Enhanced design requirements and testing procedures for **composite cylinders** intended for the storage of hydrogen (**HyCOMP**)

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Context

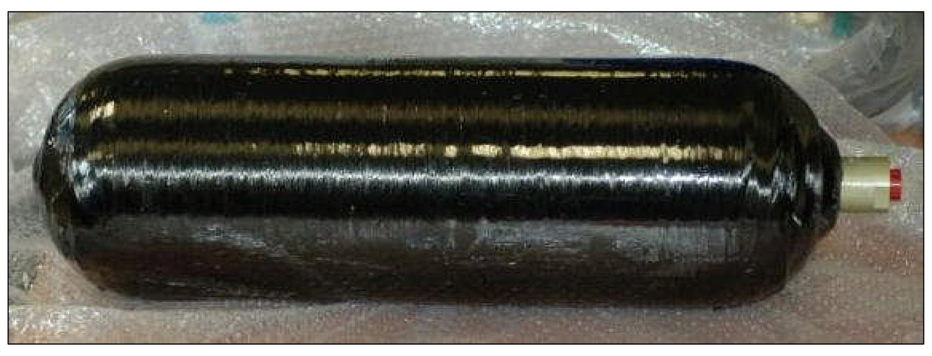
Hydrogen storage is a key issue for the extensive use of **H_2 as an energy vector** & success of the whole H_2 value chain

Production → **Storage – Distribution – Refuelling** → **Public use**

The most mature technology for storing hydrogen is in **compressed form in high-pressure cylinders**

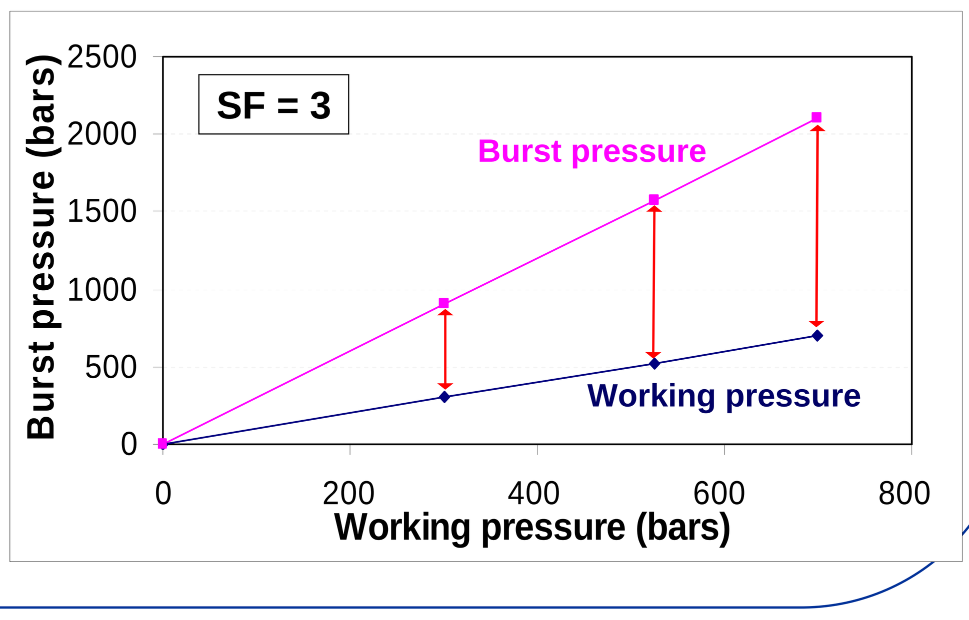
↳ High pressure cylinder storage of H_2 (700 bar) in **carbon fibre (CF) composite** are currently developed

BUT: Current regulations do not allow the full exploitation of CF materials potential:



9L type IV cylinder - NWP = 300 bars - SF = 2,25 (prototype)

- Requirements are *adapted from standards covering metallic cylinders*, and not based on degradation processes in composite materials
- The safety factor (SF) is *too conservative* for good designs: for example SF = 3 for trans-portable applications
- Thus cylinders are *overdesigned* and *costly* (high thickness of composite wrapping)



Objectives

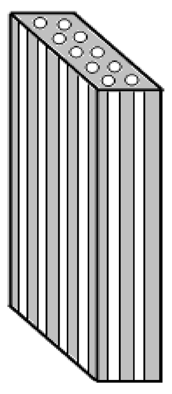
To address these issues, the European HyCOMP project (2011-2013) funded by the Fuel-Cell & Hydrogen Joint Undertaking (FCH-JU) is conducting **pre-normative research** in order to:

- Develop a better understanding of the **damage accumulation processes** in the composite wrapping and the **degradation rate** as a function of the type of load (cyclic or sustained) and environmental conditions
- Improve the full set of **requirements and procedures** defined to ensure the structural integrity of the cylinders throughout their service life (covering design type approval, manufacturing quality assurance, and in-service inspection)

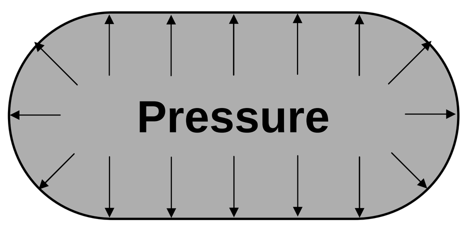
⇒ Recommendations will be proposed **to support Authorities and Industry in making enhanced RCS** on high-pressure composite cylinders at a European and international level

Materials & methods used

Damage mechanisms are first identified at a material scale (plate specimens) to avoid the complex response of a cylinder, and then confirmed at the cylinder scale:



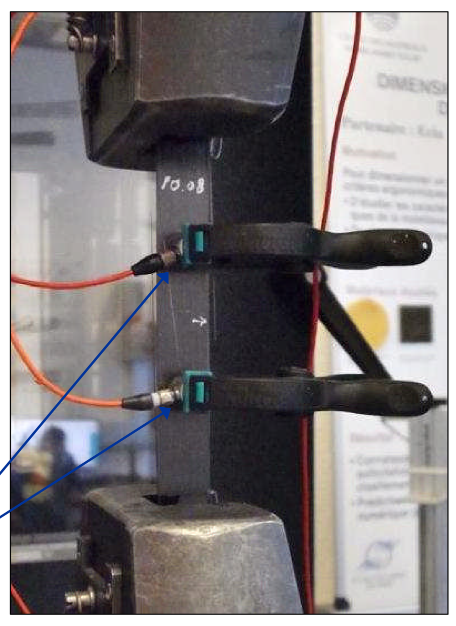
Material scale



Cylinder scale

Tested cylinders	Type	Nominal working pressure (at 15°C)	Minimal burst pressure
Faber 9L	Type III	300 bars	675 bars
CAQ 9L	Type IV		
Hexagon 19 & 36 L		700 bars	1575 bars

SF = 2.25



AE sensors

Acoustic emission (AE) as a non-destructive testing is the preferred technique:

- To **evaluate the level of damage in the composite shell** after cyclic, static or hybrid loads representative of service conditions
- To discriminate bad from good cylinders after production (**Manufacturing Quality Assurance**)

Based on the experimental damage accumulation curves, numerical models are developed to **predict residual lifetimes** *(multiscale modelling with the FEM and fractal simulations based on cellular automata)*

↳ An estimation of the probability of failure for a required lifetime will be used to define an **optimized safety factor**

Conclusions & Perspectives

This new approach will provide the scientific data necessary to improve and adapt the requirements defined for composite cylinders

As an outcome of the project, a document gathering recommendations for enhanced design requirements and testing procedures will be proposed to new and ongoing RCS activities

Expected impacts:
- Economical impact: a ***better adaptation of design and manufacturing quality requirements*** (including SF)
- A better social acceptance of H_2: ***demonstration of the structural integrity*** of composite cylinders

Website: http://hycomp.eu

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