Safe pipelines for hydrogen transport

Dutch visit at NTNU and SINTEF,

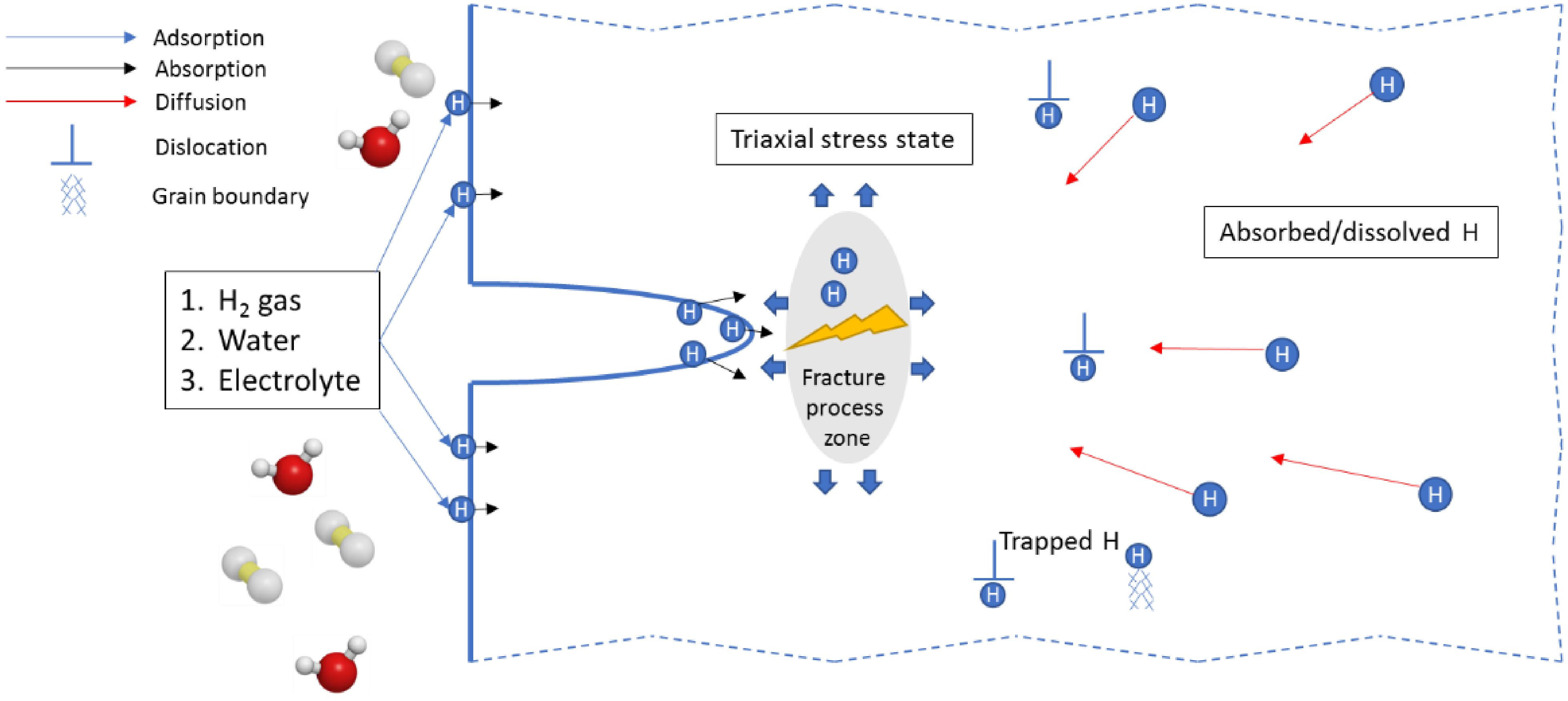
June 24th, 2022

Vigdis Olden, SINTEF Industry

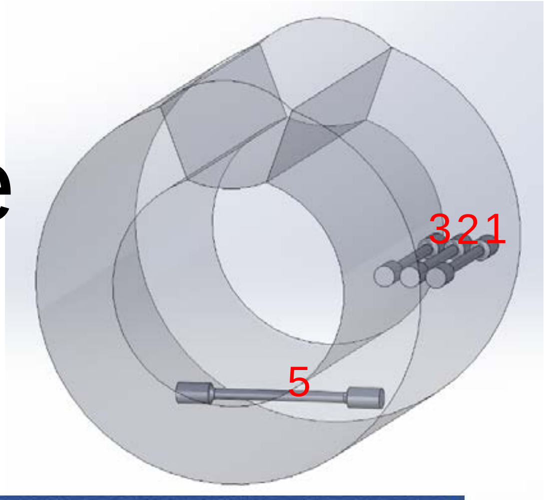
Outline

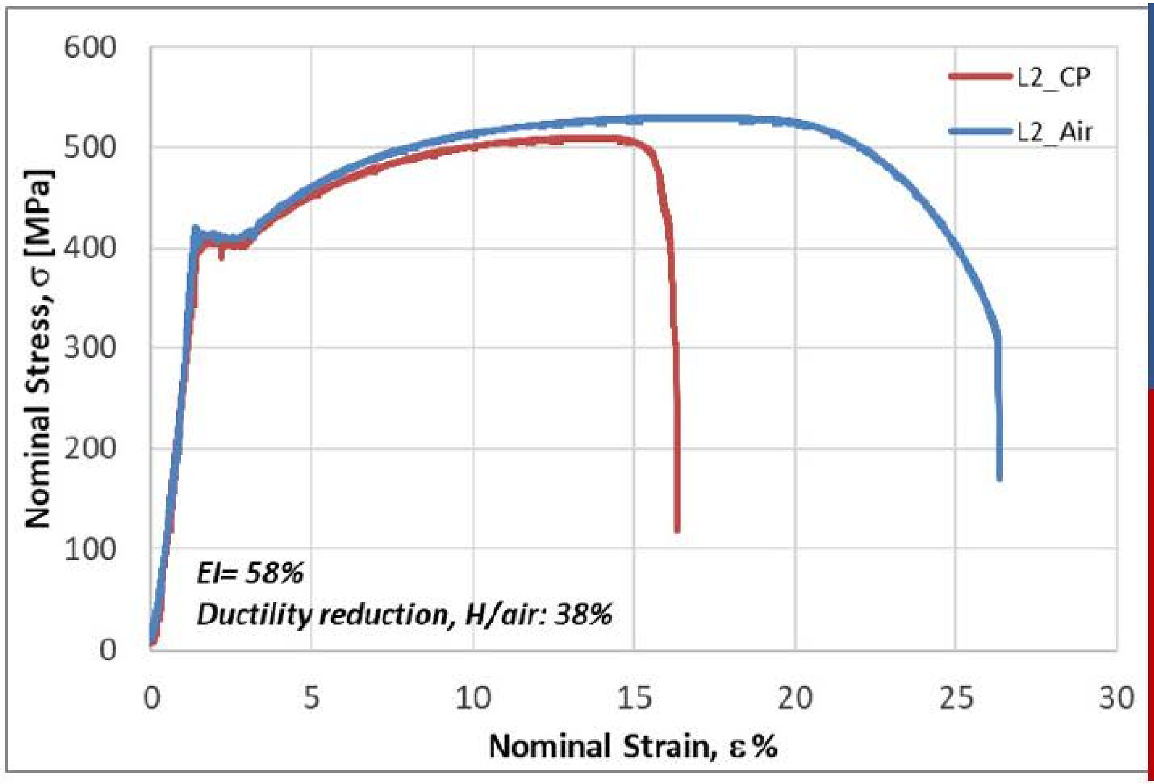
- What is hydrogen embrittlement?
- Safe transport in existing natural gas pipelines – The HyLINE project
- New national infrastructure for hydrogen-materials interaction research

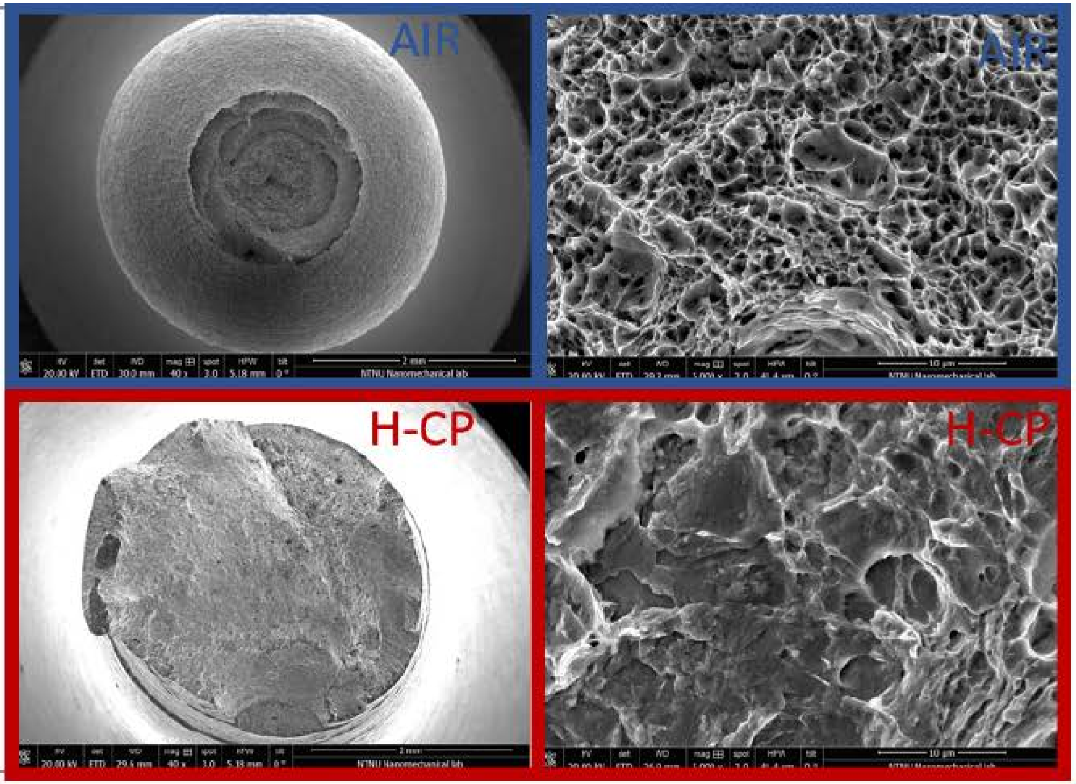
What is hydrogen embrittlement?



The mechanichal properties change

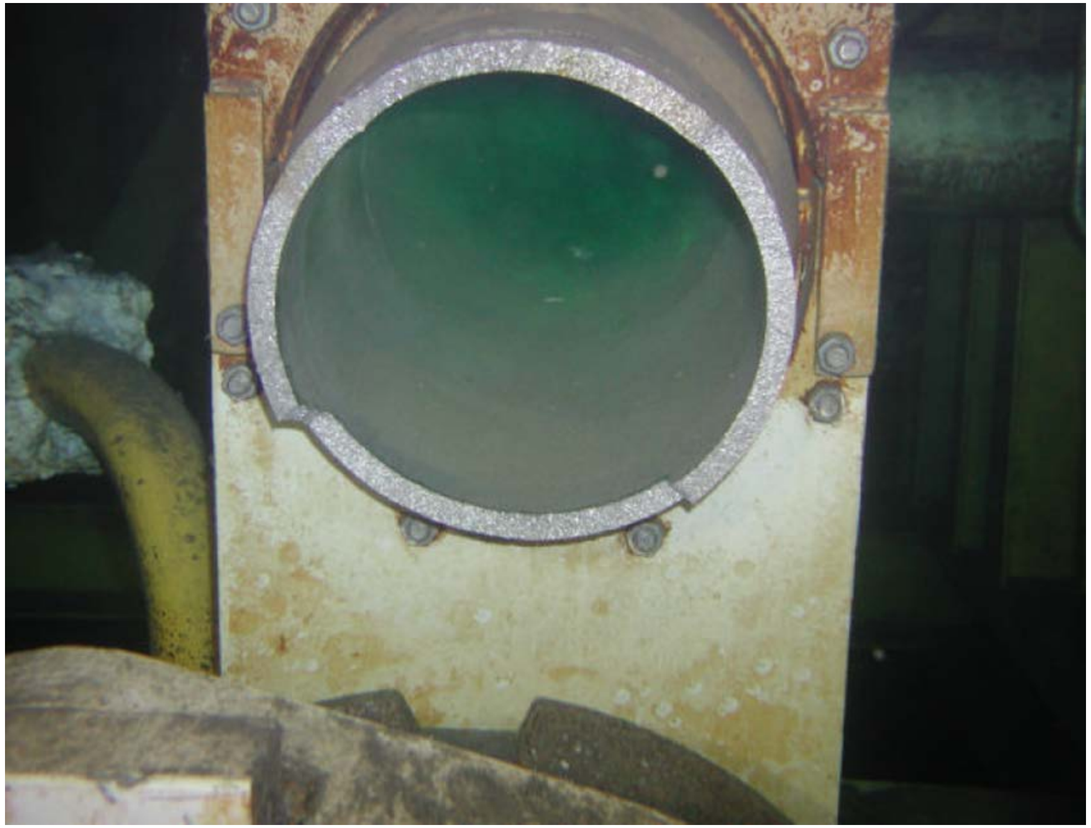


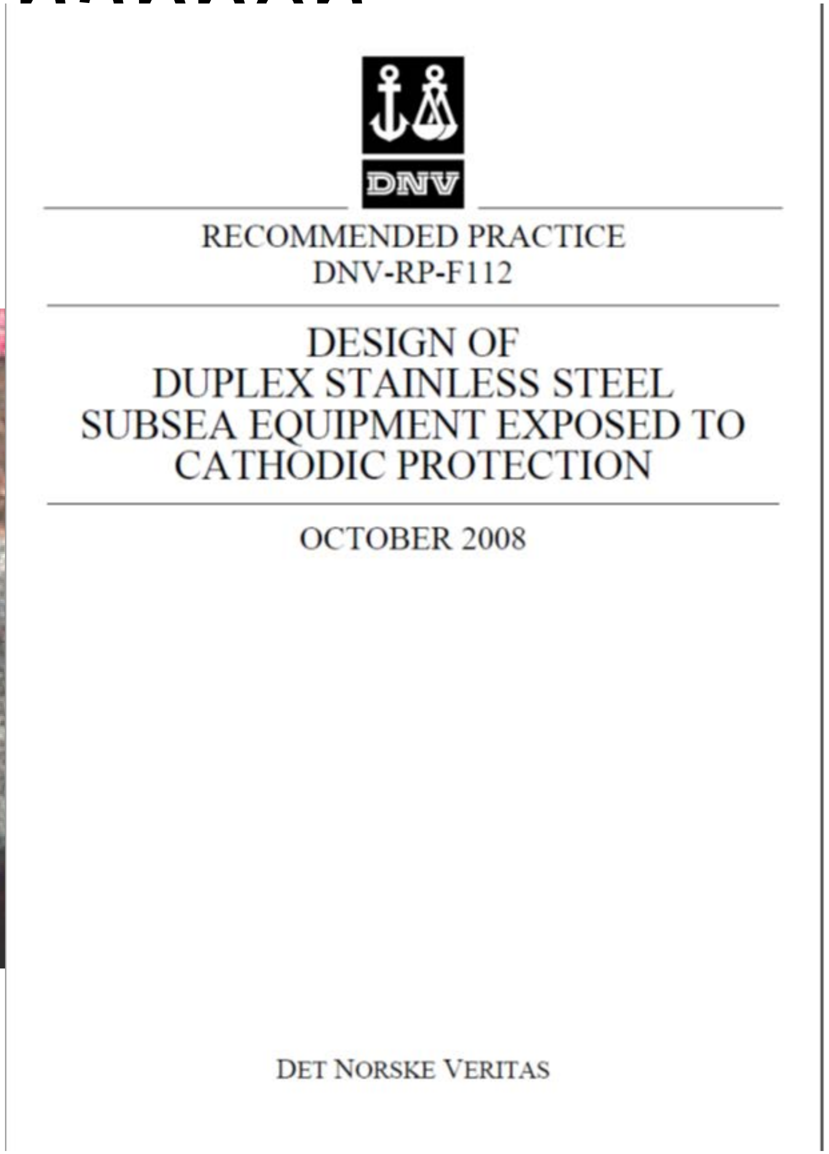




Open SINTEF report: https://hdl.handle.net/11250/2730366

What may in the worst case happen when H enter pipelines?





DNV

RECOMMENDED PRACTICE
DNV-RP-F112

DESIGN OF
DUPLEX STAINLESS STEEL
SUBSEA EQUIPMENT EXPOSED TO
CATHODIC PROTECTION

OCTOBER 2008

DET NORSKE VERITAS

HyLINE (2019-2023)

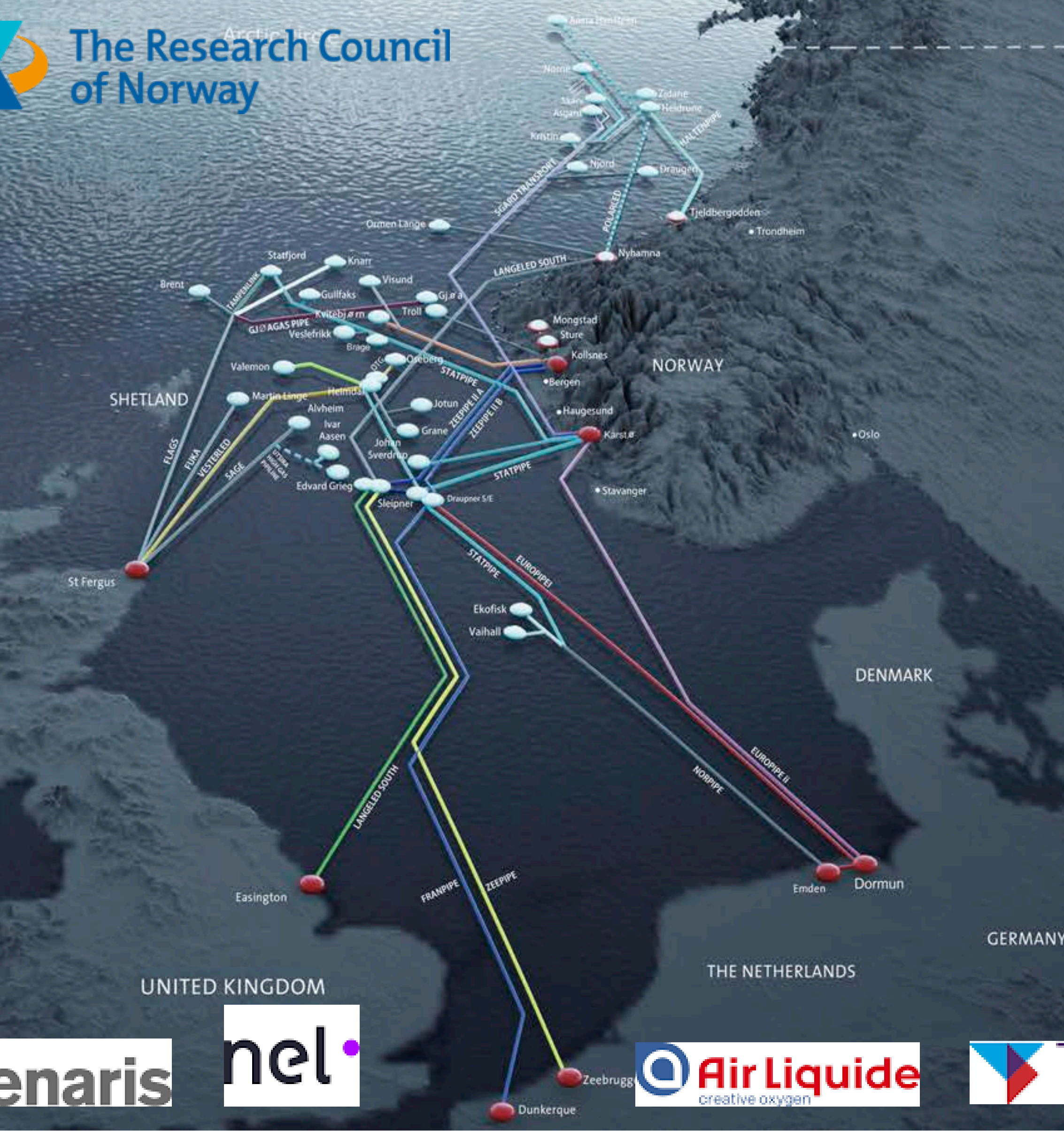
The main objective of HyLINE is to establish fundamental knowledge about the effects of hydrogen gas on pipline steels to enable a safe and efficient use of existing and new subsea pipeline infrastructure for future large-scale transport of hydrogen gas.

The Research Council of Norway

SINTEF

NTNU

KYUSHU UNIVERSITY



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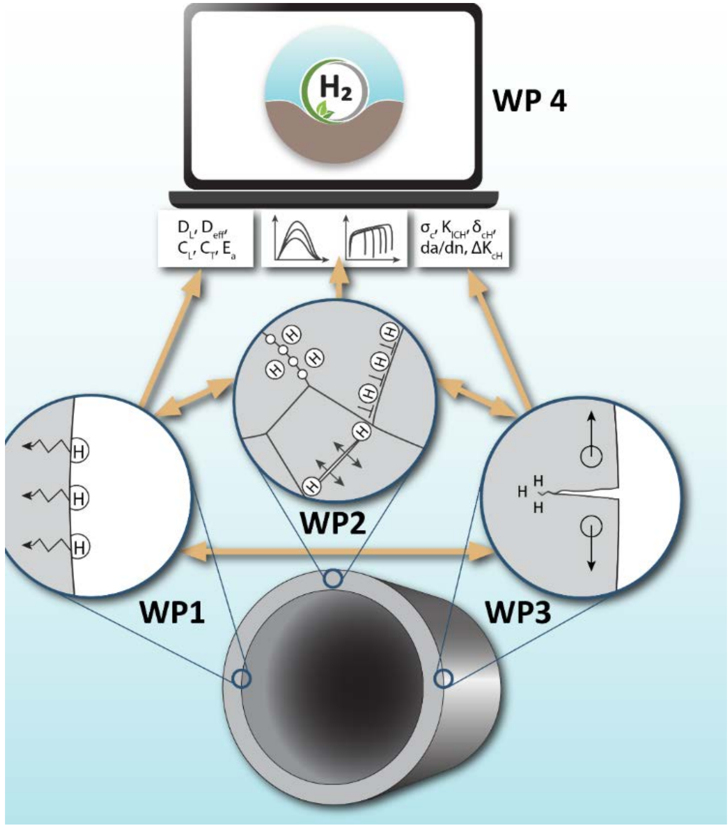
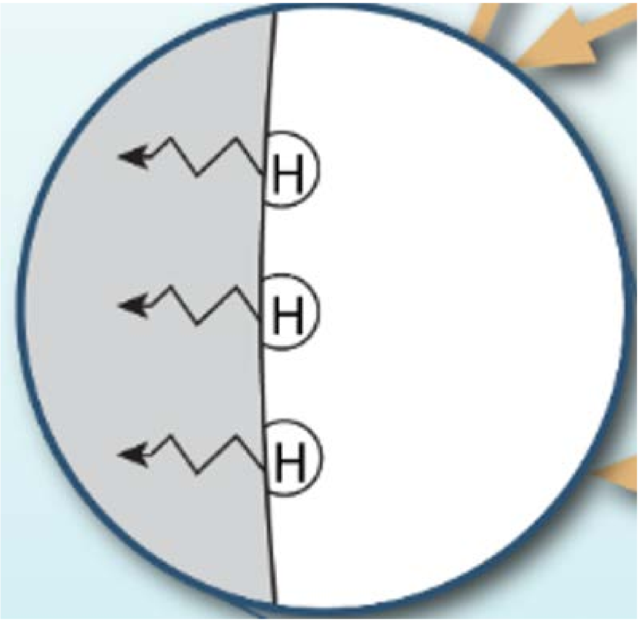
The structure of the HyLINE project



- WP1 Hydrogen uptake and diffusion
- WP2 Nano and micro scale effects
- WP3 Mechanical performance
- WP4 Structural integrity assessment & model development

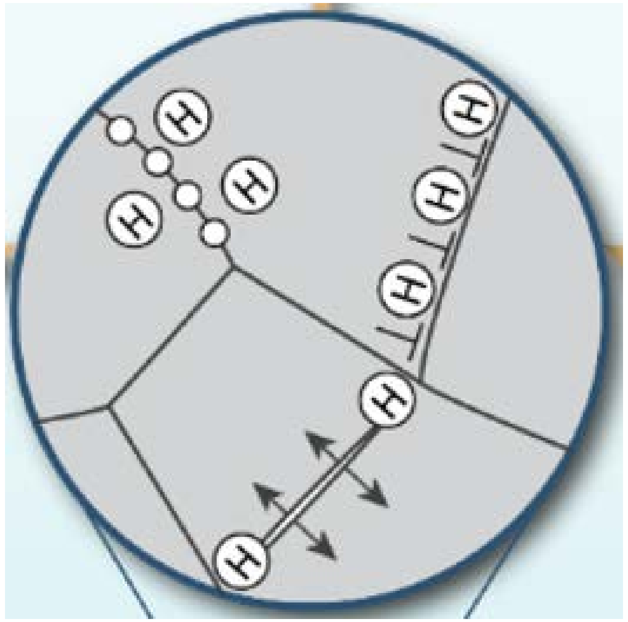
WP1 Hydrogen uptake and diffusion



- Task 1.1 Absorption and concentration
  - Characterize H diffusion properties and trapping after H charging under various hydrogen charging conditions (CP and H_2).

- Task 1.2 Influence of inhibitors
  - Examine the influence of adding ppm levels of inhibiting gases in pressurized hydrogen gas.
  - Close collaboration with WP3

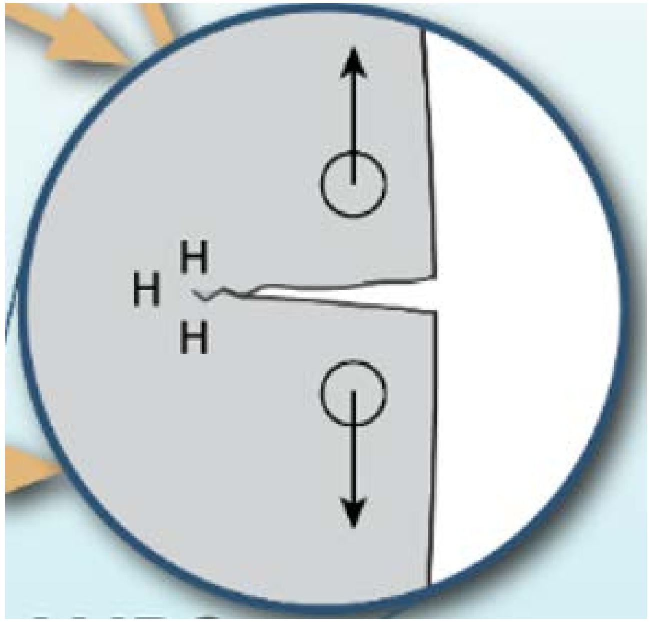
WP2 Nano and micro scale effects



- Task 2.1 Small scale mechanical testing
  - In situ nano and micro-mechanical testing under different H charging conditions. Focusing on the mechanical response.
- Task 2.2: Advanced multiscale characterization
  - Material and microstructural characterization ranging from observation of single dislocations to strain localization behaviour in the microstructure under H influence.



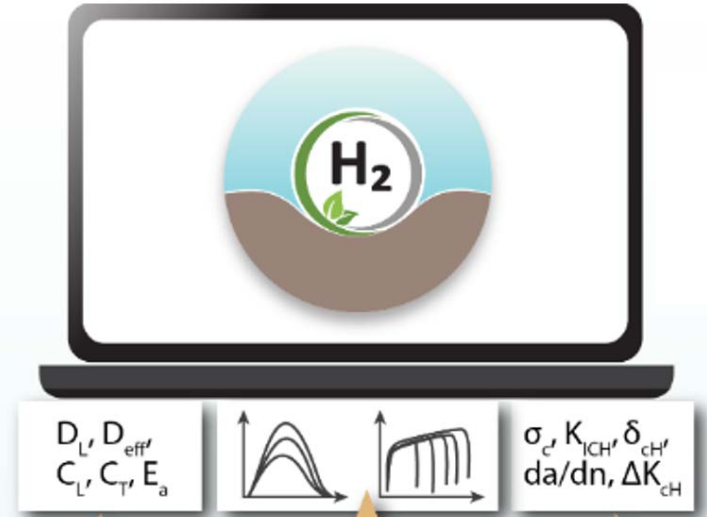
WP3 Effects of hydrogen on mechanical performance



- Task 3.1 Material screening
  - Mechanical testing and metallurgical characterization to give basis for choice of materials for the main study.
- Task 3.2 Fracture toughness
  - SENT testing under H_2 gas and electrochemical charging conditions.
    Establish fracture toughness threshold.
- Task 3.3 Fatigue properties
  - Fatigue crack growth rate testing under various H charging conditions, including H_2 gas with inhibitors.

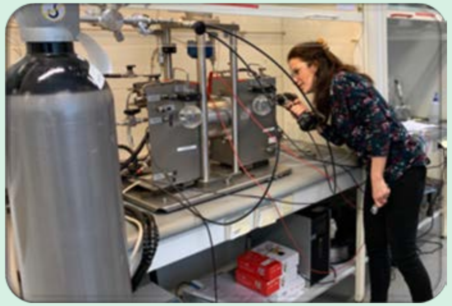


WP4 Structural integrity assessment & model development



- Task 4.1 Hydrogen related parameters
  - Empirical models for entry, diffusion and trapping of H as a function of the charging conditions.
- Task 4.2 Hydrogen influenced Gurson model
  - Modification of the Gurson damage model to take hydrogen enhanced plasticity into account.
- Task 4.3 Cohesive zone model
  - CZM is sought extended to account for H assisted fatigue and combined with the Gurson model to capture ductile to brittle transition.

New national infrastructure for hydrogen - material research – SMART-H



Nano scale mechanical lab.

For studying mechanisms on nano and micro scale.

NTNU

Analytical lab.

Hydrogen uptake and diffusion

NTNU

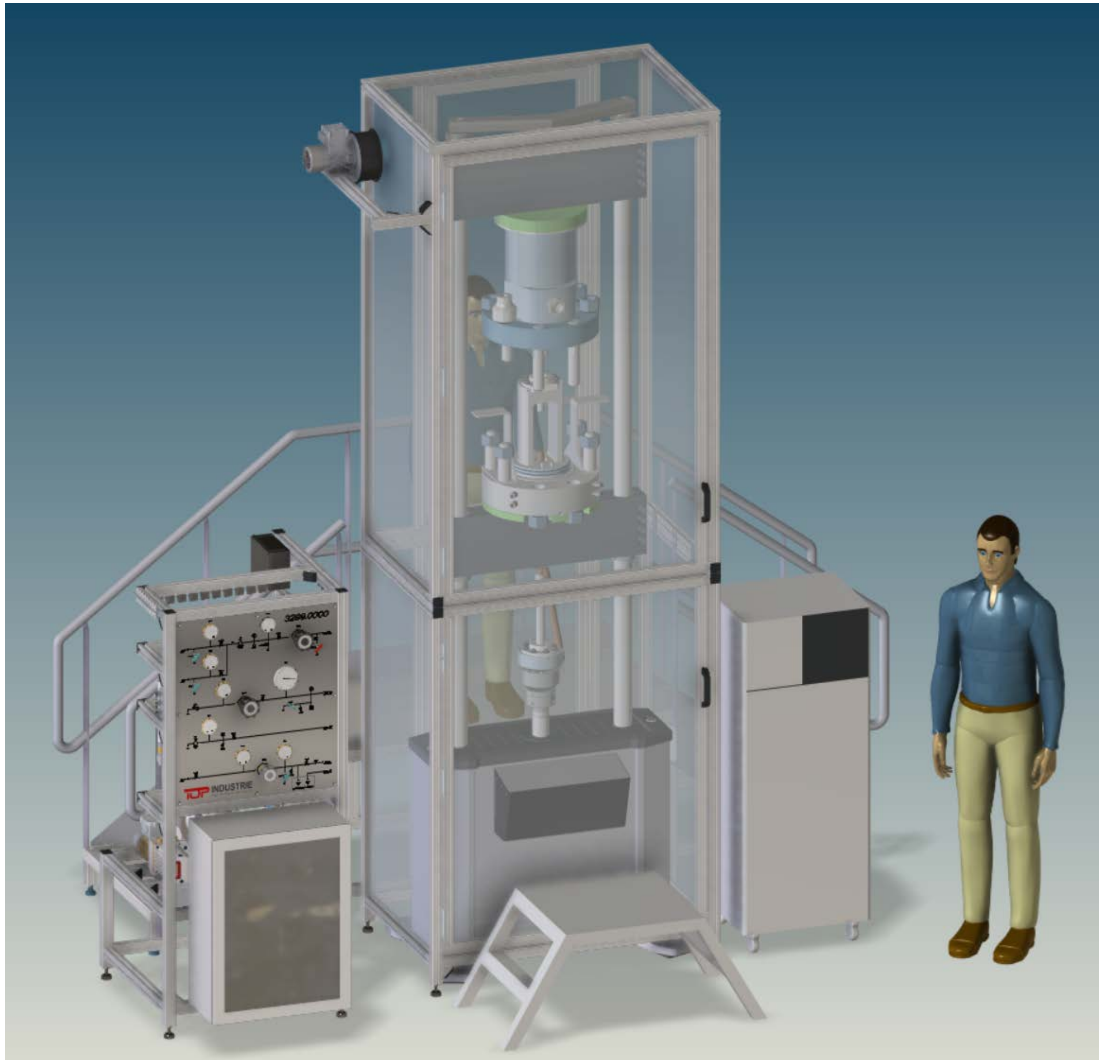
SINTEF

Macro mechanical lab.

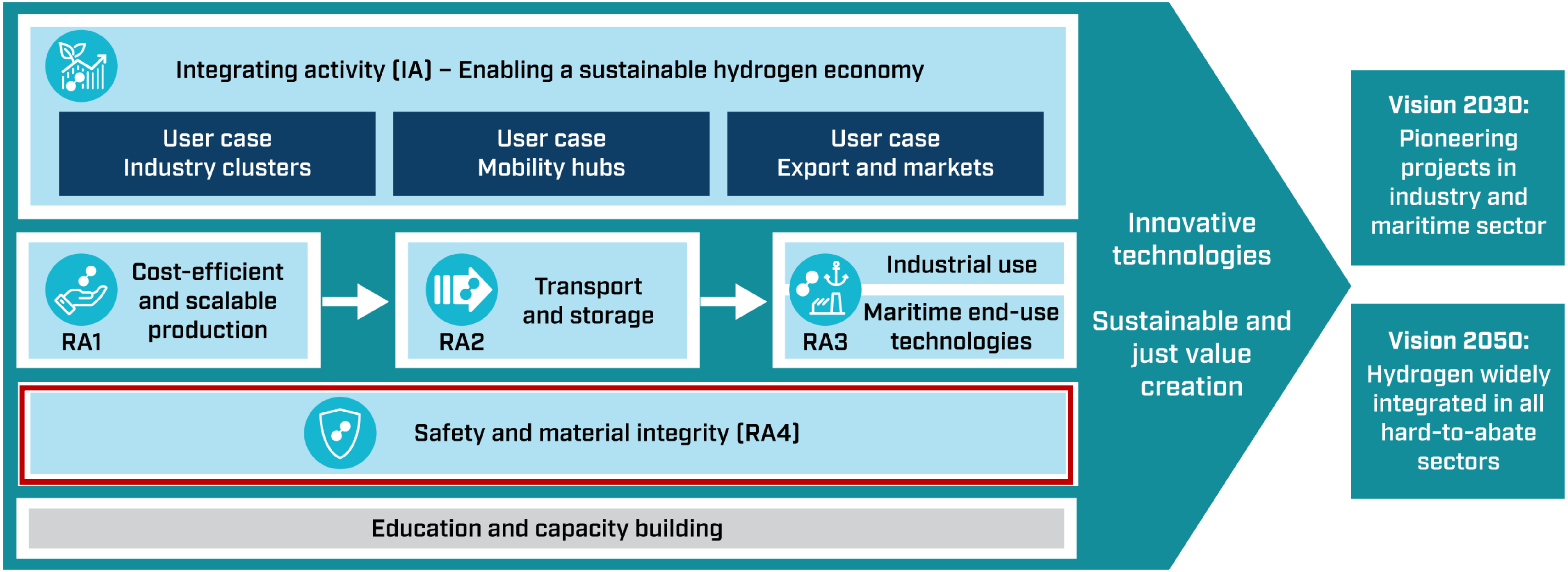
100 kN mechanical test rig. Up to 500 bar H_2 and 200°C.

SINTEF

Macro mechanical test rig – will be installed at Tiller outside Trondheim in November.



FME HYDROGENi (2022-2030) – Hydrogen for net zero by 2050



https://www.sintef.no/en/sintef-group/sintef-is-looking-for-the-next-generation-of-problem-solvers/vacant-positions/position/145128/