Mass measurements of H2 absorbed in metal hydrides and revised ISO16111

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WP 3: Development and validation of traceable methods for mass measurements of hydrogen absorbed in metal hydrides

Objective: devoted to the development of a consistent method to assess the absorbed mass (or volume) of hydrogen in a reversible hydride tank

Partners:

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FHA: Aragon Hydrogen Foundation
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CEA: Commissariat à l'Energie Atomique
Technical contact: Olivier GILLIA

SP Technical Research Institute of Sweden
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Solid Storage With Metal Hydride

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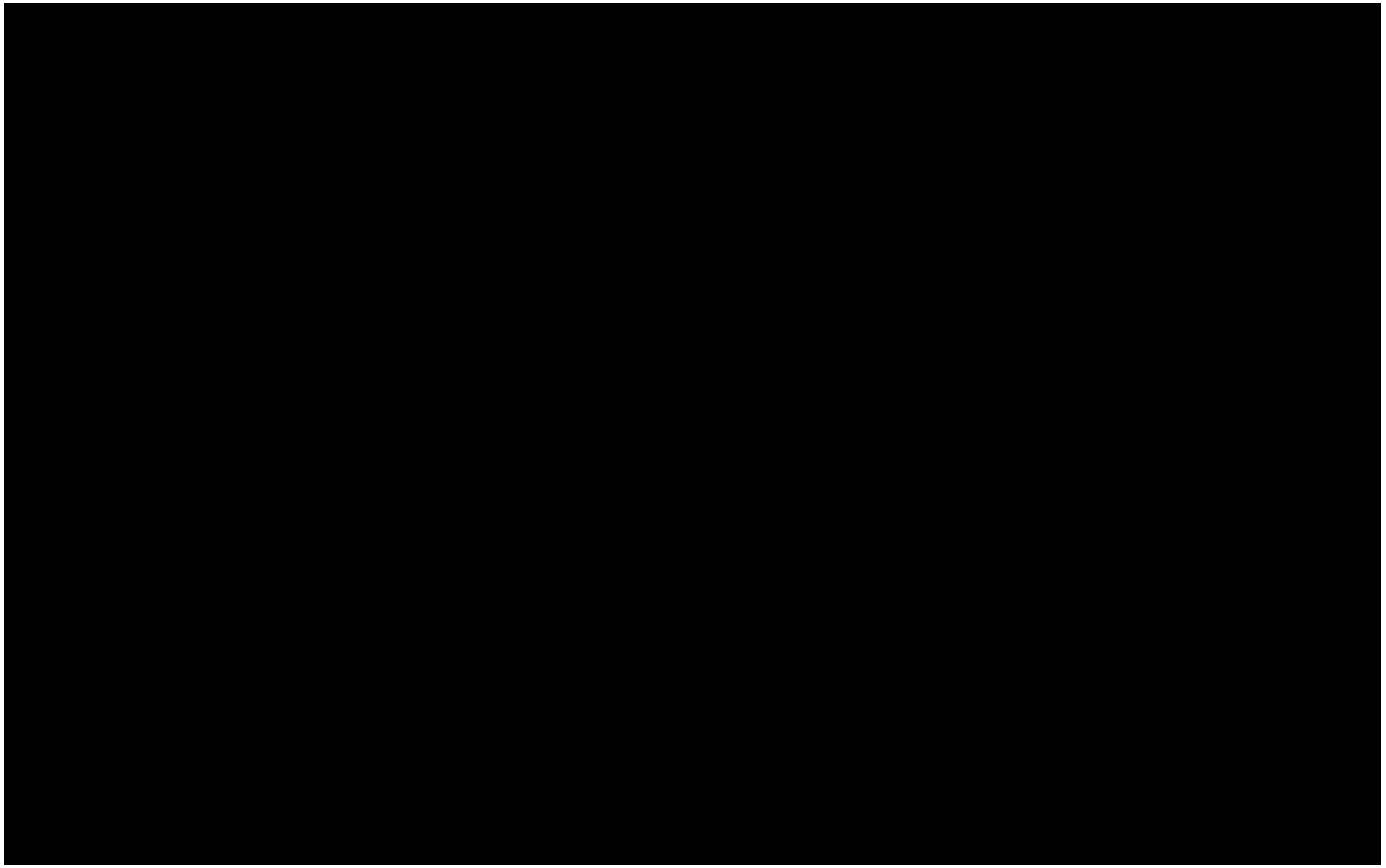
How does it work?



Solid Storage with Hydride

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Advantage : Low pressure (2-5 bar at room temperature) but hydrogen mass is similar to compressed gas at 700 bar or more.
Disadvantage : Mass depends of the hydride.

	MHT-C20	MHT-Hycube	MHT-Magnum
Mass of H_2	2g	85g	200g
Cooling/Heating system	Air	Air	Water

Magnum in bundles

Example of applications

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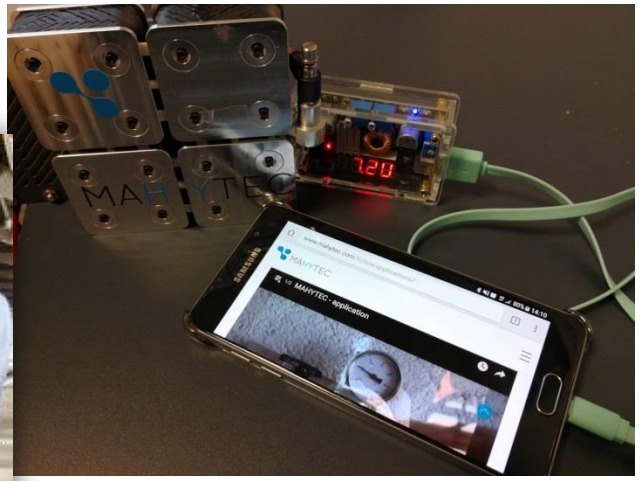
Energy for small cars

Energy for nomadic system



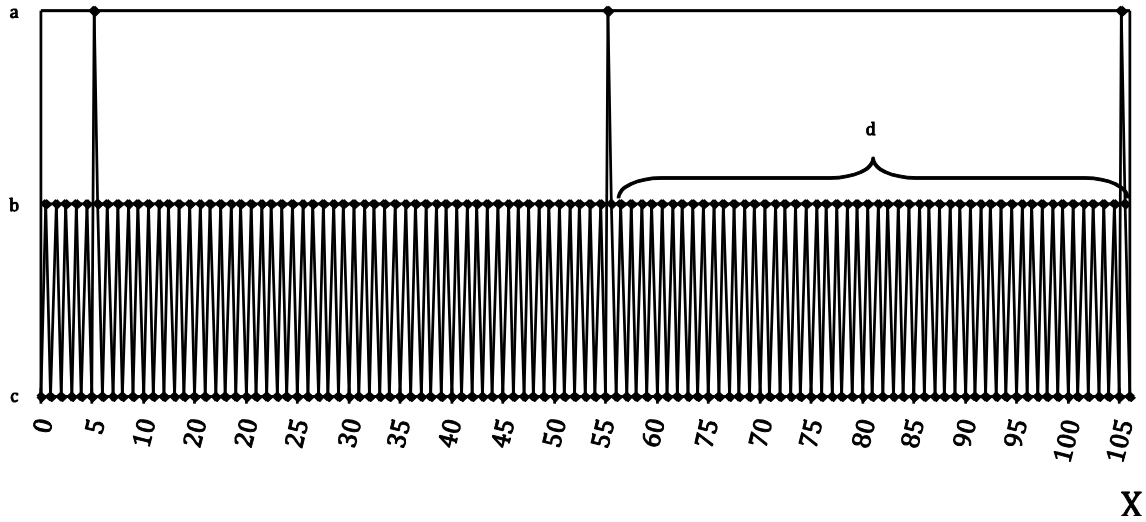
Energy « in the pocket or in the bag »

UN regulation for transport of dangerous goods : UN3468

ISO 16111 : Transportable gas storage devices — Hydrogen absorbed in reversible metal hydride

Tank Qualification and testing .

6.2.6.Hydrogen cycling and strain measurement test



The MH assemblies shall be hydrogen charge cycled from not more than **5 % of rated capacity to not less than 95 %** of rated capacity.

Why the assessment of hydrogen volume/mass in hydride tanks is a challenge?

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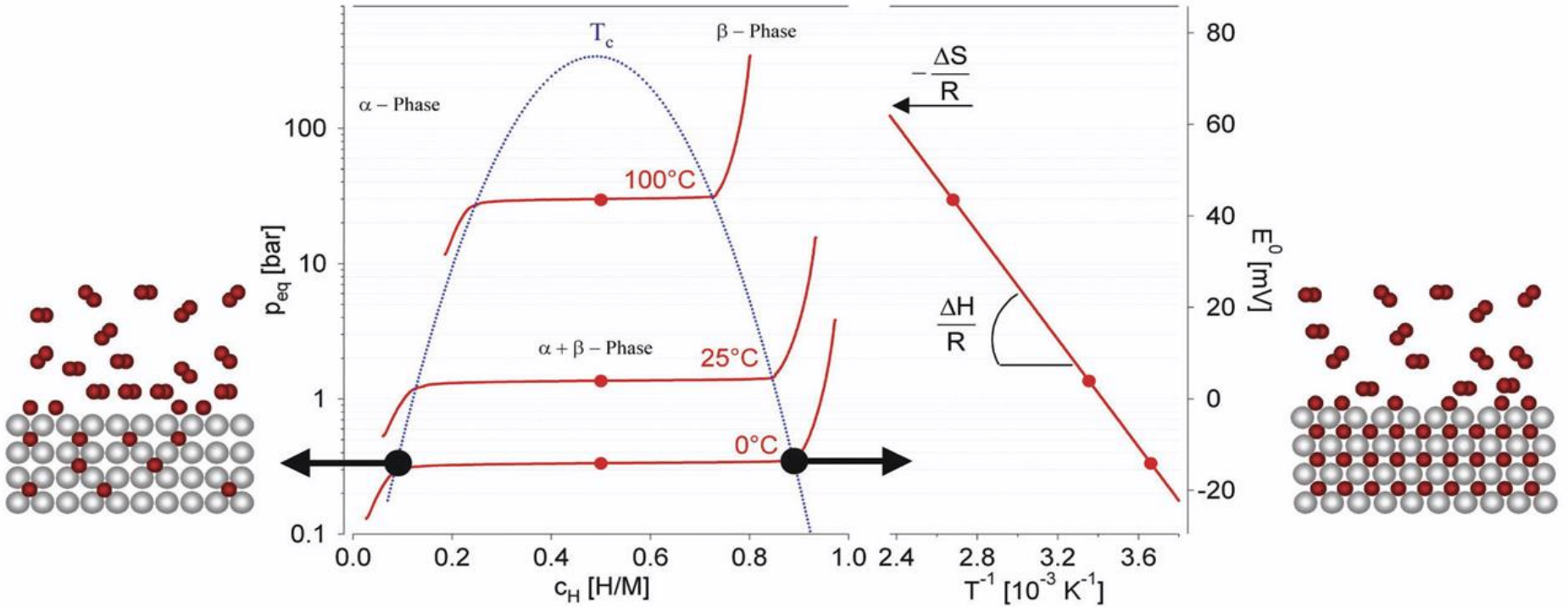

Hydrogen absorption/desorption phenomenon in hydride
(Ref : A.Zuttel)

Why the assessment of hydrogen volume/mass in hydride tanks is a challenge?

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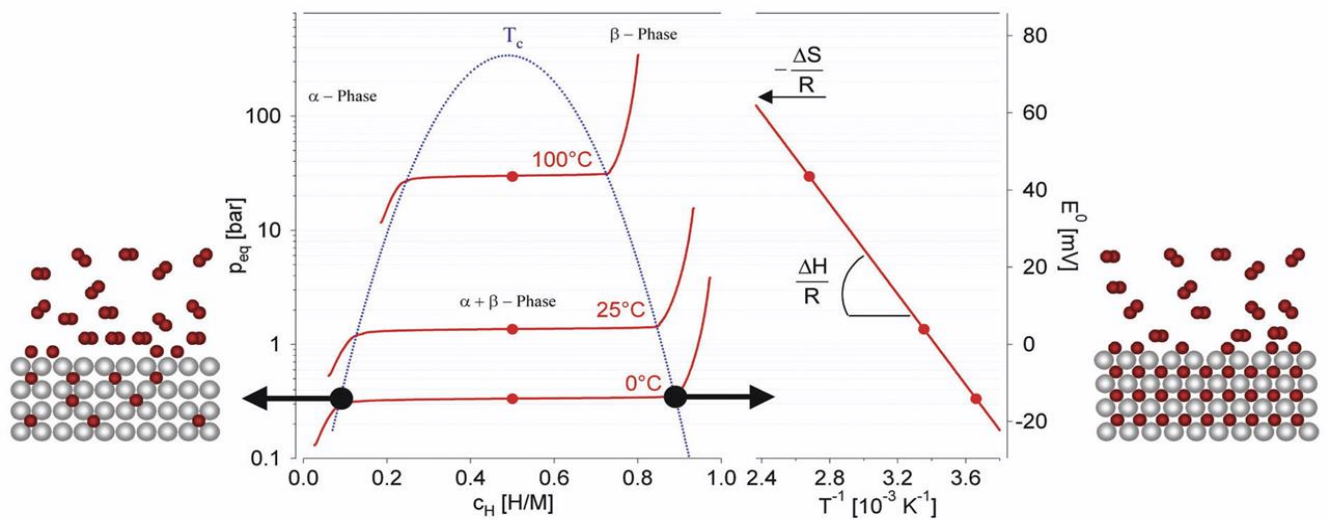

No clear or univocal state equation of gas between observable variables (V,P,T)

The fine assessment of the volume or mass of hydrogen in a metal reversible hydride tank requires to know the history of loading of the tank and initial conditions

Why the assessment of hydrogen volume/mass in hydride tanks is a challenge?

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Mass measurement (Precision Balance)

Mass=Mtank+Mhydrogen and Mhydrogen is about 1 or 2 % of Mass Tank-> Risk of error

Volume measurement (Flowmeter)

Pressure and temperature can change

Need to compare the method to be confident in the assessment of hydrogen mass/volume in hydride

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MASS TOTAL OF TANK, VALVE AND HYDRIDE	710g
MASS OF HYDRIDE	100g
MASS OF HYDROGEN STORED	1.5 g
OPERATING TEMPERATURE	5°C to 45°C
STORAGE TEMPERATURE	-10°C to 65°C
MAXIMUM PRESSURE	75 bar
MAXIMUM REFILLING PRESSURE	15 bar
ABSOLUTE WORKING PRESSURE AT 22°C	2 bar (+/- 0.5 bar)
HYDRIDE TYPE	AB5
STATE OF HYDRIDE	ACTIVATE
ACTIVATION OF HYDRIDE	11/11/2016

Each partner got a tank
And developed its own testing protocol.

The goal is to get PCT curves

Method 1: Mass measurements

To perform this test, we fill the tank with a pressure of 10 bar. We weight the tank once full with hydrogen. Under constant temperature (T=22°C), we measure the pressure and the mass into the tank before removing 0,1g of H2 at regular time intervals.

Characteristics of device:

Scale: Max 750g, e=0.01g, d=0.001g

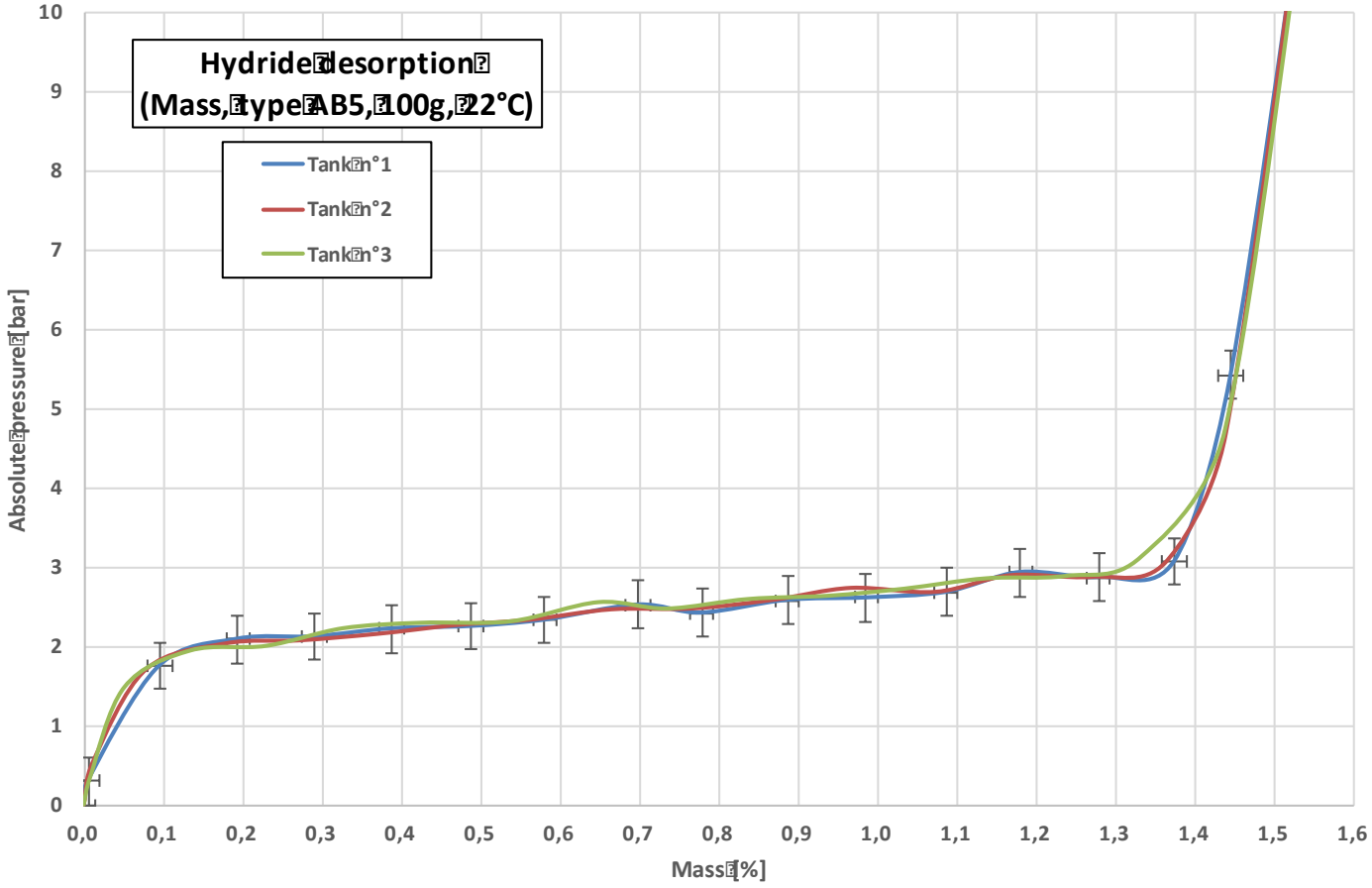
Digital pressure gauge: EM: -1…30 bar, error: ±0.2%

Condition test:

Loading: $P_{loading}$= 10bar & $T_{loading}$= 22°C

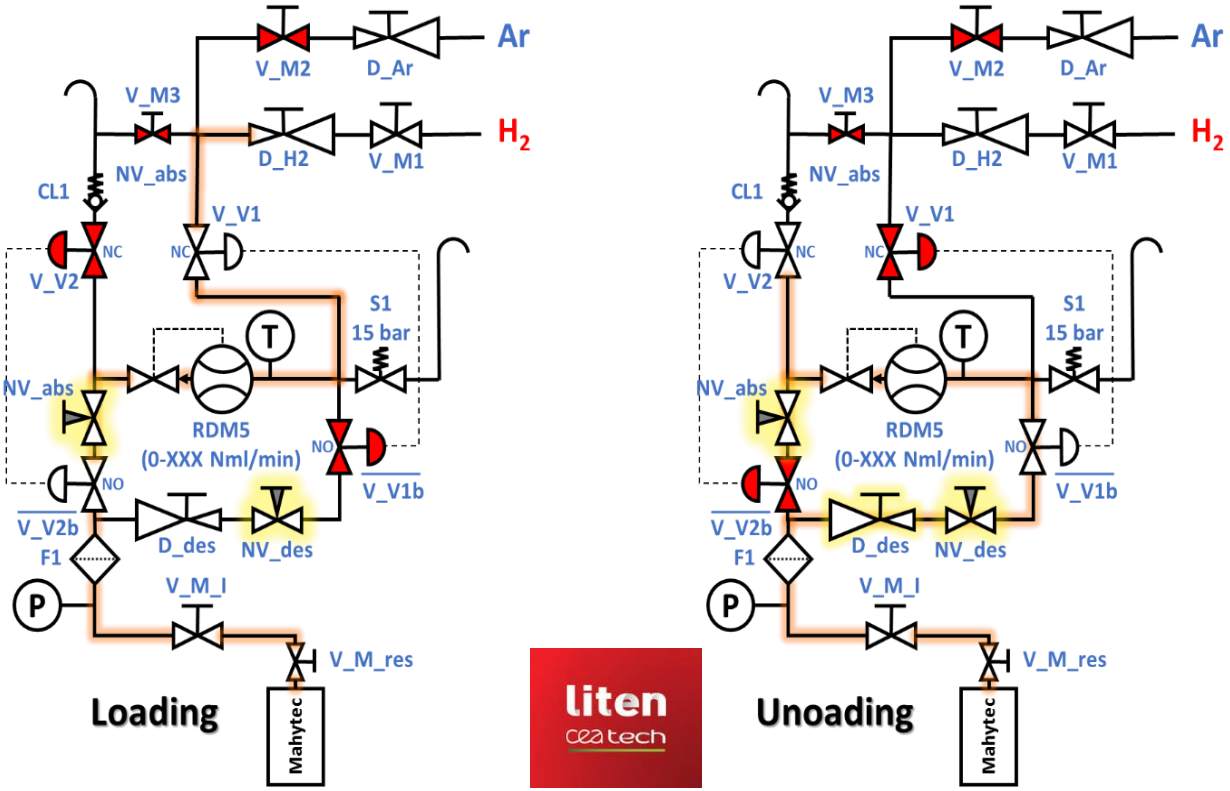
Unloading: $T_{Unloading}$= 22°C

Method 1: Mass measurements



Method 2: Flowrate measurements

Each partner used its own P&ID



CEA test bench

Method 2: Flowrate measurements

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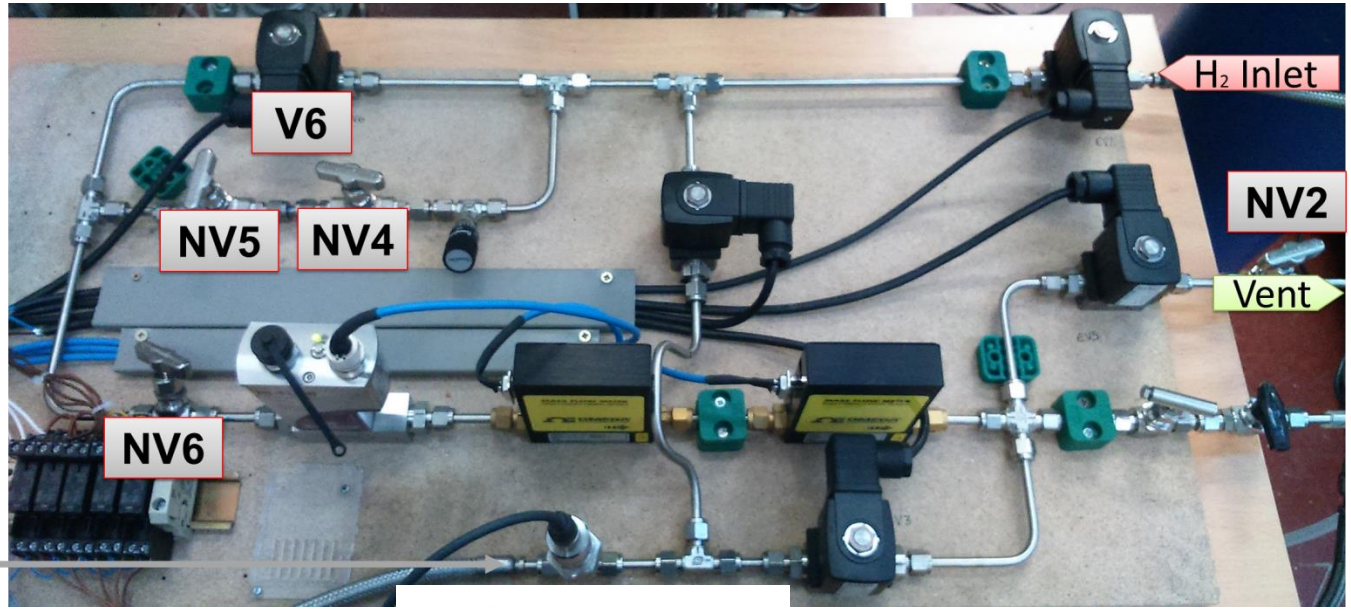


FUNDACIÓN PARA EL DESARROLLO DE LAS NUEVAS TECNOLOGÍAS DEL HIDRÓGENO EN ARAGÓN

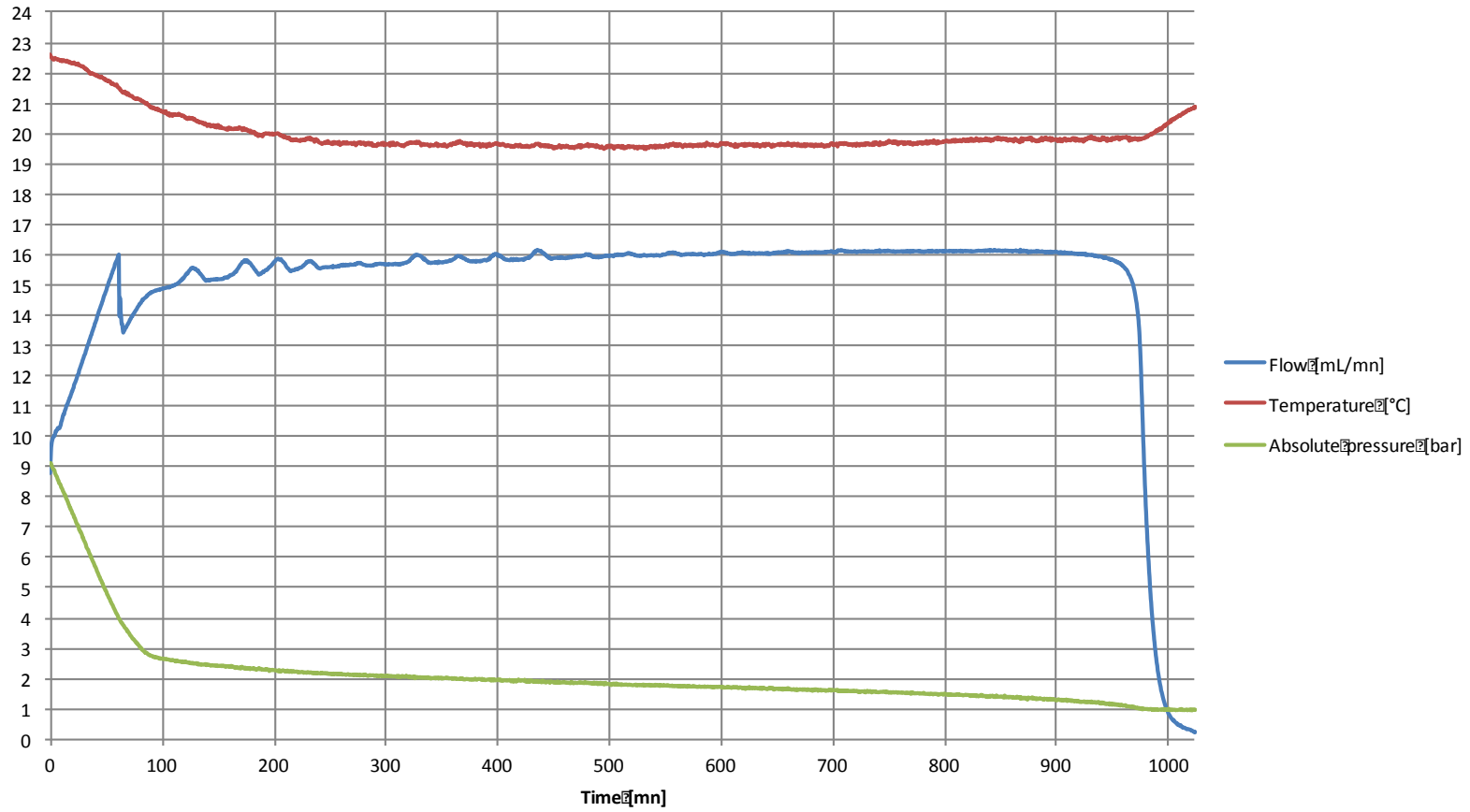
FHA Testing system

Method 2: Flowrate measurements

The temperature on the surface of the tank, the output pressure and the flow of hydrogen were recorded. At the output of the tank, we use a pressure regulator set at 0.45bar. The flowmeter has always the same pressure at this input.

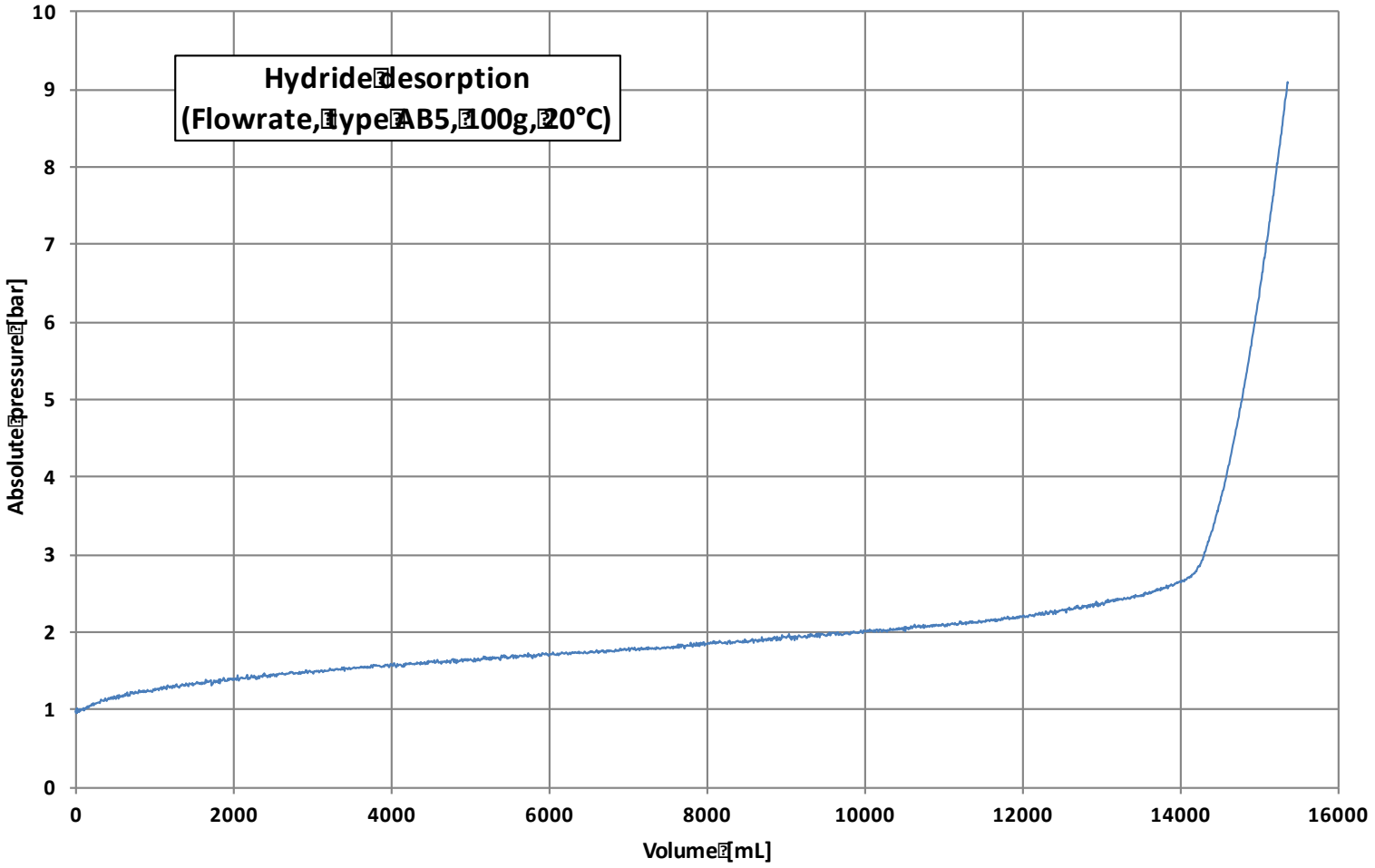
- Thermocouple T on the tank
- Pressure sensor: 15bar max
- Output Pressure Regulator: 0 to 1bar
- Needle valve: Cv=0.004
- Flowmeter: 65NmL/mn max

Method 2: Flowrate measurements

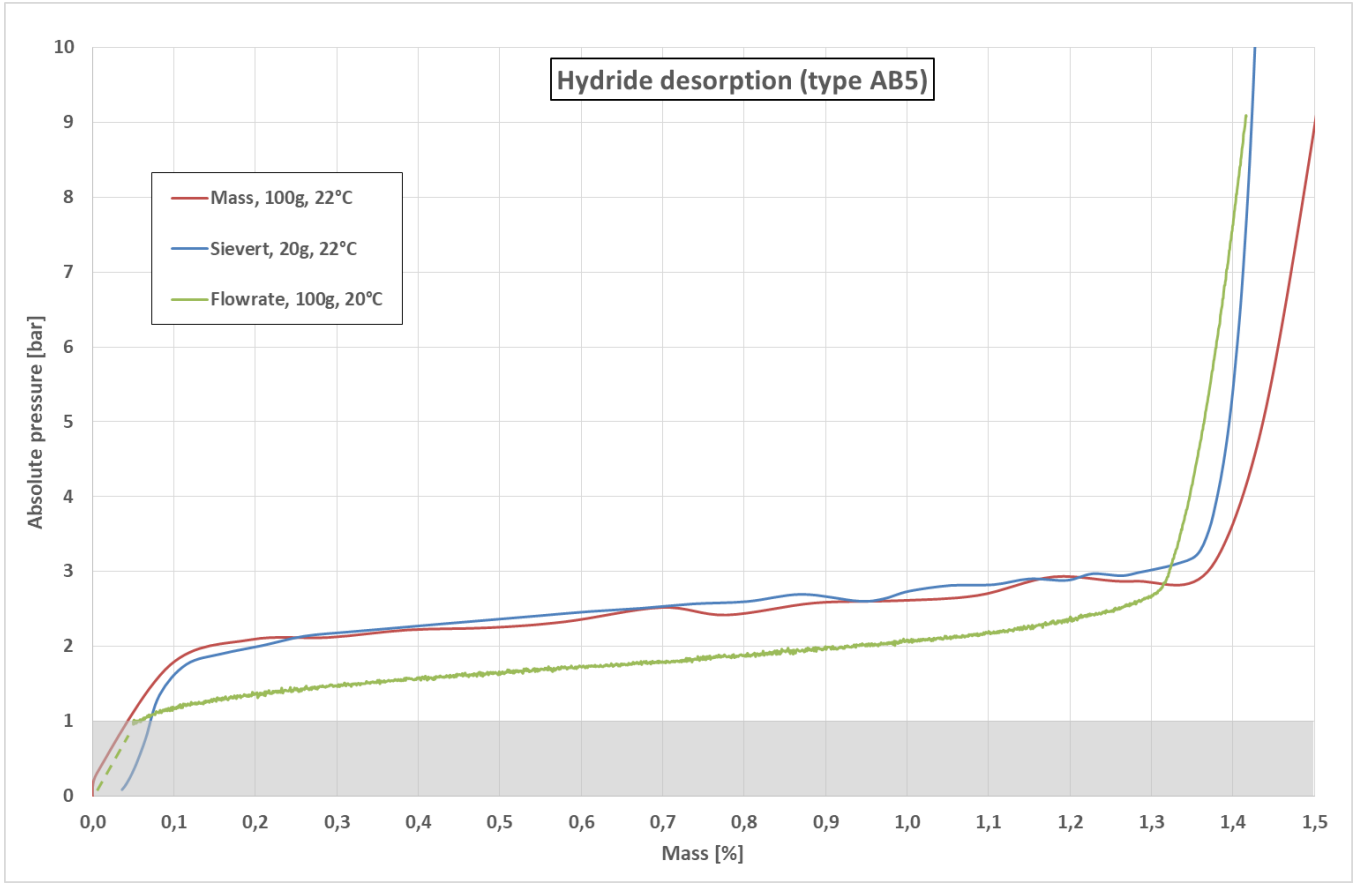


Temperature condition unstable during test

Method 2: Flowrate measurements



Comparison of the method



ISO 16111-2018

In the ISO 16111-2018 standard a part is dedicated to :

Documentation accompanying the product

- Charging specifications
  - The manufacturer shall provide the following information, for the initial filling and refilling of the MH assembly:
    - **method for determining when the rated capacity described has been achieved**;

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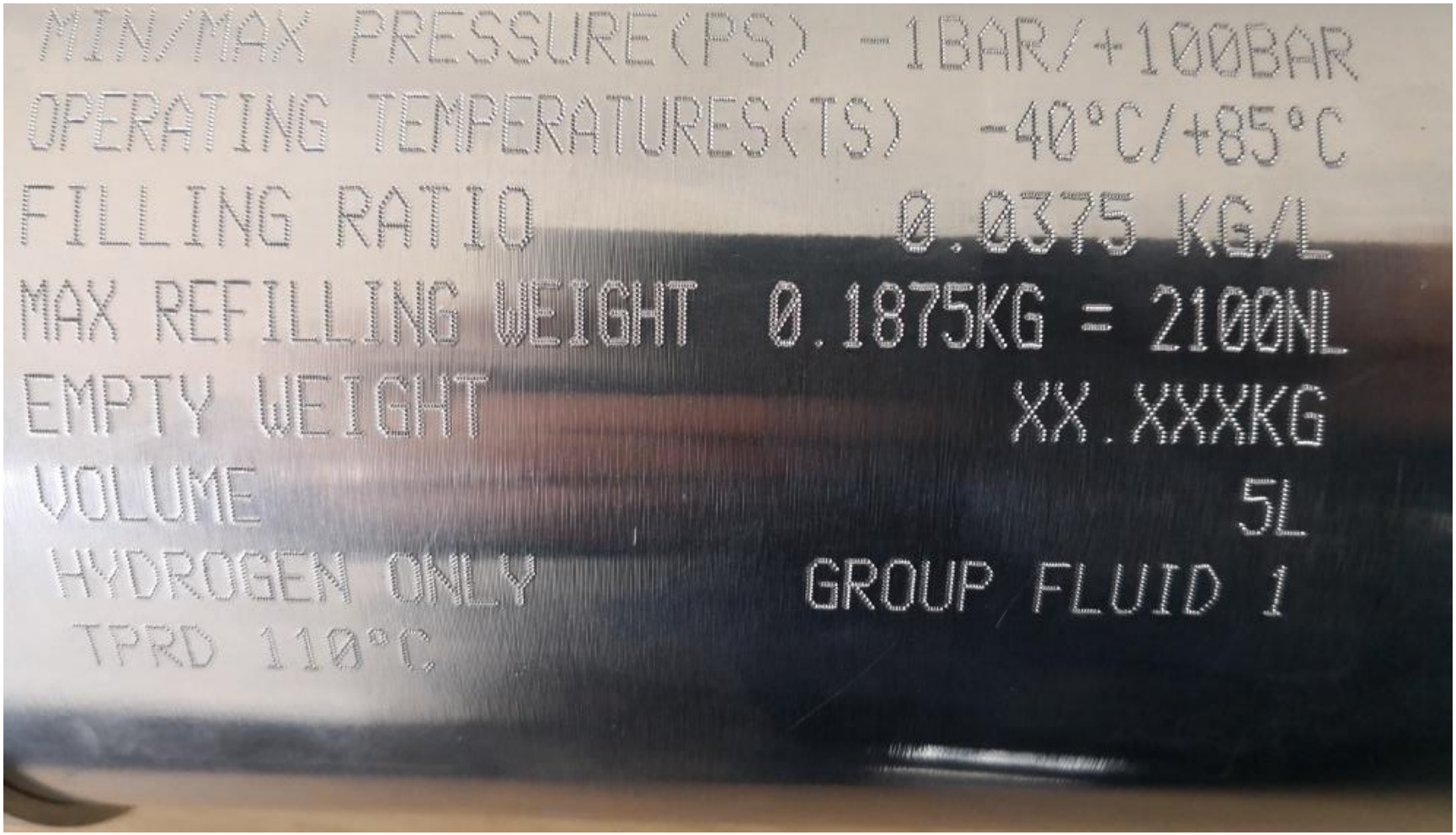

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Thank you for your attention.

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AND NOW PRACTICE TIME