Liquid Hydrogen Lab – LHL

R&D Infrastructure for cryogenic H_2 applications

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Aviation Forum Austria 2026

Vienna, 18.03.2026

Austria's Research Center for Hydrogen Technologies

HyCentA
HYDROGEN CENTER AUSTRIA

HyCentA Research
Leading Hydrogen Innovation

- **120+ researchers** mechanical engineering, physics, chemistry, process engineering, electrical engineering
- **600+ projects** successfully completed
- **20+ years of R&D expertise**
- **State-of-the-art research**, testing and refueling infrastructure
- **International Cooperations**

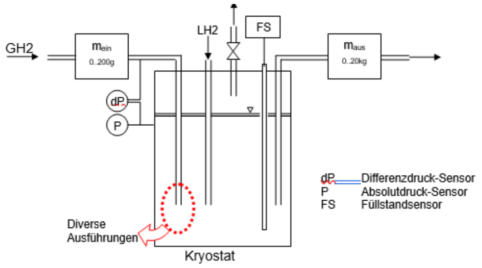
Extra-university research organization at Graz University of Technology (TUG)

TU Graz

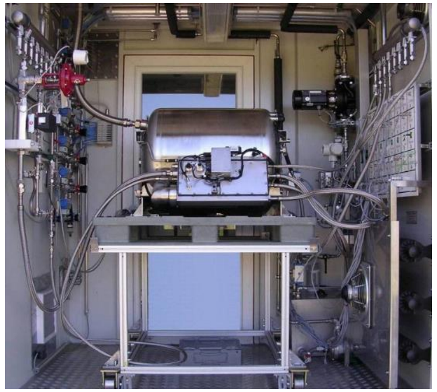
FVT MAGNA OMV

LH_2 Experience at HyCentA

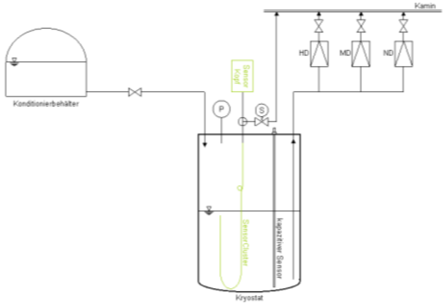
2006 - 2007:
LH_2 - Periphery
Pressure build-up system with individually developed system components



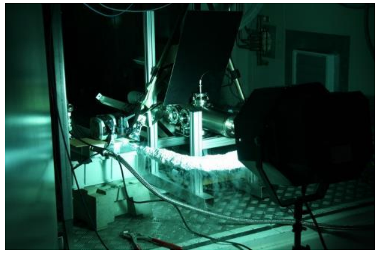
2006 - 2008:
LH_2 - liquid hydrogen tank system
(made by MAGNA)
BMW Hydrogen 7



2007:
Sensorcluster LH_2 - automotive measuring system (complete monitoring of a liquid hydrogen tank)

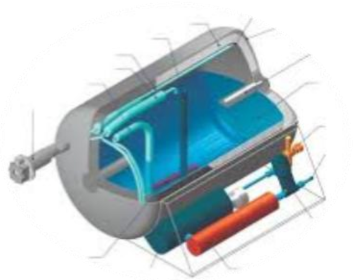


2006 - 2007:
CryoSens - robust LH_2 flow measurement for automotive applications cryogenic and gaseous hydrogen for pressures up to 350 bar



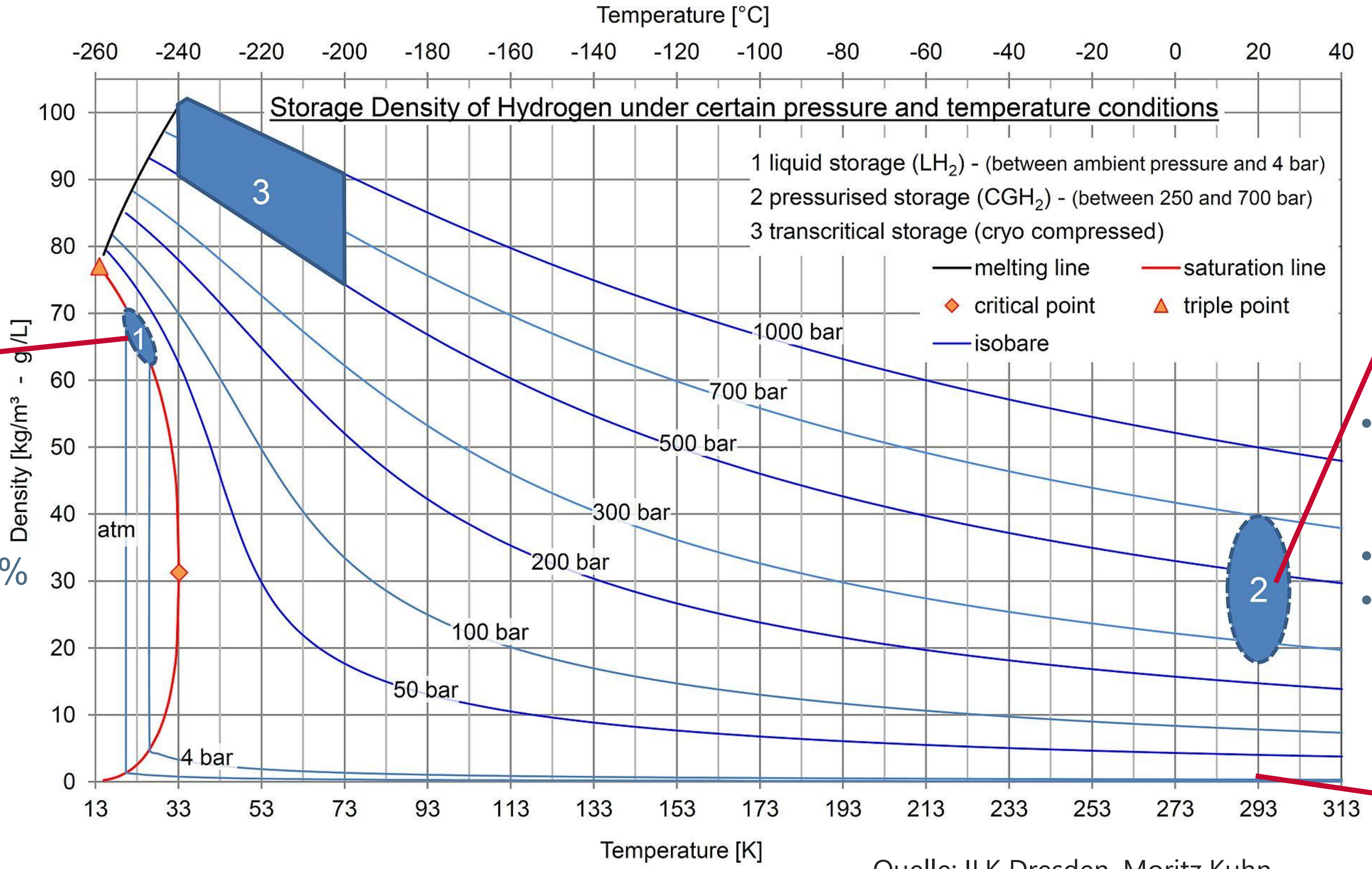
2010 - 2013:
Slush - mixture of liquid and solid hydrogen at extremely low temperatures.
Advantage: higher density than LH_2

Energy density hydrogen



LH2
At T < -253°C
in cryogenic
vessels

- High energy demand for liquefaction (20-30% of LHV)
- 70 kg/m³
- System weight (potential): > 35 wt%



Quelle: ILK Dresden, Moritz Kuhn

CGH2
Gasous H_2
in pressure vessels

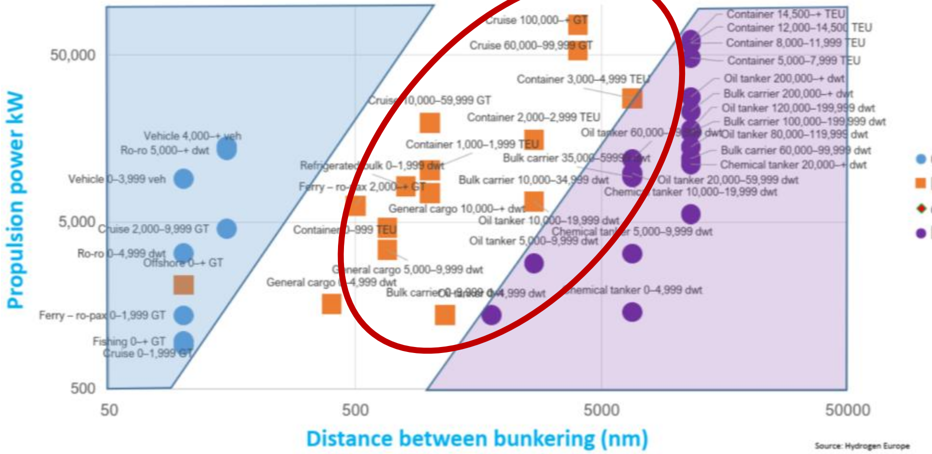
- Compression energy 6–15 % of lower heating value
- 40 kg/m³ at 700 bar
- System weight 6 wt%

Density at ambient: 0.09 kg/m³

Need for LH2

- **Aviation**: Roughly **two-thirds of today's kerosene consumption** – which directly correlates with CO_2 emissions – comes **from flights operated with short- and medium-range** aircraft (flights with fewer than 165 PAX and flights with fewer than 250 PAX, respectively).
  - These aircraft account for **70 percent** of the **global fleet**
- **Heavy-duty**: Prototype fleet already on public roads
- **Shipping:** for shorter range ships and cruisers

Source: Airbus, https://www.airbus.com/en/innovation/low-carbon-aviation/hydrogen/zeroe
Source: Hydrogen-powered aviation A fact-based study of hydrogen technology, economics, and climate impact by 2050



Source: Hydrogen Europe, "Hydrogen," in Riviera Marine Fuels Webinar Week, 2020

Source: 'MF Hydra': World's first liquid hydrogen-powered ferry gets operational (interestingengineering.com)

Source: Daimler Trucks, Mercedes-Benz Trucks provides outlook on hydrogen-based GenH2 Truck at IAA Transportation 2022 in Hanover

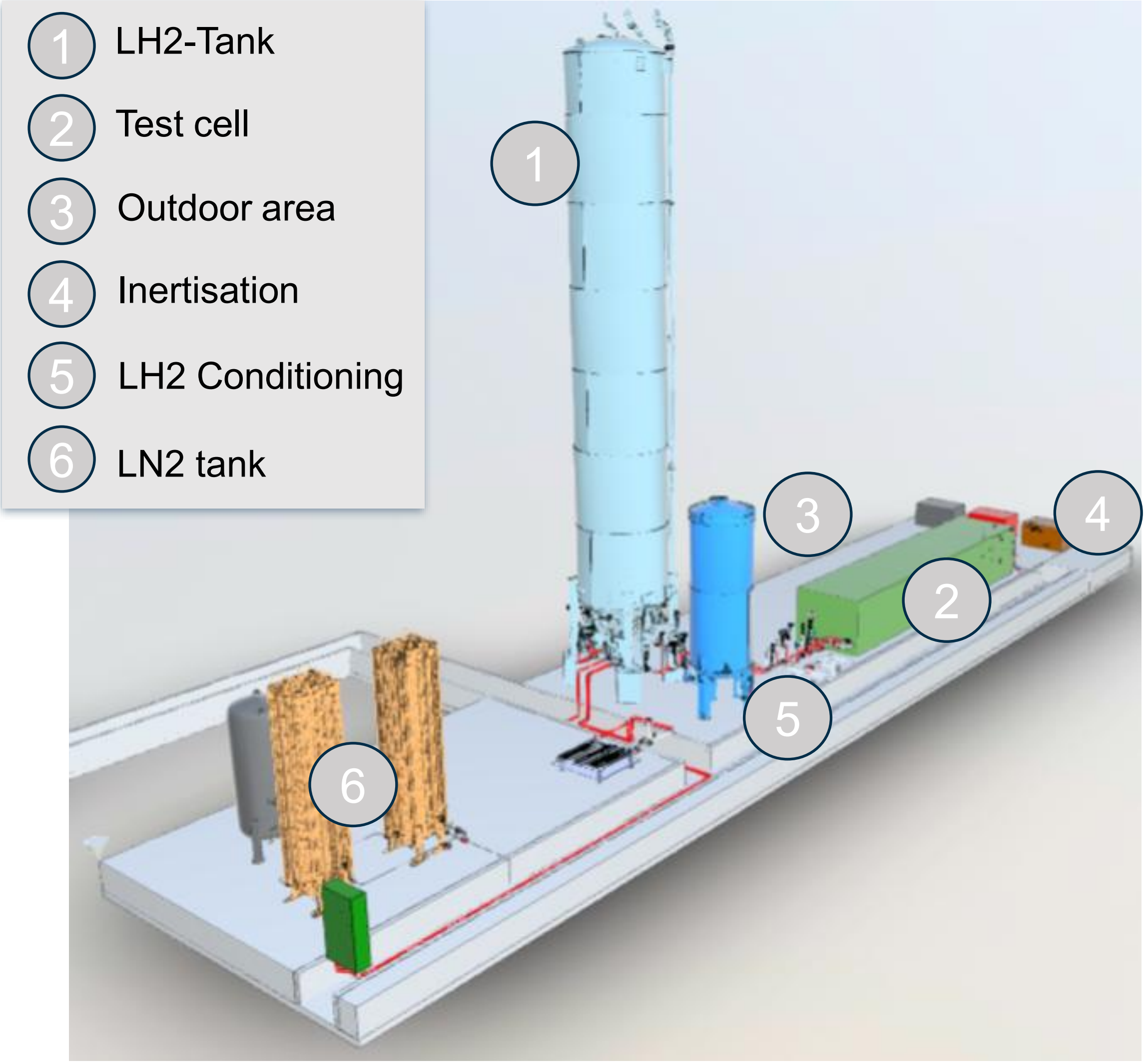
Challenges for LH2

- **Efficiency and losses:**
  1. **Before refueling**: Liquefaction
     - 20 % to 30 % of calorific value needed for liquefaction
  2. **While refueling**: Reverse gas losses
     - 20 % - 100 %
     - Cool Down / volume increase / pressure difference
  3. **After refueling**: Boil-off
     - 0.3 % - 3 % per day
- **Hydrogen safety:**
  - Cryogenic leakage (internal/external)
  - Explosive mixtures in venting lines
  - Boiling Liquid Expansion Vapor Explosion - BLEVE

Source: Kees van Wingerden, Experiments to investigate the possibility and effects of BLEVEs of storage tanks containing liquified hydrogen, SH2IFT

Source: H. Eichlseder, M. Klell, Alexander Trattner, "Hydrogen in Automotive engineering", Springer 2023

Liquid Hydrogen Lab



- 4400 kg LH_2 stationary tank
- Multiple testing stations
- Outdoor space for testing larger tanks for aviation
- LH_2 conditioning container and optional cryogenic pump
  - Up to 860 kg/h and 36 bar LH_2 supply
- 4000 kg LN_2 stationary tank
- Helium station for inertisation
- State-of-the-art CAx infrastructure for 3D CFD simulations and digital-twins
- Commissioning and start of test operation: Q4 2026
- Normal operation: Q1 2027

Testing and Future Expansions

- **Types of tests**
  - **Material testing** (sealants, insulation, light-weight materials, embrittlement)
  - **Component tests** (valves, sensorics, filling/venting lines, injectors)
  - **Storage systems** (filling and extraction tests)
  - **Systems** (cryo-pumps, filling wagons, liquefaction unit, ortho-para-conversion reactor, utilization)

Phase 1 – Starting phase with Focus on R&D and ensured LH_2 supply

- **External supply of the LHL** with GH_2 and LH_2 through gas suppliers
- **Focus on component and tank testing**

Phase 2 – Further development and future scaling

- **Direct supply of LH_2 to the LHL** from the liquefaction plant on-site
- **Planned expansion of the LHL** through additional R&D infrastructure of HyCentA and partners
- **Openness for further projects and strategic partnerships** in the innovation ecosystem

Liquefaction

Material fatigue

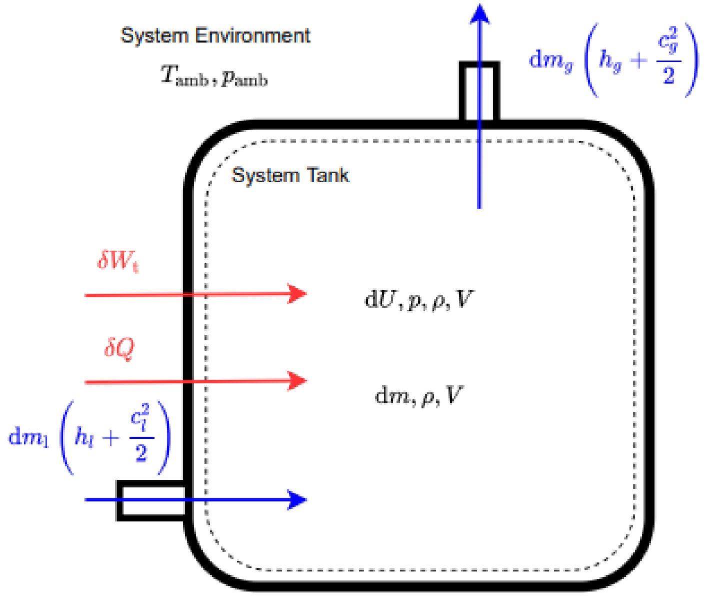
LH2 utilization (FC, turbine)

Gas Extraction

Filling station

LH2 Simulation Activities at HyCentA

1. 0D Tank Filling Model

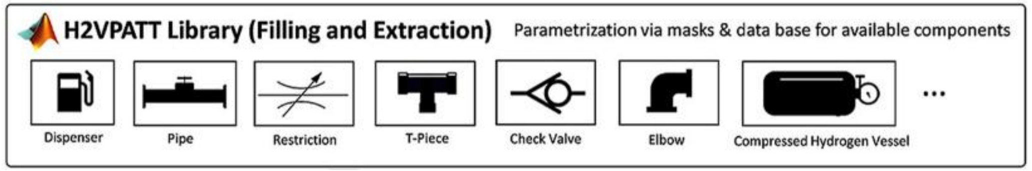


- **Thermodynamics** of the **refueling processes**
- **Modeling of losses**:
  - **Reverse gas** losses during filling
  - **Boil-off**
- **Goal: Determining optimal parameters** for LH2 processes with **minimal losses**

See more: https://www.sciencedirect.com/science/article/pii/S0360319925021962

2. 0D Filling Station and Storage System Model

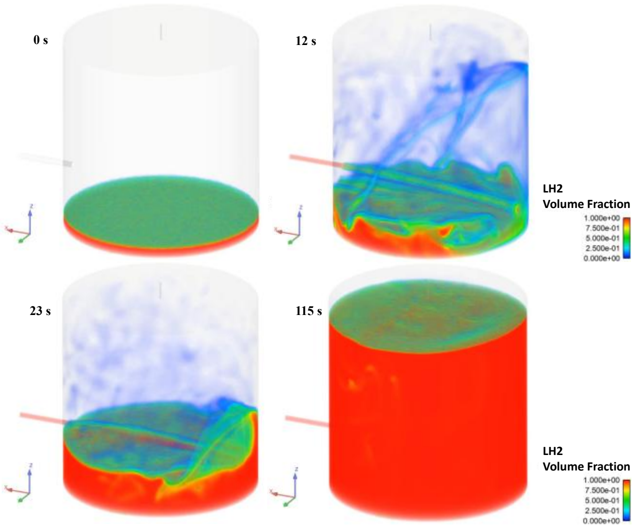
- **Simulink Library** for calculating arbitrary **CGH2** and **LH2 hydrogen storage systems**
- Modeling of **components along the system**
- Display of **component-wise** pressure **losses**



See more: https://www.sciencedirect.com/science/article/pii/S0360319923039885

3. 3D CFD Models

- **Detailed investigation** into the **filling process** and thermodynamic phenomena
- Leakage simulations for **safety assessments**



Simulation-based LH2 Safety Assessments

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Development of possible failure scenarios

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Scenario modelling

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Simulation-aided assessment of failure scenarios

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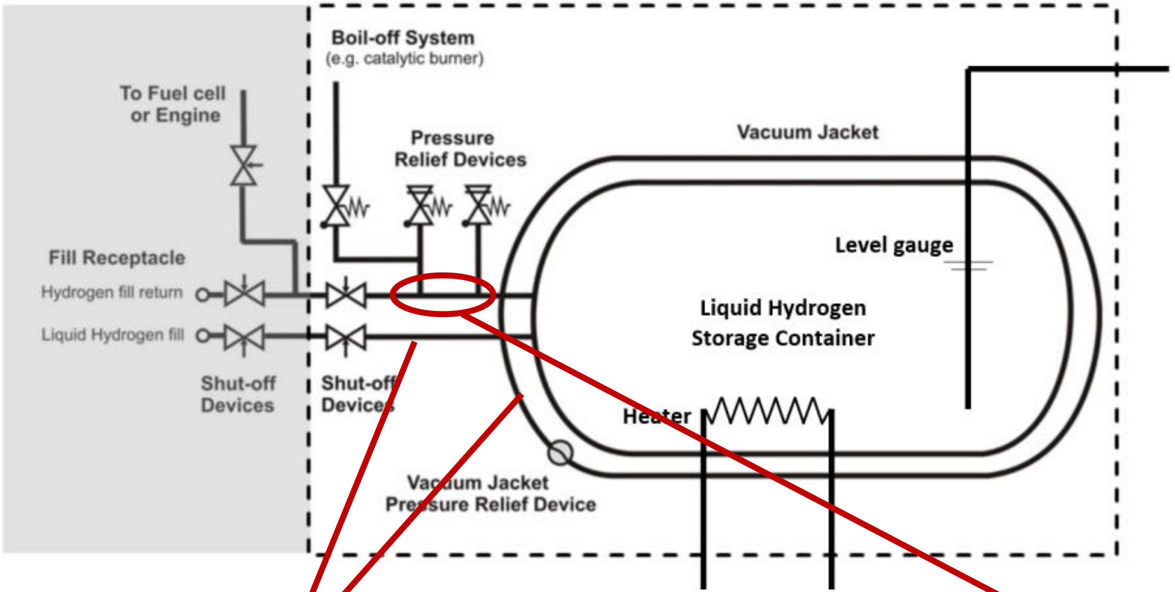
Derivation of mitigation strategies

Source: T. Jordan, "Pre-normative REsearch for Safe use of Liquid Hydrogen (PRESLHY)", White Paper, KIT, 2018.



2.) Cryogenic leaks in LH2 filling lines or tank – hydrogen/air/both entering vacuum spaces

1.) Venting - air entering the system through venting line leaks and undergoing phase transformations and posing ignition risk

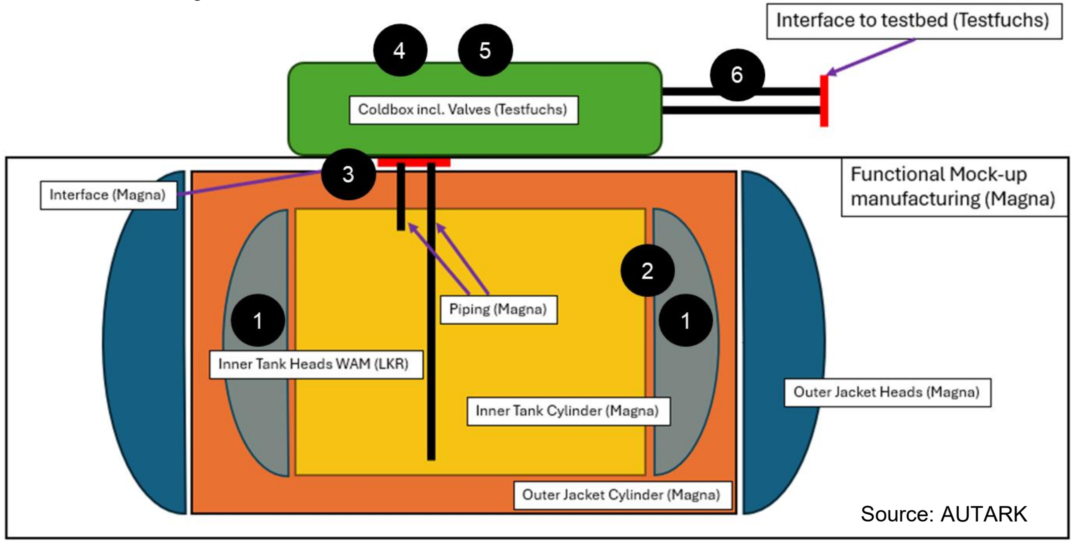
AUTARK - Austrian liquid hydrogen tank system technologies

- **AUTARK - first research project for the Liquid Hydrogen Lab approved for funding**
- Main focus:
  - **Decreasing weight** of LH2 storage systems for aviation
  - **Increased hydrogen safety** of the storage system (e.g. venting)
  - Development of **novel valve components**
- Role of **HyCentA:**
  - In-depth **3D CFD simulations** of **venting** phenomena
  - **Experimental validation** of **valves,** the **cold box** and the **tank**
  - **Experimental assessment** of **venting** and **detonations/deflagrations**
- Consortium:


Source: Magna

Physical test articles
❶ Inner tank (IT) dome (heads) incl. HEX
❷ Inner tank (IT) welded assembly
❸ Tank / Coldbox interface
❹ Cold Box built in aluminium
❺ Aluminium SOV+PRV in aluminium
❻ Venting pipes with CV

HEX: heat exchanger
CV: check valve
SOV: shut of valve
PRV: pressure relief valve
OJ: Outer jacket



Source: AUTARK

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UAR INNOVATION NETWORK

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