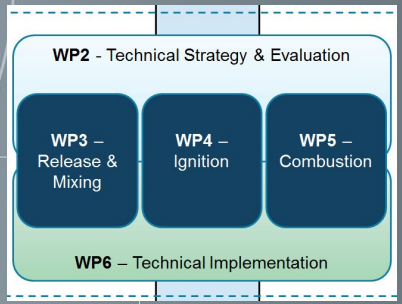
# Recommendations for Regulations, Codes and Standards

Dissemination Conference
Deborah HOUSSIN (AL)
17.09.2026

ELVHYS project No. 101101381 is supported by the Clean Hydrogen Partnership and its members. UK participants in Horizon Europe Project ELVHYS are supported by UKRI grant numbers 10063519 (University of Ulster) and 10070592 (Health and Safety Executive)

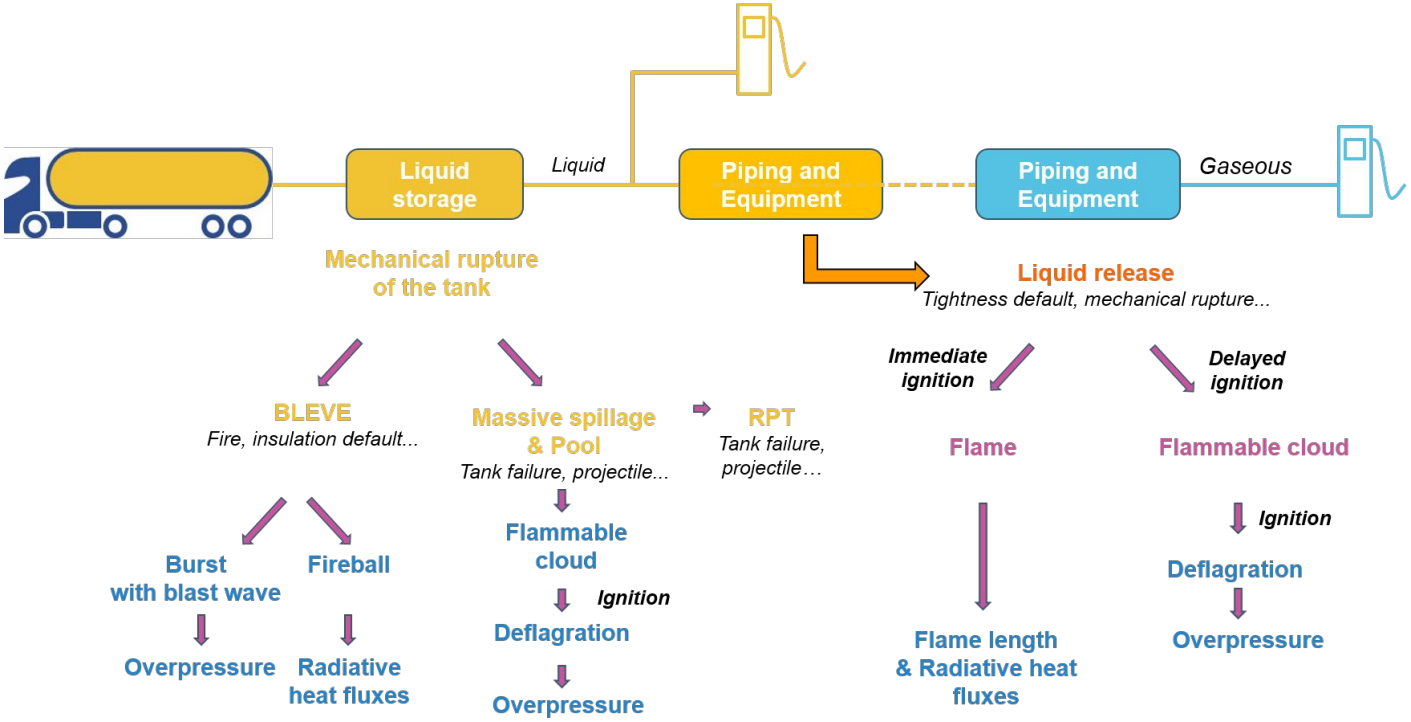
# PRESLHY project | 01/2018 - 12/2020+

## Main recommendations



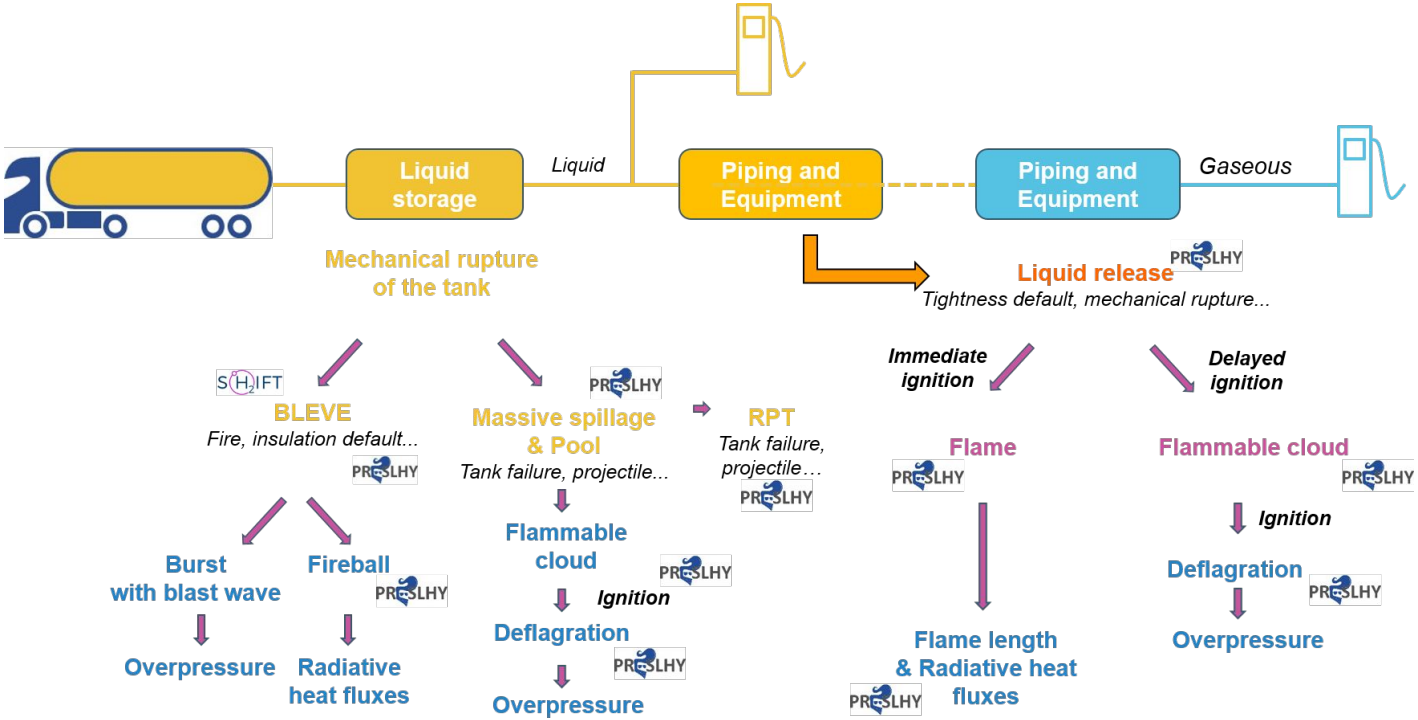
# $LH_2$-based application

## *Main feared events*



# Studied phenomena in PRESLHY project

## *Main feared events*



# RCS recommendations from PRESLHY project

## *Context*

- **Objective**
  - Provide general rules and good practices for a safe use of liquid hydrogen
  - Efficiently and widely communicate on PRESLHY findings and outcomes

- **Starting point: background on $LH_2$ risks**
  - Review of the knowledge gaps and PIRT (Phenomena Identification and Ranking Table)
  - Review of existing RCS on $LH_2$
    - To summarize: a lack of homogeneity, sometime inconsistency and potentially over-conservatism in RCS

- **Information used to formulate RCS recommendations is based:**
  - on PRESLHY new research results (experiments, analytical modelling, numerical simulation)
  - and on already published research work, as well, when applicable to $LH_2$

# RCS recommendations from PRESLHY project

## *Overview*

- **19 recommendations formulated**
  - Phenomena, concrete consequences and potential associated mitigation ways, for the following topics:
    - Release, flowrate, dispersion in free field
    - Ignition, flame and explosion
    - Burst of the storage vessel

- **Calculation means to evaluate consequences and define - when possible - hazard distances through:**
  - Analytical models
  - Engineering correlations
  - Numerical modelling

# RCS recommendations from PRESLHY project

## *In detail (3/3)*

Release, flowrate, dispersion in free field

| | Topics | Specificities |
|---|---|---|
| #1 | ***Limit potential liquid release*** | Good practice |
| #2 | ***Limit liquid release flowrate*** | Good practice |
| #3 | ***Ground medium*** | Good practice |
| #4 | ***Avoid retention pit*** | Good practice |
| #5 | ***Leak detection*** | Good practice |
| #6 | ***Cryogenic gaseous release rate*** | Calculation |
| #7 | ***Multiphase release rate*** | Calculation |
| #8 | ***Hazard distances assessment due to the formation of a flammable cloud*** | Calculation |

# RCS recommendations from PRESLHY project

## *In detail (2/3)*

Ignition, flame and explosion

| | Topics | Specificities |
|---|---|---|
| #9 | ***Avoid confinement*** | Good practice |
| #10 | ***Avoid ignition*** | Good practice |
| #11 | ***Avoid electrostatic charges*** | Good practice |
| #12 | ***Limit congestion*** | Good practice |
| #13 | ***Limit fire propagation*** | Good practice |
| #14 | ***Avoid water deluge*** | Good practice |
| #15 | ***Fire detection*** | Good practice |
| #16 | ***Hazard distances assessment due to a jet fire*** | Calculation |
| #17 | ***Thermal load assessment from a jet fire*** | Calculation |
| #18 | ***Fireball size*** | Calculation |

# RCS recommendations from PRESLHY project

## *In detail (3/3)*

Burst

| | Topics | Specificities |
|---|---|---|
| #19 | ***Measures avoiding storage burst** are required* | Good practice |

# RCS recommendations from PRESLHY project

## *To summarize*

- **Good practices** have been defined or confirmed

- Some areas of $LH_2$-based infrastructure or activities required **specific attention**

  **(e.g. bunkering, storage, confinement…)**

- **Several tools or calculation approaches have been validated for consequence assessment**
  - New tools
  - And some existing tools developed for $GH_2$ have been validated for $LH_2$ as well
  - Advice for appropriate consequence assessment/modelling

# PRESLHY project public reports

## *Focused on outcomes*



PRESLHY

Pre-normative REsearch for Safe use of Liquid Hydrogen (PRESLHY)

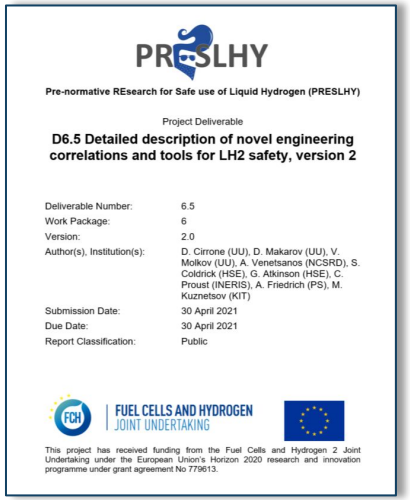
Project Deliverable

**Novel guidelines for safe design and operation of $LH_2$ systems and infrastructure**

| | |
|---|---|
| Deliverable Number: | D6.2 |
| Work Package: | WP6 |
| Version: | 2.0 |
| Author(s), Institution(s): | L. Bernard, AL, D. Houssin, AL, S. Jallais, AL, T. Jordan, KIT, D. Cirrone, UU |
| Submission Date: | 30 April 2021 |
| Due Date: | 30 April 2021 |
| Report Classification: | Public |

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No 779613.



PRESLHY

Pre-normative REsearch for Safe use of Liquid Hydrogen (PRESLHY)

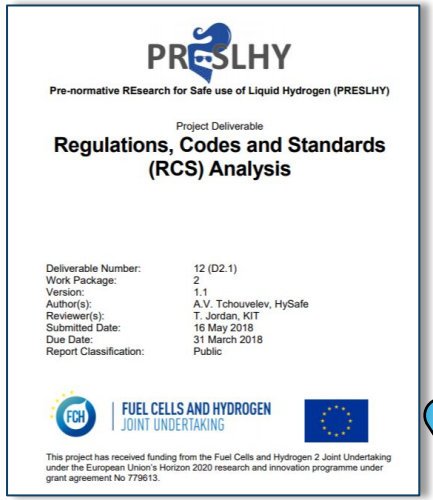
Project Deliverable

**D6.5 Detailed description of novel engineering correlations and tools for LH2 safety, version 2**

| | |
|---|---|
| Deliverable Number: | 6.5 |
| Work Package: | 6 |
| Version: | 2.0 |
| Author(s), Institution(s): | D. Cirrone (UU), D. Makarov (UU), V. Molkov (UU), A. Venetsanos (NCSRD), S. Coldrick (HSE), G. Atkinson (HSE), C. Proust (INERIS), A. Friedrich (PS), M. Kuznetsov (KIT) |
| Submission Date: | 30 April 2021 |
| Due Date: | 30 April 2021 |
| Report Classification: | Public |

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PRESLHY

Pre-normative REsearch for Safe use of Liquid Hydrogen (PRESLHY)

Project Deliverable

**Regulations, Codes and Standards (RCS) Analysis**

| | |
|---|---|
| Deliverable Number: | 12 (D2.1) |
| Work Package: | 2 |
| Version: | 1.1 |
| Author(s): | A.V. Tchouvelev, HySafe |
| Reviewer(s): | T. Jordan, KIT |
| Submitted Date: | 16 May 2018 |
| Due Date: | 31 March 2018 |
| Report Classification: | Public |

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

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PRESLHY

Pre-normative REsearch for Safe use of Liquid Hydrogen (PRESLHY)

Project Deliverable

**D6.3 Recommendations for RCS**

| | |
|---|---|
| Deliverable Number: | 6.3 |
| Work Package: | 6 |
| Version: | 2.0 |
| Author(s), Institution(s): | D. Houssin (AL), S. Jallais (AL), (KIT), A. T (HySAFE), T. Jordan |
| Submission Date: | 30 A |
| Due Date: | |
| Report Classification: | |

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

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www.preslhy.eu

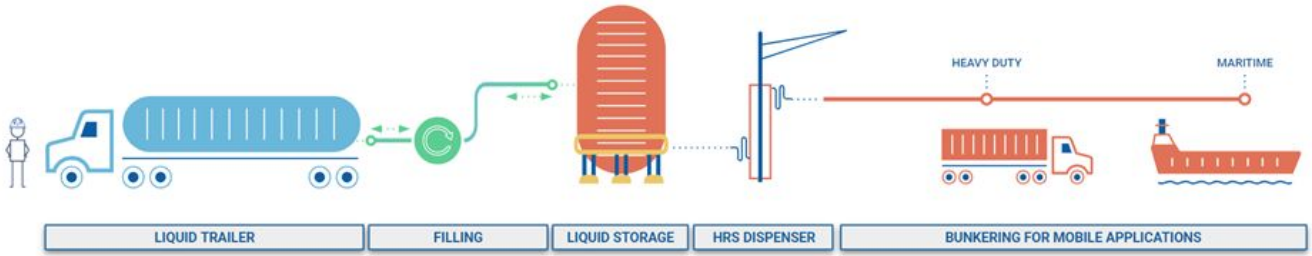
# ELVHYS project | 01/2023 - 09/2026

## Trends for recommendations

# ELVHYS

## *The project in a few words*

- **Project overview**
  - A **European research initiative** (Horizon Europe / Clean Hydrogen Partnership) running from **2023 to 2026**
- **Core mission**
  - **Enhancing safety and efficiency in liquid hydrogen transfer** operations (loading/unloading) in public areas for mobile applications (trucks, ships, and bunkering stations)
- **Key focus areas**
  - **Risk analysis of major hazard scenarios**, including fires, explosions, and cryogenic tank BLEVEs.
  - Developing safety **guidelines**, standardized transfer procedures, and input for international Regulations, Codes, and Standards (RCS)
- **Studied $LH_2$ transferring operations**
  - 3 defined configurations for the project
    - For stationary tanks
    - For trucks
    - For ships



# Disclaimer

- What was presented during the final dissemination conference was preliminary
- It was not discussed among partners and SAB members
- Some information was only just become available and could not have been fully integrated or interpreted with complete accuracy
- The recommendations were therefore not set in stone
- Discussions are underway to establish a final version of the RCS recommendations

- Nevertheless,
  a summary of the presented preliminary recommendations is provided without details in the next slides

# RCS recommendations

## *Global view*

- **Due to late outcomes from the project, RCS recommendations currently being defined**
- **Hereafter the main fields addressed, and an overview of the number of recommendations, which will be enriched in the coming weeks**

| | Topics | Recommendations |
|---|---|---|
| #1 | *Methodologies and means for risk assessment* | 5 |
| #2 | *$LH_2$ storage* | 3 |
| #3 | *$LH_2$ transfer procedure* | 4 |
| #4 | *$LH_2$ unignited releases* | 9 |
| #5 | *$LH_2$ releases in enclosed space* | 6 |
| #6 | *Venting and flaring of $LH_2$ storage tanks* | 2 |
| #7 | *BLEVE and tank in fire* | 3 |
| #8 | *Hazard distances* | 2 |
| #9 | *List of calculation means/approaches/tools - Analytical, Integral, Numerical* | 1 |

# Relevant standards / initiatives

## *Non-exhaustive list*

- **ISO**
  - ISO TS 15916:2026 “Basic considerations for the safety of hydrogen systems”.
  - ISO 13984:2026 “Liquid hydrogen - Land vehicle fuelling protocol”.
  - ISO 13984:1999 “Liquid hydrogen - Land vehicle fuelling system interface”.
  - ISO 13985:2006 “Liquid hydrogen - Land vehicle fuel tanks”
  - ISO 21012:2018 “Cryogenic vessels - Hoses”
  - ISO 21009-1:2022 “Cryogenic vessels - Static vacuum-insulated vessels - Part 1: Design, fabrication, inspection and tests”
  - ISO 21009-2:2015 “Cryogenic vessels - Static vacuum insulated vessels - Part 2: Operational requirements”
  - ISO 21013-2:2007 “Cryogenic vessels - Pressure-relief accessories for cryogenic service - Part 2: Non-reclosable pressure-relief devices”.
  - ISO 21013-3:2016 “Cryogenic vessels - Pressure-relief accessories for cryogenic service - Part 3: Sizing and capacity determination”.

# Relevant standards / initiatives

## *Non-exhaustive list*

- **ISO**
  - ISO TR LH2 “Safety Distances” (the WG will be initiated before the end of the year)
  - ISO NP 19889-3 “Hydrogen technologies — Interoperability — Part 3: Interface between liquid hydrogen trailer and hydrogen fuelling station” (an intention to launch the NP)
  - ISO NP 25666 “Safety Requirements for Liquid Hydrogen Maritime Onshore Terminals” (the WG will be initiated in 2027) .
  - ISO NP 19889-3 “Hydrogen technologies — Interoperability — Part 3: Interface between liquid hydrogen trailer and hydrogen fuelling station” (an intention to launch the NP)

# Relevant standards / initiatives

## *Non-exhaustive list*

- **IGC**
  - IGC Doc 59/98/E “Prevention of excessive pressure in cryogenic tanks during filling”.
  - IGC Doc 77/01/E “Protection of cryogenic transportable tanks against excessive pressure during filling”.
- **EIGA**
  - EIGA 06/19 “Safety in storage, handling and distribution of liquid hydrogen”
- **CGA**
  - CGA G5.5 - Standard For Hydrogen Vent Systems

# Relevant standards / initiatives

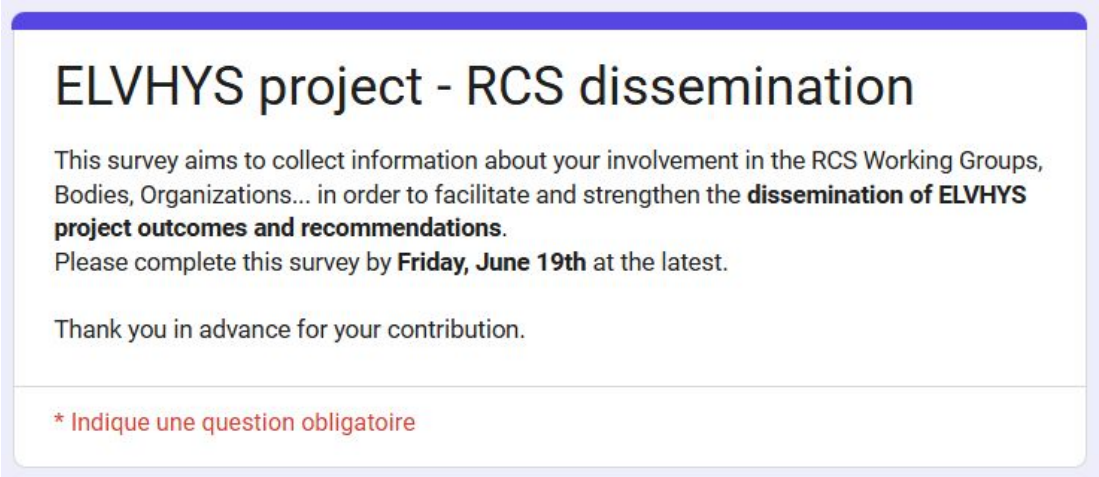
*Non-exhaustive list*

- **IMO**
  - IGC Code (International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk)
  - Interim Guidelines for the Safety of Ships Using Hydrogen as Fuel
  - Interim Guidelines for the Safety of Ships Using Fuel Cell Power Installations (MSC.1/Circ.1647)
- **CEN/TC**
  - …
- **SAE**
  - …
- **EUROCAE/SAE**
  - …

# Conclusions and coming steps

# RCS survey

## *Collect information with a Survey*



ELVHYS project - RCS dissemination

This survey aims to collect information about your involvement in the RCS Working Groups, Bodies, Organizations... in order to facilitate and strengthen the **dissemination of ELVHYS project outcomes and recommendations**.
Please complete this survey by **Friday, June 19th** at the latest.

Thank you in advance for your contribution.

* Indique une question obligatoire

⇒ **In 2025: 6 answers**
**In 2026: 10 answers**

# Towards consensus-based recommendations

- **Reminder**
  - What was presented during the Dissemination Conference was preliminary
  - It was not discussed among partners and SAB members
  - The recommendations were therefore not set in stone

- **Expected**
  - Please review recommendations
  - Propose additional recommendations

Since the Dissemination Conference...

# ELVHYS project | 01/2023 - 09/2026

## Updated proposals for recommendations & Dissemination strategy October 2026



# New version of the ELVHYS RCS recommendations

## *Underway - Big view*

**4 categories**

**42 recommendations**

- **Category A: Terminology and risk assessment** ..... **6 recommendations**
- **Category B: Consequence assessment and hazard distances** ..... **10 recommendations**
- **Category C: Design of facilities and mitigation** ..... **17 recommendations**
  - Prevention and detection 5 recommendations
  - $LH_2$ storage 3 recommendations
  - Protection in open areas 4 recommendations
  - Enclosed spaces 3 recommendations
  - Venting and flaring 2 recommendations
- **Category D: Transfer operations** ..... **9 recommendations**

# Dissemination strategy

## *Key target - Priority 1*

| Document | Body | Status | ELVHYS recommendations to be addressed |
|---|---|---|---|
| ISO TS 15916 – Basic considerations for the safety of hydrogen systems | ISO/TC 197 | Published (2026) | A-1, A-2, A-3, A-5, A-6, B-1, B-3, B-4, B-6, B-7, B-9, C-11, C-13, C-14, C-15 |
| ISO TR on $LH_2$ safety distances | ISO/TC 197 | Working group to be initiated (end of 2026) | A-1, A-3, A-4, B-1, B-2, B-3, B-4, B-5, B-6, C-9 |
| ISO 13984 – Liquid hydrogen – Land vehicle fuelling protocol, and ISO 13985 – Land vehicle fuel tanks | ISO/TC 197 | ISO 13984 published (2026); ISO 13985 revision planned | B-8, C-1, C-2, C-4, C-5, C-7, C-8, C-17, D-1, D-2, D-3, D-5, D-6, D-7 |
| ISO NP 19889-3 – Interface between $LH_2$ trailer and hydrogen fuelling station | ISO/TC 197 | Intention to launch a new work item | C-1, C-4, C-5, C-8, D-1, D-5, D-6, D-7 |
| ISO NP 25666 – Safety requirements for $LH_2$ maritime onshore terminals | ISO/TC 197 | Working group to be initiated (2027) | A-4, B-5, B-9, C-1, C-13, C-14, C-15, D-5, D-9 |
| EIGA Doc 06/19 – Safety in storage, handling and distribution of liquid hydrogen | EIGA | Published | B-3, B-5, B-8, B-10, C-1, C-3, C-4, C-8, C-9, C-10, C-11, C-12, C-16, D-1, D-2, D-3, D-4, D-6, D-7, D-8 |
| NFPA 2 – Hydrogen Technologies Code | NFPA | Published | A-3, A-4, B-1, B-2, C-4, C-9, C-11, C-12, C-14 |

# Dissemination strategy

## *Key target - Priority 2*

| Document | Body | ELVHYS recommendations to be addressed |
|---|---|---|
| ISO 21009-1 / -2 – Cryogenic vessels – Static vacuum-insulated vessels | ISO/TC 220 | B-7, C-2, C-3, C-5, C-6, C-10, D-2, D-3, D-4, D-8 |
| ISO 21013-3 – Pressure-relief accessories for cryogenic service – Sizing and capacity determination | ISO/TC 220 | B-7, B-8, B-10, C-2, C-6, C-16, C-17 |
| ISO 20421-1 / -2 – Large transportable vacuum-insulated vessels | ISO/TC 220 | C-7, D-2, D-7, D-8 |
| EIGA Doc 151 – Prevention of excessive pressure during filling of cryogenic vessels | EIGA | C-2, D-5 |
| CGA G-5.5 – Hydrogen vent systems | CGA | B-10, C-16, C-17 |
| ISO 20088 series – Determination of the resistance to cryogenic spillage of insulation materials | ISO/TC 67 | C-10 |
| IMO Interim Guidelines for the safety of ships using hydrogen as fuel | IMO | C-7, C-13, C-15, D-9 |
| ISO WD 25578 – Liquid hydrogen fuelling nozzle and receptacle (under development) | ISO/TC 197 | C-1 |
| ISO WD 26018 – Components for liquid hydrogen storage systems (under development) | ISO/TC 197 | C-2, C-5 |

# Dissemination strategy

## *Who - Where // Covered vs Gap*

| Target RCS | Committee / body | Relay organisations identified | Coverage |
|---|---|---|---|
| ISO TS 15916 | ISO/TC 197 WG 29 | | Covered |
| ISO TR on $LH_2$ safety distances | ISO/TC 197 | | To be designated |
| ISO 13984 / ISO 13985 | ISO/TC 197 WG 35, WG 1 | | Covered |
| ISO NP 19889-3 | ISO/TC 197 | | Single relay |
| ISO NP 25666 | ISO/TC 197 | | Single relay |
| ISO WD 25578 / ISO WD 26018 | ISO/TC 197 | | Single relay |
| EIGA Doc 06/19, EIGA Doc 151 | EIGA | | Single relay |
| CGA G-5.5 | CGA | | Single relay |
| NFPA 2 | NFPA | | Gap |
| ISO 21009, ISO 21013-3, ISO 20421 | ISO/TC 220 | | Gap |
| ISO 20088 series | ISO/TC 67 | | Gap |
| IMO Interim Guidelines | IMO (CCC sub-committee) | | Covered |

# Final dissemination

***Consensual RCS recommendations***
***will be available***
***in the public final version of ELVHYS D2.5***

***"RCS recommendations for $LH_2$ transferring operations and facilities"***

# Thank you for your attention

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Co-funded by the European Union

Clean Hydrogen Partnership

UK Research and Innovation

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