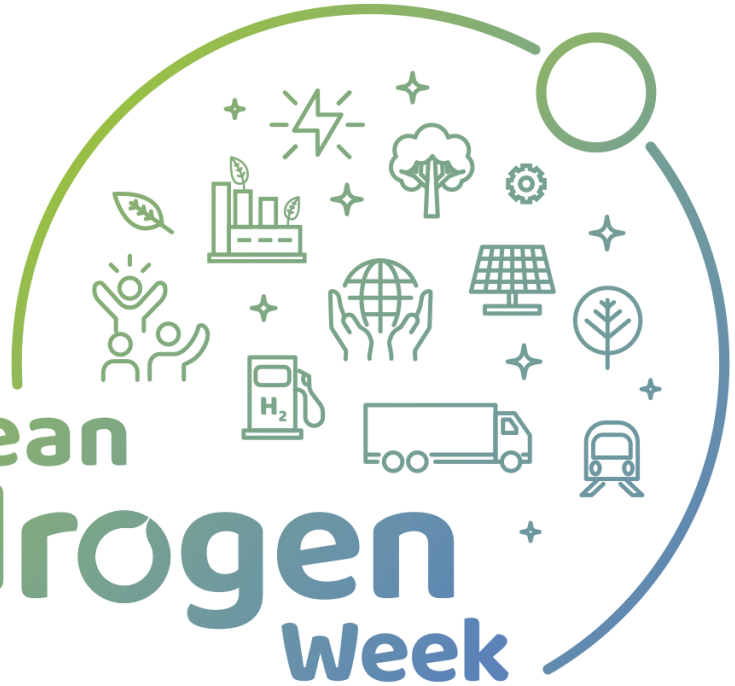
PRESLHY

Pre-normative Research for Safe Use of Liquid Hydrogen



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FCH

European Commission

PRESLHY Project Overview

Call year:
2017

Call topic:
FCH-04-4-2017: PNR for a safe use of liquid hydrogen

Project dates:
01/2018- 05/2021

Total project budget:
1 905 862,50 €

% stage of implementation
01/11/2020: 80%

FCH JU max. contribution: 1 724 277 €
Other financial contribution: - €

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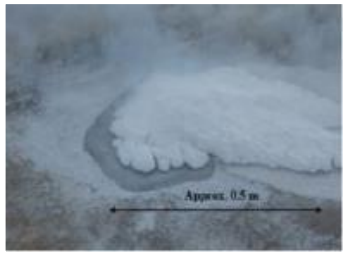
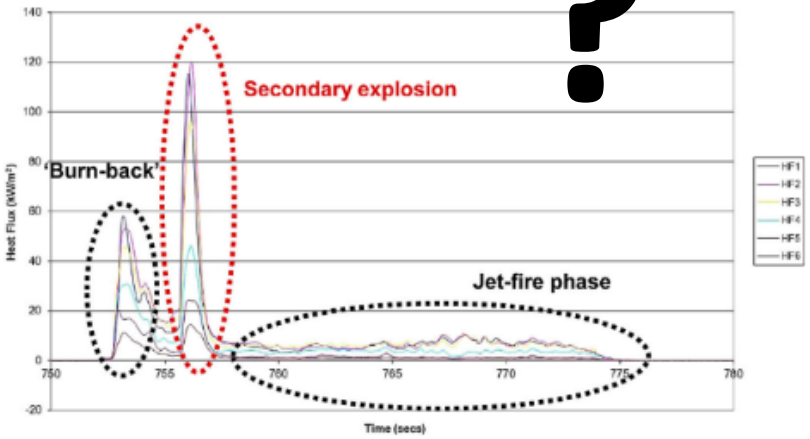
PRELHY Partners

PRESLHY Motivation




- Scale-up of existing and new applications increase H2 demand.
- Liquid hydrogen (LH2) provides **larger densities** and gains in **efficiency** and **potentially reduces risks** compared to compressed gaseous transport and storage
- Many **knowledge gaps** wrt accidental behavior of LH2 and **inconsistent** and **potentially over-conservative RCS** (e.g. NFPA 2 and EIGA)

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PRESLHY Main Objectives

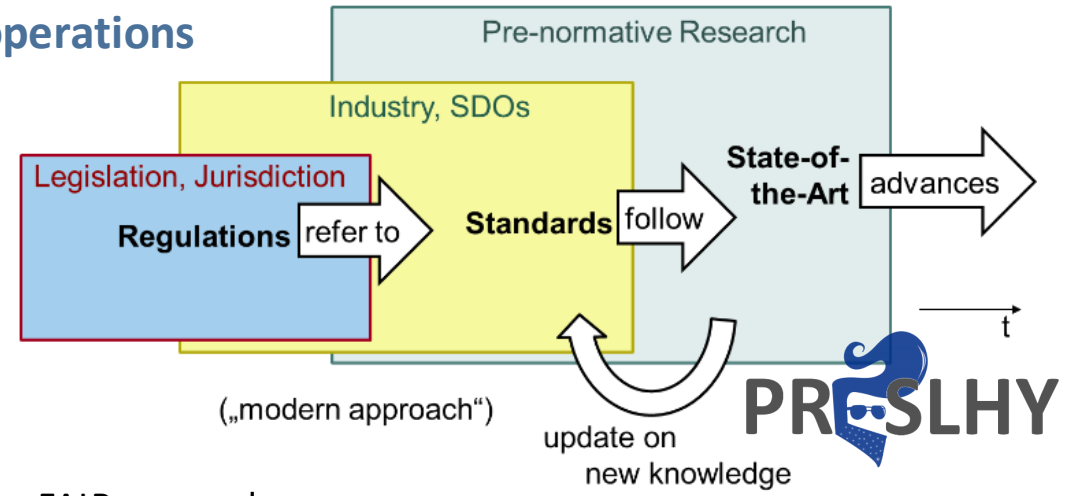
- Report **initial state-of-the-art and knowledge gaps** with priorities with respect to the intended use of liquid or cryogenic hydrogen technologies
- Execute adjusted **experimental program** addressing release, ignition and combustion phenomena with highest priorities

→ Close knowledge gaps

- Develop **suitable models and engineering correlations** and integrate them in a suitable open risk assessment toolkit

→ Provide enhanced recommendations for safe design and operations of liquid or cryogenic hydrogen technologies

- Support international SDOs in updating of existing standards or developing of new international



→ Support development of performance based, risk informed, internationally harmonised standards

- Document and publish detailed, aggregated and interpreted data in a FAIR way and
- disseminate the **enhanced state-of-the-art**

PRESLHY Networking

European Hydrogen Week

hySafe
INTERNATIONAL ASSOCIATION FOR HYDROGEN SAFETY

EHSP
RCS SCG

JRC (HIAD)

ISO TC 197
CEN/CENELEC TC6

IEA Hydro... Tas...

US DOE

ISO/PWI 24077: „Safe Use of LH2 in Non-Industrial Settings“ established on 6.12.2018

Presentation at CEN/CENELEC on 28.01.2020

Presentation at IEA Safety Task on 19.10.2018

Common Workshops on 06.03.2019 and Spring 2021

FCH
FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

WP1 – Manage-ment (KIT)

WP2 - Strategy (AL)

WP3 – Release & Mixing (NCSRD)

WP4 – Ignition (HSE)

WP5 – Combus-tion (KIT)

WP6 – Implementation (UU)

Advisory Board

H2@Scale
U.S. Department of Energy

SH2IFT

GexCon, IFE, Equinor + Shell

KHI, Toyota

Project Progress/Actions – Aspects

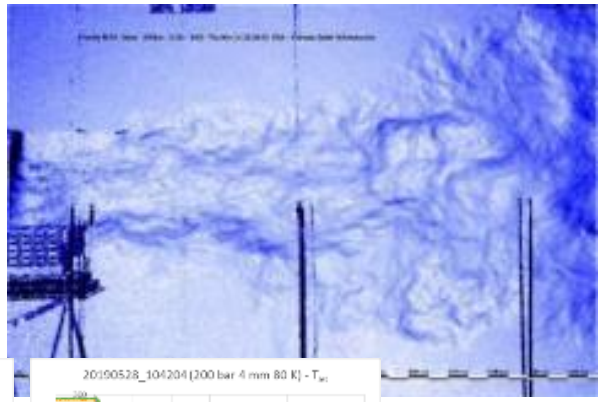
Achievement to-date

INCONSISTENT, RCS WITH A FRAGMENTED INCOMPLETE SCIENTIFIC BASIS

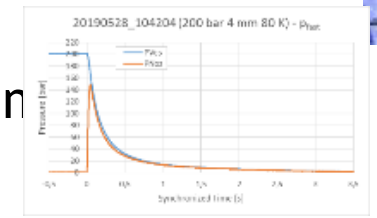
RISK INFORMED, HARMONISED INTERNATIONAL STANDARD FOR SAFE USE OF LH2 IN NON-INDUSTRIAL SETTINGS

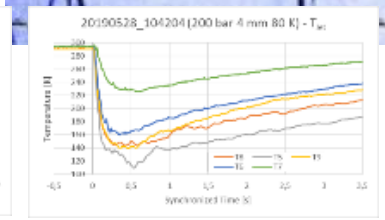
- Initial state of the art and RCS and priorities documented
- Experimental program on highly ranked priorities completed
- Knowledge gaps closed with respect to release/mixing, ignition and combustion
- ISO and CEN informed and ISO TC 197 PWI 24077 initiated
- Guidelines to be injected in standardization process under development
- Proposal for NWI

Closed Knowledge Gaps - Release



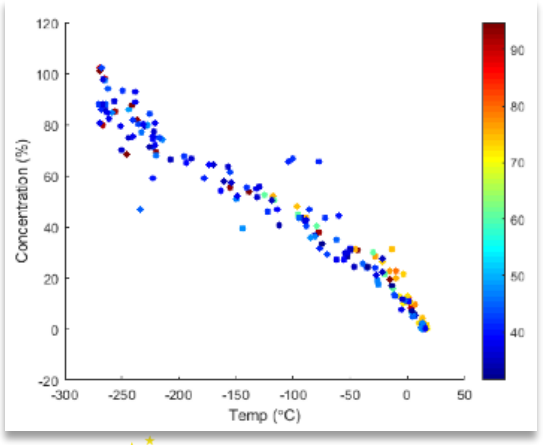
- 1 D model for multi-phase release including non-equilibrium processes





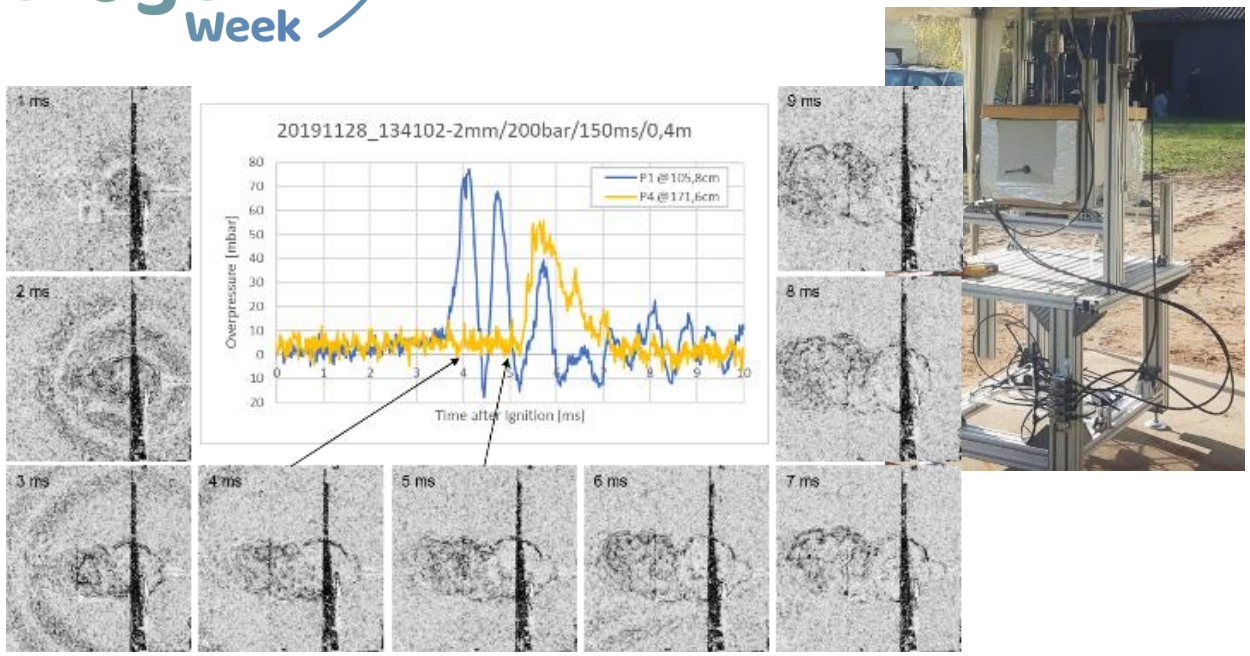
- Discharge coefficients for circular nozzles D=0.5-4 mm
  5 - 200 bar; 20 – 300K (KIT/PS E3.1 DISCHA tests)
  see https://doi.org/10.5445/IR/1000096833

- No rainout for large scale above ground horizontal releases
  (HSE E3.5: rainout tests)



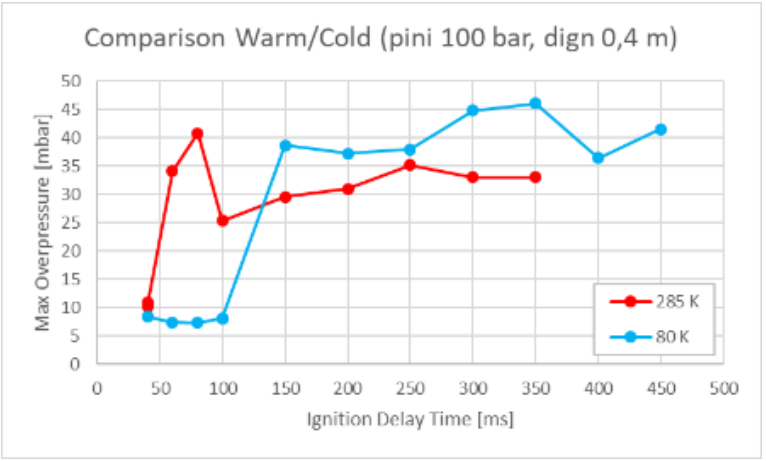
- Correlation of T and concentration of mixtures of H2 with cryogenic origin and air

Closed Knowledge Gaps - Transient Combustion Effects



> 100 Ignited jet tests combined with discharge experiments E5.1
T = 80K .. 300K
p = 5 .. 200bar
D_{nozzle}= 0.5 .. 4mm

Iterative procedure for identifying most critical ignition time and location



- Better understanding of transient jets and combustion processes
- Inventory based map of worst effects (pressure & thermal)
- to be extrapolated to large inventories for RCS

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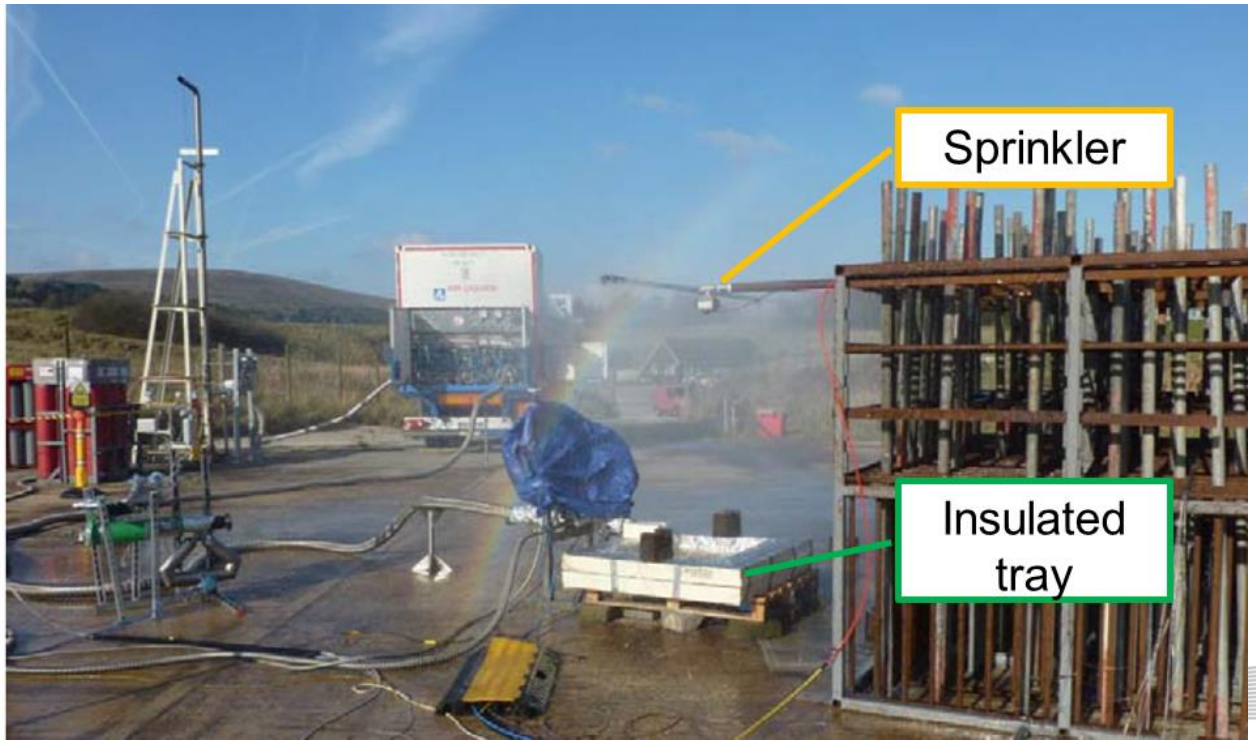
Closed Knowledge Gaps - Multi-phase accumulations with explosion potential

- Repeated spills in gravel bed might generate highly reactive condensed phase mixtures – not on other substrates (E4.4 Ignition above pool)



- Water sprays on LH2 and LH2 spills on small water pools non critical (E4.4 and E4.X)

Closed Knowledge Gaps - Combustion in confined/congested domains

- Stronger pressure loads for cold tests in comparison with warm tests with the same volume, hydrogen concentration and blockage ratio

E5.3 Semi-confined channel at KIT/PS


E5.5 Test set-up at HSE, Buxton

- Increase in critical and effective expansion ratios determine flame acceleration in cryogenic mixtures
- Reduced run-up distance for detonation transition DDT in cryogenic mixtures (← density effects)
- Influence of blockage ratio on DDT less pronounced
- Effects in free unconfined domains to be investigated

PRESLHY Exploitation Plan and Expected Impact

Exploitation

- Closure of knowledge gaps
- Enhancing the state-of-the-art
- Developing models for risk assessment
- Deriving recommendations for users and SDOs
- Initiating review or development of standards

Impact

Enabling the safe and economic introduction of LH2/cryogenic hydrogen technologies with a flexible, but robust framework consisting of

- improved knowledge basis and
- consistent recommendations and
- performance-based, harmonized specific standards to be referred by regulation

Outreach

www.preslhy.eu

PRESLHY Exploitation & Dissemination Activities

Management (WP1)

Implementation (WP6)

Task 1.3 Website

Data Management

Engineering tools

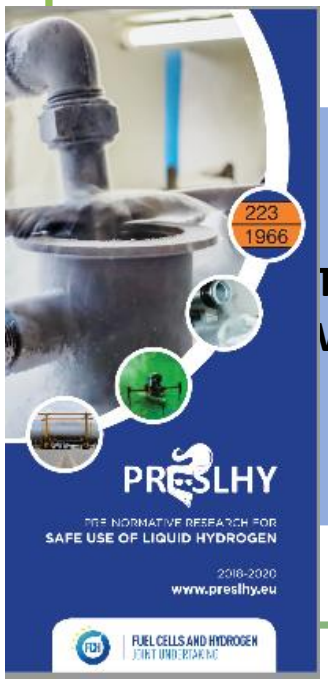
Handbook

Guidelines

RCS Recommendations

White Paper

Task 6.6 Dissemination Conference



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Acknowledgement

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European Commission | Horizon 2020 European Union funding for Research & Innovation

… and many thanks to all contributors
(e.g. Equinor, SHELL, …)

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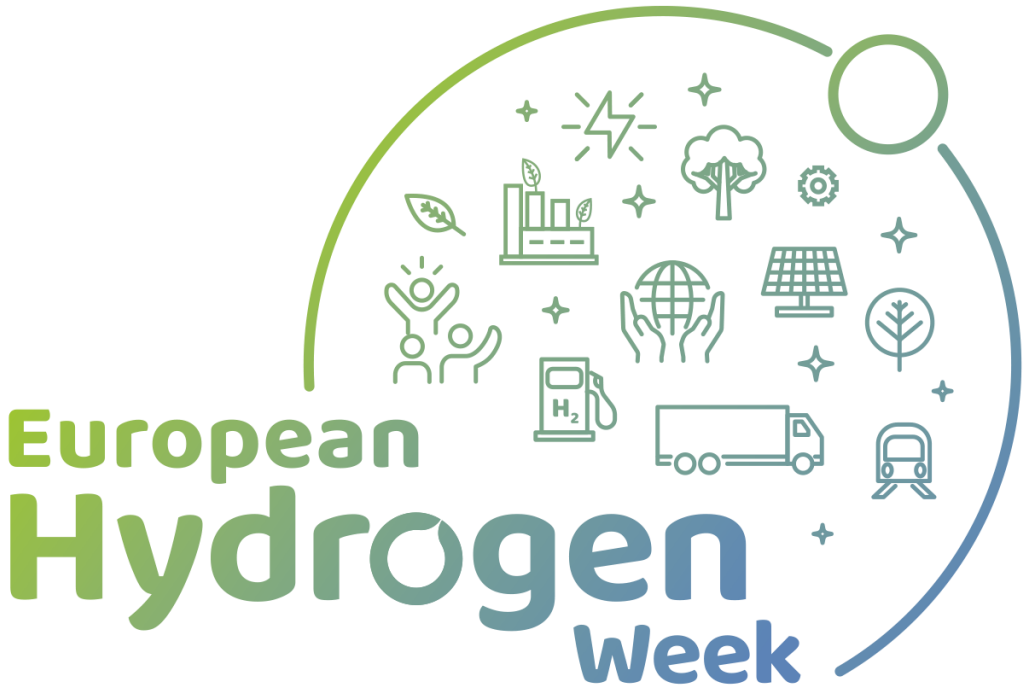

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