject to hydrogen enhanced fatigue

To provide

- an easy to implement methodology
- based on lab-scale experimental tests under H_2 gas
- to assess the service life / design of a real scale component
- taking into account fatigue loading under H_2 gas

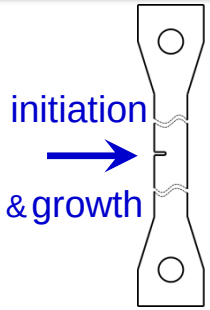
PROJECT TARGETS AND ACHIEVEMENTS

Status before project	MAIP target	Project Target	Current status/ achievements	Expected final achievement
Lack of RCS dedicated to hydrogen infrastructures	"…Removal of non-technical market barriers particularly through the development of RCS"	To propose a design methodology Recommendations for implementation in international standards.	50% The methodology relies on the experimental results and the analysis of existing RCS	90% Validation of the methodology with full scale testing remains challenging

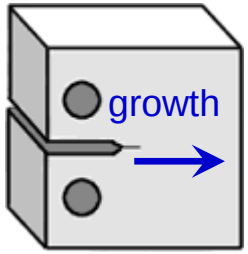
PROJECT TARGETS AND ACHIEVEMENTS

Status before project	AIP target	Project Target	Current status/ achievements	Expected final achievement
Lack of RCS	Design code for pressure equipment in hydrogen service	Development of a design methodology	50% Comparative analysis of existing codes for PV design	90% Validation of the methodology
What are the appropriate tests under H_2 pressure ?	Experimental implementation of design approach and design testing approach	Development of methodology based on **lab-scale tests** under hydrogen gas and taking into account fatigue.	50% Three types of lab-scale tests are developed. Needed data identified.	90% To define the appropriate testing method
Missing materials data under hydrogen pressure	Metallic material characterization for hydrogen service	Analysis of FC initiation and FC propagation under H_2 pressure	70% Experimental tests are ongoing	100% (only for one material AISI 4130)

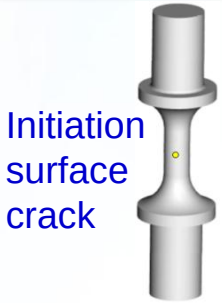
Experimental developments and results



Notched tension



Compact tension

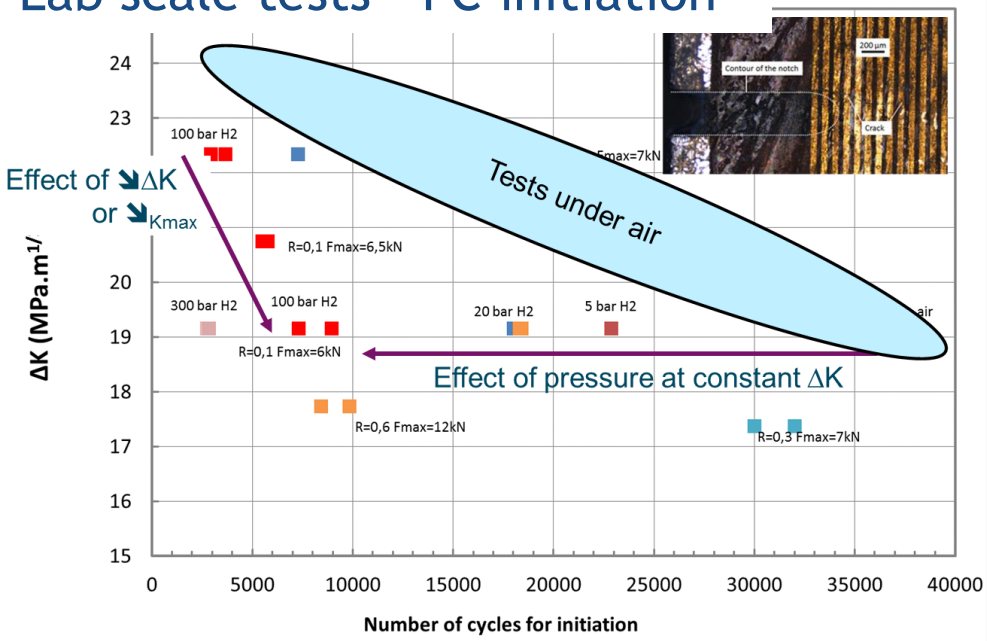


Drilled LCF bar

Relevant pressure cycle

Disk test by pressure

Lab scale tests – FC initiation



Full scale tests (CSM, Tenaris, JRC)

$$N_R^{H2} = \alpha N_R^{hydraulic}$$

To derive α from lab-scale tests

Methodology development

- Analysis of existing RCS on a given geometry
  - Relevant codes identified (EN13445, ASME KD10, KHK S 0220)
  - To identify the different approaches
    their advantages and drawbacks
    the missing points concerning fatigue under H_2

- Methodology : 2 main options

  - "Classical design" with data obtained under hydrogen pressure
  - Design under neutral gas + use of a multiplier "hydrogen safety factor"

  ➔ Understanding effects of R, f, P on crack initiation and propagation

RISKS AND MITIGATION

- Validation of the methodology
  - Risk: full scale testing under cycling hydrogen pressure
  - Remedial action taken: 2 sizes of cylinders considered
- Experimental implementation
  - Risk: specific experimental developments
  - Remedial action taken: 3 types of tests considered

SYNERGIES WITH OTHER PROJECTS AND INITIATIVES

- Several partners involved in the following projects : *HyComp*, *HyIndoor*, *HyTransfer* dedicated to Hydrogen structural integrities or Prenormative research

- Two letters of interest from SNL (USA) and Hydrogenius (Japan)
- Profs. Murakami (Hydrogenius) and Somerday (SNL) attended one technical meeting
- Mathryce invited in forums and workshops organised by SNL and Hydrogenius
- Current discussion to perform some specific lab-scale tests at 1000 bar H_2 at SNL (crack initiation tests ?)

HORIZONTAL ACTIVITIES

- Several partners are involved in RCS working groups. In particular, ISO/TC 58/ WG 7 dedicated to *Gas cylinders – Compatibility between gases and materials*

- It is planned to present the methodology to such committees in CEN and ISO

- A workshop will be organised in 2015 on methodology to design hydrogen components under fatigue

DISSEMINATION ACTIVITIES

Conferences / workshops	Place	Date	Topic presented
Int. H_2 forum	Japan	01/13	Mathryce project
ICHS 2013	Belgium	09/13	Mathryce project
H_2 testing workshop	USA	04/13	Testing under H_2
H_2 design code workshop	USA	07/14	Mathryce approach for RTD
Steel & Hydrogen 2014	Belgium	05/14	Fatigue experimental developments
ASME PVP 2014	USA	07/14	H_2 enhanced fatigue
HY-Storage, Embrittlement, Applications	Brazil	10/14	- H_2 enhanced fatigue - Comparison of existing standards

- Papers foreseen in IJHE following HY-SEA conference

EXPLOITATION PLAN/EXPECTED IMPACT

- Increase of knowledge on metal/hydrogen/fatigue interactions, including crack initiation
- Experimental developments to address hydrogen enhanced fatigue

- A **design code** dedicated to pressure vessel design including rules **for hydrogen enhanced fatigue** is necessary to **ensure safety** and **facilitate competitive development** of dedicated infrastructures. Particular concern: H_2 buffer vessels ($p \geq 850$ bar, public access)
- The results are intended for uptake by RCS organisations to improve or develop more appropriate ones