WORKSHOP 2
on WP2 methodology

25th January 2021

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under Grant Agreement No 101006794. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation programme, Hydrogen Europe and Hydrogen Europe research.

Agenda

Time	Topic	Speaker
9:30 – 9:45	Introduction to MultHyFuel	Joana Fonseca, Hydrogen Europe
9:45 – 10:15	Dispenser design and geometry	Sebastien Quesnel, ENGIE
10:15 – 11:05	WP2.1 Practical research: Leakage characteristics	Christophe Proust, INERIS
11:05 – 11:15	BREAK	
11:15 – 12:05	WP2.2 Practical research: Fire and explosion hazards	Louise O’Sullivan, Health and Safety Executive
12:05 – 12:30	WP1 Permitting and risk assessment requirements in the EU	Joana Fonseca, Hydrogen Europe

Safety and Permitting for Hydrogen at Multifuel Retail

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"(…) lack of guidelines and instructions for local authorities can cause **delays**, **extra costs** and **divergent interpretations** from case-to-case, further complicating the obligations of HRS operators."
2018, https://www.hylaw.eu/

Definition of **commonly applicable, effective, and evidence-based guidelines** to facilitate the construction of HRS in multi-fuel refuelling stations through

- Identification of relevant gaps in the current legal and administrative framework;
- Acquisition of experimental data from engineering research;
- Active engagement with a community of stakeholders in the overall process.

Stakeholder engagement plan

WP1

State of the art review
Preliminary extensive diagnosis of the existing rules, standards and best practices in the domain.

WP2 & WP3

Analysis and experimentation
New data acquisition through practical experimentation and analysis of information collected.

WP3

Synthesis of results
Generate best practice guidance for national implementation of evidence-based policies.

WP4

Engagement plan
Actively engage a community of stakeholders throughout the process for validation of results and gap identification.

WP5

Communication and dissemination
Maximize project's impact through adequate dissemination of results.

Stakeholder engagement plan

- Involvement of key stakeholders for **validation** of solutions proposed and final results.
- A series of **workshops** will be organised at strategic stages of the project.

WS #	Topic	Planned Date
1	Validation of the 3 case study configurations defined in T3.1	8th June 2021
2	WP2 methodology	25th January 2022
3	Results from WP2 and WP3	April 2023
4	Development of the best practice guidelines	July 2023
Final	Adoption of best practice guidelines	December 2023

Workshop 2

Target group:

Public authorities
HRS operators and manufacturers

Key main goals:

- Validation of components studied
- Validation of forecourt and dispenser replica
- Is the data proposed able to address questions you have?

Meeting Set-Up and Etiquette

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- Please make sure to have your name and company's name as your username

- Please remain muted throughout the course of the workshop when you are not speaking. If you would like to take the floor, please use the "raise hand" function provided in the zoom platform.

- To engage and provide feedback, feel free to use the chat or participate orally unmuting your microphone

- This meeting will be recorded. To ask for the recording please send an e-mail to info@multhyfuel.eu

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Status and questioning:

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About the link between **WP3 and WP2 :**

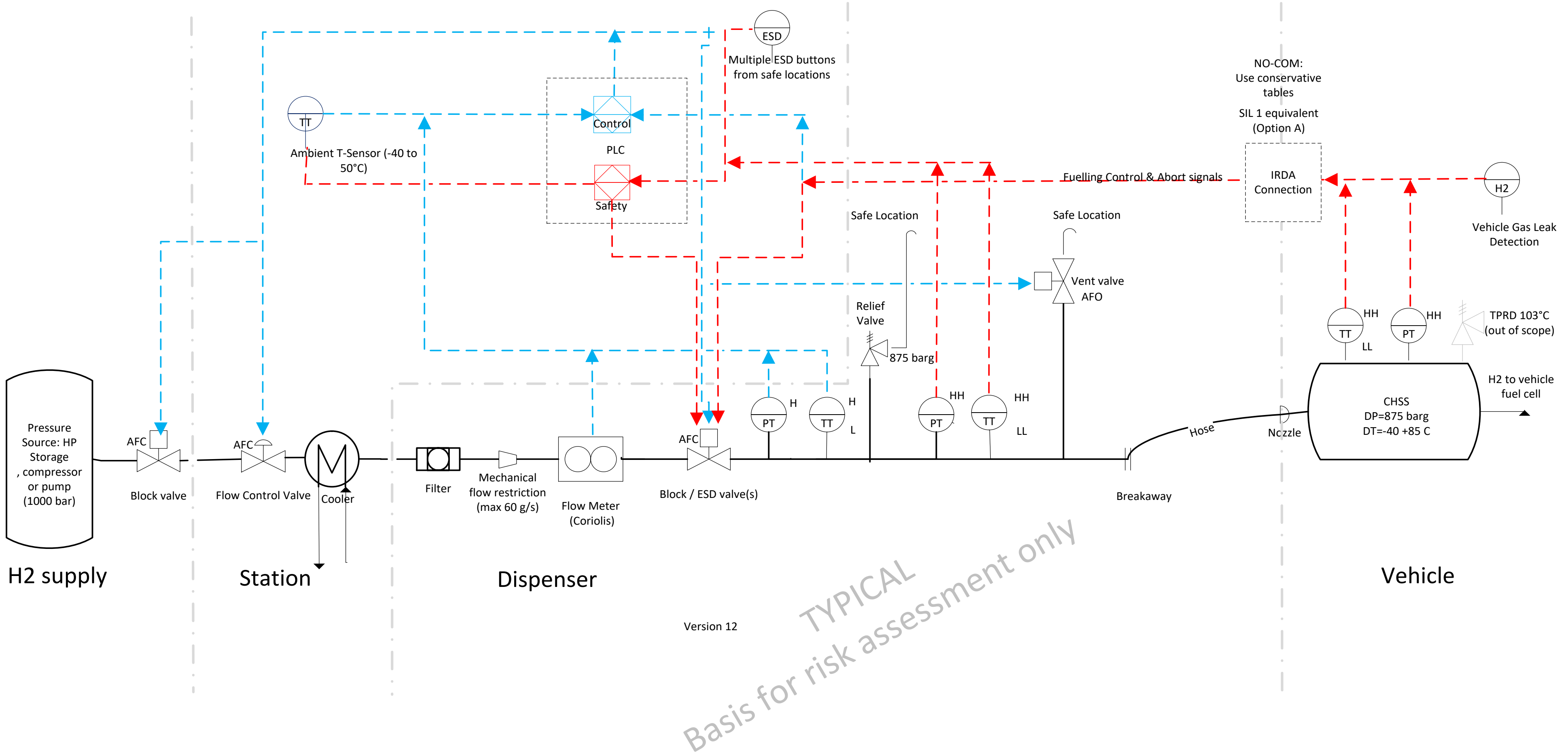
- Work undertaken so far:
  - **In WP3** : a wide spectrum risk analysis exercise was performed on the basis of rather generic scenarios (full bore rupture, x % of the full cross section leakage,…). Critical scenarios need to be refined (=>WP2)
  - **In WP2** :
    - a logico-mathematical model giving the probability of the leakage and leakage cross section was devised. The outcome of the model is closely linked to the nature of the components and to the nature of the solicitation (fatigue, misuse, …) ;
    - leakage and explosion testing are foreseen. The representativity depends on details of the dispenser (components, geometry, openings,...).
- Pending question :
  - A generic description of a dispenser was defined internally to select components and make a link between the generic scenarios and the component based model : ***Do you have comments about the choice made by the consortium about the generic dispenser proposed ?***

Difficulty: many different designs

- ➢ Select a list of typical components (not all are suited to HP hydrogen)
- ➢ Select a set of typical geometries (volume, opening, blockage)

Components thay may leak (i)

Information from PRHYDE project



Components thay may leak (ii)

DRC = Double ring compression fitting
C&T = Cone and thread fitting
NPT = National pipe thread fitting

Designation	Inlet diameter	Outlet diameter	Working pressure	Specificities
Gas Detector	-	-	-	Catalytic
Check Valve	1/4" DRC	1/4" DRC	250 bar	-
Heat Exchanger	3/8" C&T	3/8" C&T	975 bar	Insulated
Hose	3/8'' C&T	3/8'' C&T	875 bar	Length 4 m
Flow Valve	1/4" C&T	1/4" C&T	975 bar	-
Flow Valve	9/16" C&T	9/16" C&T	975 bar	-
Double Block and Bleed	9/16" C&T	9/16" C&T	975 bar	Vent connection 1/4" C&T
Pressure Control Valve	9/16" C&T	9/16" C&T	975 bar	Vent connection 1/4" NPT
Pressure indicator and transmitter	1/4" C&T	1/4" C&T	975 bar	Ex
Pressure Safety Valve	-	-	975 bar	6 mm - Vent connection 1" NPT
Restricted Orifice	1/4" C&T	1/4" DRC	975 bar	0.7 mm
Solenoid Valve	6-8 mm	4-6 mm	10 bar	-
Temperature Transmitter	1/4" C&T	-	-	Ex
Shock Detector	-	-	-	-
Break-Away	3/8'' C&T	3/8'' C&T	875 bar	-
Nozzle	3/8'' C&T	3/8'' C&T	875 bar	-

Car nozzle

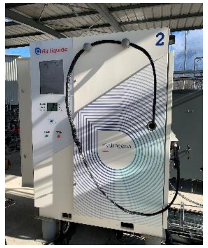
Around 50 connections inside the dispenser…

Do you have comments about the choice made by the consortium about the components?

Geometry of the dispenser (i)

- Volume: 1 m^3 or less (details next slide)
- Geometries (details next slide)
  - 1 dispenser with bottom “valve-fitting-connection”-box ***(A)***
  - 1 dispenser with “whole-volume” “valve-fitting-connection”-box ***(B)***
- Blockage ratio: 50% or less (details next slide)
- Ventilation openings: several possibilities
  - 1 opening in the upper part of the dispenser: vertically or horizontally or totally open-top
  - 2 openings: one at the top, one at the bottom → the most used
  - size: for a 2 m-height dispenser, openings height will be around 20-30 cm on the whole width of the dispenser for instance
  - Maybe forced ventilation has to be considered ?
- Maximum flowrates
  - Today: 60 $g.s^{-1}$ for cars, 120 $g.s^{-1}$ for buses
  - For future: 180 $g.s^{-1}$ and maybe up to 300 $g.s^{-1}$…
  - Possible representative leakage : 0.1 mm or 3% of maximum piping section at maximum pressure inside the container?

(A)



(B)

Geometry of the dispenser (ii)

Do you have comments about the choice made by the consortium about the geometry ?

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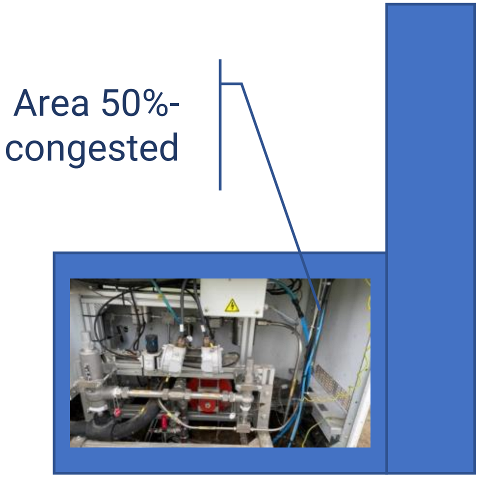
Dispenser (A)

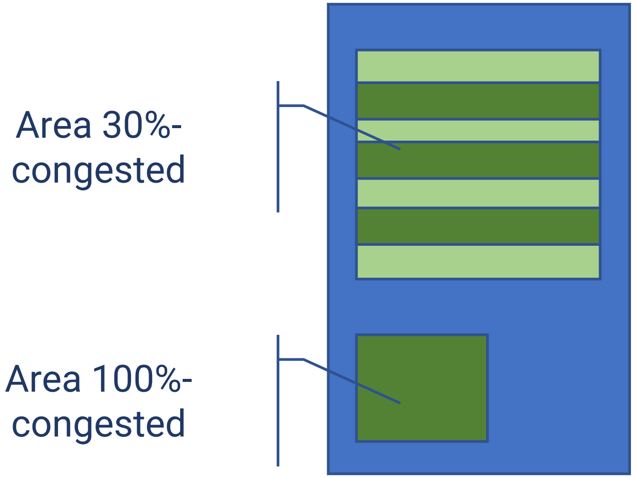
- Size
  - H 1 m x L 0.80 x W 0.4 m
- Congestion
  - 50%
  - Bottom
- Ventilation
  - Natural

Dispenser (B)

- Size
  - H 1.9 m x L 0.75 x W 0.6 m
- Congestion
  - 30%
  - In the whole enclosure
- Ventilation
  - Natural & Forced

(A)





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Status and questioning:

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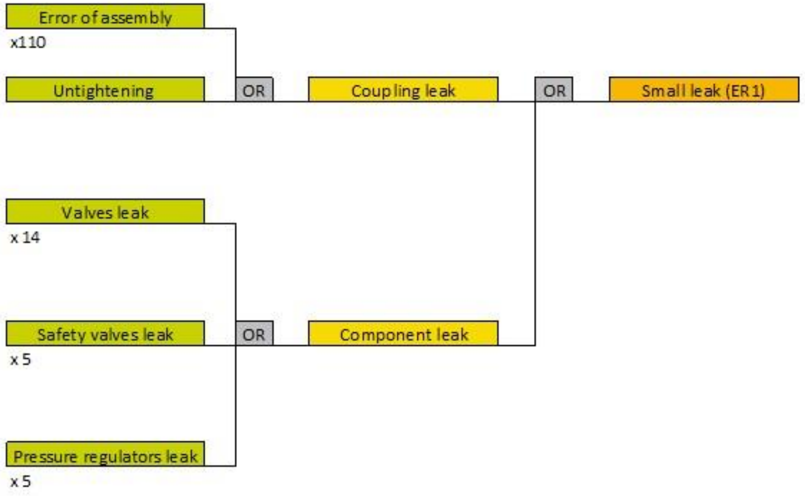
About **leakage characterisation** (WP2.1)

- Work undertaken:
    - 2.1.1: Preparation of a tool to predict leakage frequencies and flowrates from components in their context of utilization
    - 2.1.2 : Selection of CFD tools and of a validation database
- Pending questions :
    - A close link between the practical leakage situations and the risk analysis is required. ***Do you see important leakage scenarios that might have been overlooked ?***
    - The most important scenarios (typically 4) will be produced experimentally during long range realistic testing : ***According to you what could be the priorities of those "long range practical testing" and why ?***

WP2.1 – Leakage characteristics (i)

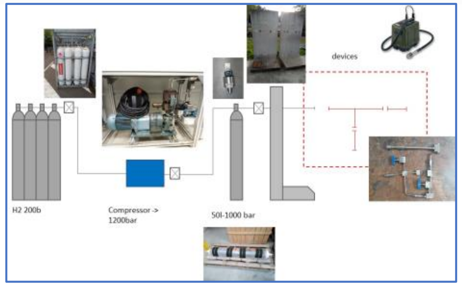
Content



Component	Causes of leakage	Leakage frequency (max)
Electrical valve	Deficient assembly (connected/disconnected once over 10 years) **OR** untightening of the screws (pressing the flat seal) due to pressure cycling	2 x 1/1000 x 1/10 + 300 x 1/10000 = O(10^{-2})/y
Spring safety valve	Deficient assembly (connected/disconnected once over 10 years) **OR** untightening of the screws (pressing the flat seal) due to pressure cycling **OR** damage to the spring	2 x 1/1000 x 1/10 + 300 x 1/10000 + 1/1000= O(10^{-2})/y
Membrane P regulator	Deficient assembly (connected/disconnected once over 10 years) **OR** untightening of the screws (pressing the flat seal) due to pressure cycling **OR** damage to the membrane	2 x 1/1000 x 1/10 + 300 x 1/10000 + 1/100= O(10^{-2})/y

« Durability » models for :

- Assembly (maintenance)
- Fatigue
- Cycling (untightening)
- Corrosion



Leakage cross section :

- Full bore : corrosion, fatigue, mis-assembly (a part lacking)
- <full bore : bad assembly(local damage), untightening (space screw-nut)

WP2.1 – Leakage characteristics (ii)

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Components

- 1000b 9/16'' pipe
- 1000b 3/8'' pipe
- 1000b hose
- Autoclave U couplings
- Autoclave T couplings
- Unions to sensors
- Couplings to breakaway (3/8'')
- Breakaway (3/8'')
- Coupling to nozzle (3/8'')
- Nozzle
- Pressure Release Valve
- Flow Control valve
- …

Solicitations

- Mounting procedure (deficient/missing part)
- Mounting procedure (untightened)
- Pressure cycling (untightening)
- Fatigue
- Corrosion
- Overstress (bending/hose)
- …

- Pending questions :
  - ***Do you see important leakage scenarios (component and/or solicitation) that might have been overlooked ?***
  - ***According to you what could be the priorities of the "long range practical testing" and why ?***

Cycling of hydrogen pressure between 0 and 1.050 bar

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WP2.2 – Context/definitions

Definition	Description
ALARP	As Low As Reasonably Practicable
UVCE	Unconfined Vapour Cloud Explosion
VCE	Vapour Cloud Explosion
HRS	Hydrogen Refuelling Station

WP2.2 – Discussion points

The points we would like to discuss at the end of the presentation are:

- Would there be further considerations in relation to multi fuel forecourts ?
- In terms of local regulation – could the proposed data address questions you have?

WP2.2 – Outline

Work package 2

Fire and Explosion Hazards

Hazard effects on

- Forecourt
- Dispenser
- Members of the public on forecourt

WP 3 highlighted areas requiring enhanced information and harmonisation

- Separation distances
- Multi-fuel escalation

WP2.2 – Approach

Knowledge gaps identified

- Work package 1.2 - Permitting requirements and risk assessment methodologies for HRS in the EU
- Work package 3.3 - Preliminary risk analysis review

Experimental work to fill knowledge gaps

- Separation distances
- Multi fuel escalation

Increased knowledge

- Replica forecourt and dispensers
- Pressure effects with time and distance
- Temperature effects with time and distance
- Interactions between conventional fuels and hydrogen fuel.

Project benefits to end users / stakeholders

- Greater understanding to enable the harmonisation of standards governing separation distances / forecourt layout
- Data to support risk assessment of individual forecourt layouts
- Data to support the rollout of hydrogen dispensers into a multi fuel station

WP2.2 – Gap analysis

Separation distances

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Outcomes of deliverable

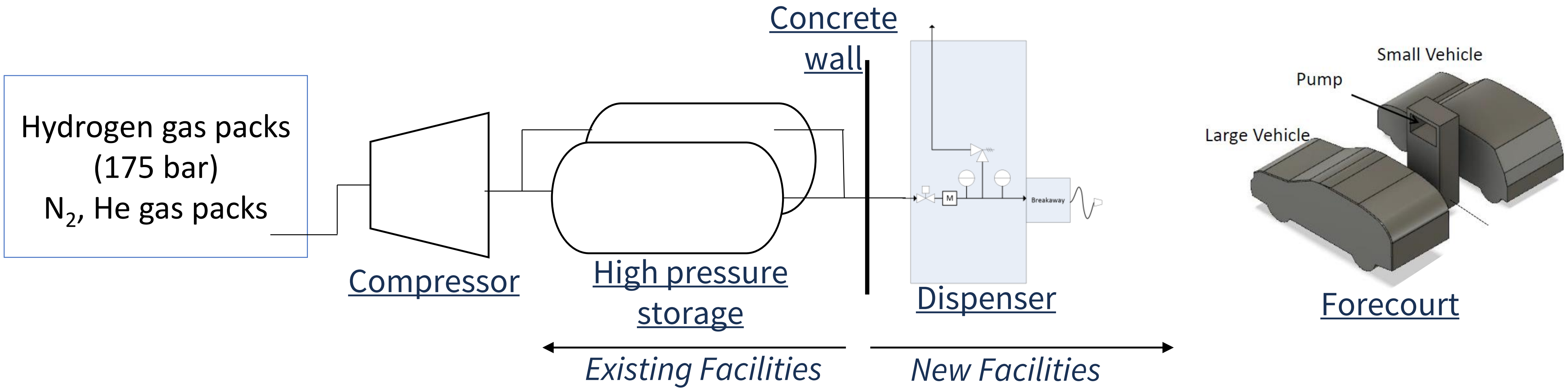
There are significant differences in the general procedure and policies for HRS deployment

Work package 1
Deliverable 1.2

Permitting requirements and risk assessment methodologies for HRS in the EU

- ISO 19880-1:2020(E)
- Belgium VLAREM II
- Finland QRA thermal & pressure effects
- Norway ATEX ALARP
- Austria VETAX
- Hungary National legislation based on ISO 19880-1:2020 (E)
- Netherlands ALARP
- Italy Ministerial Decree 23/10/2018
- Germany TRBS 3151
- EI Blue Book
- France
- Poland Directive 94/63/EC

WP2.2 – Experimental work



- **Compression and high pressure storage:** Existing facilities on site (Max. Pressure 1000 barg, 2 x 50 L capacity)
- **Hydrogen dispenser:** Design and Manufacture of a “standard” replica dispenser. Featuring realistic dimensions, internal distribution and main components.
- **Forecourt:** Representation of a realistic forecourt, especially congestion around the hydrogen dispenser. It may include other pumps, vehicles (or structures representing them), vent stack, structures, etc.

WP2.2 – Measurements proposed

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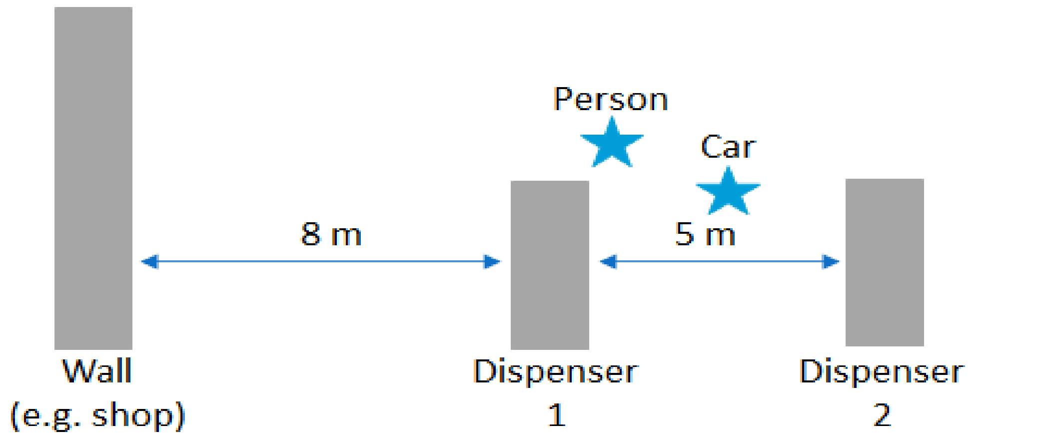
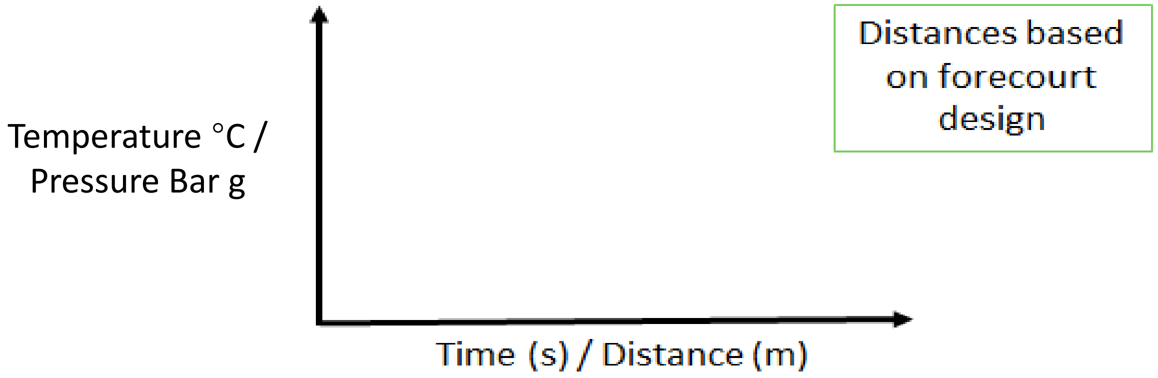
Measurements proposed

- Pressure
- Peak Pressure
- Flame / Heat
- Thermal Radiation IR

Forecourt Design



Experimental Measurements



WP2.2 – Experimental work (i)

Test Type	Scenario Ref WP3.3	Release type and size	Release location	Igniter location	Pressure bar g	Incoming Flow g/s from supply	Ventilation	Forecourt layout
non ignited	Dispenser Hose loss for H2 containment (Small leak / 0.1 0.2 millimetres diameter) on pipe / valve /hose Small pipework leak	0.1 - 0.2 mm diameter	Internal dispenser	NA	700	60	Standard	Type 1 (dispenser only)
							Increased	
							None	
					350	120	Standard	
							Increased	
							None	
					350	300	Standard	
							Increased	
							None	
non ignited	Dispenser 10% of Diameter Leak on Pipe medium pipework leak	10 % diameter of the pipe	Internal dispenser	NA	700	60	Standard	Type 1 (dispenser only)
							Increased	
							None	
					350	120	Standard	
							Increased	
							None	
					350	300	Standard	
							Increased	
							None	

WP2.2 – Experimental work (ii)

Test Type	Scenario Ref WP3.3	Release type and size	Release location	igniter location	Pressure bar g	Incoming Flow g/s from supply	Ventilation	Forecourt layout
ignited	Dispenser loss for H2 containment (Small leak / 0.1 0.2 millimetres diameter) on pipe / valve /hose Small pipework leak	0.1 - 0.2 mm diameter	Internal dispenser	inside dispenser	700	60	Standard	Type 1 (dispenser only)
							Increased	
							Standard	Type 2 (1 vehicle)
					350	120	Standard	Type 1 (dispenser only)
							Increased	
							Standard	Type 2 (1 vehicle)
					350	300	Standard	Type 1 (dispenser only)
							Increased	
							Standard	Type 2 (1 vehicle)
ignited	Domino (A domino in this instance is a line of fuel dispensers) - Medium pipework leak from a dispenser which is ignited outside of the dispenser . With obstacles such as vehicles and adjacent dispensers .	Medium pipework leak 10% of diameter of pipe	internal dispenser / external cloud created	External dispenser	700	60	Standard	Type 1 (dispenser only)
								Type 2 (1 vehicle)
								Type 3 (2 vehicles)

WP2.2 – Experimental work (iii)

Test Type	Scenario Ref WP3.3	Release type and size	Release location	igniter location	Pressure bar g	Incoming Flow g/s from supply	Ventilation
ignited	Dispenser hose breakaway failure - Due to drive off breakaway failure Pipe size = 9.6 mm ED	Large pipe work leak	Simulated breakaway	External to dispenser (delayed ignition, spark ignition in the order of seconds)	700	60	Standard
ignited	Burst Hose Hose whip - due to drive off		Hose	External dispenser	700	60	Standard
ignited	Burst Hose Hose whip - due to drive off		Hose	External dispenser	350	120	Standard

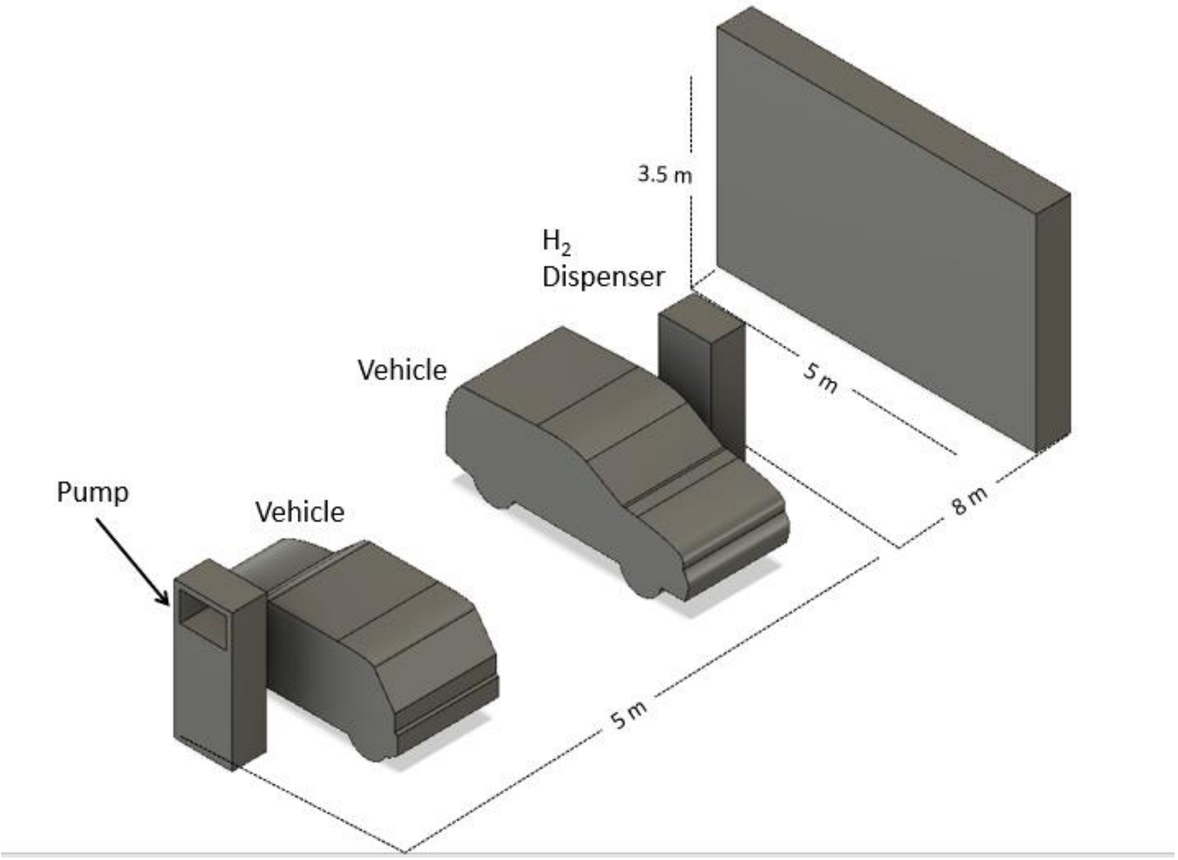
WP2.2 – Forecourt (i)

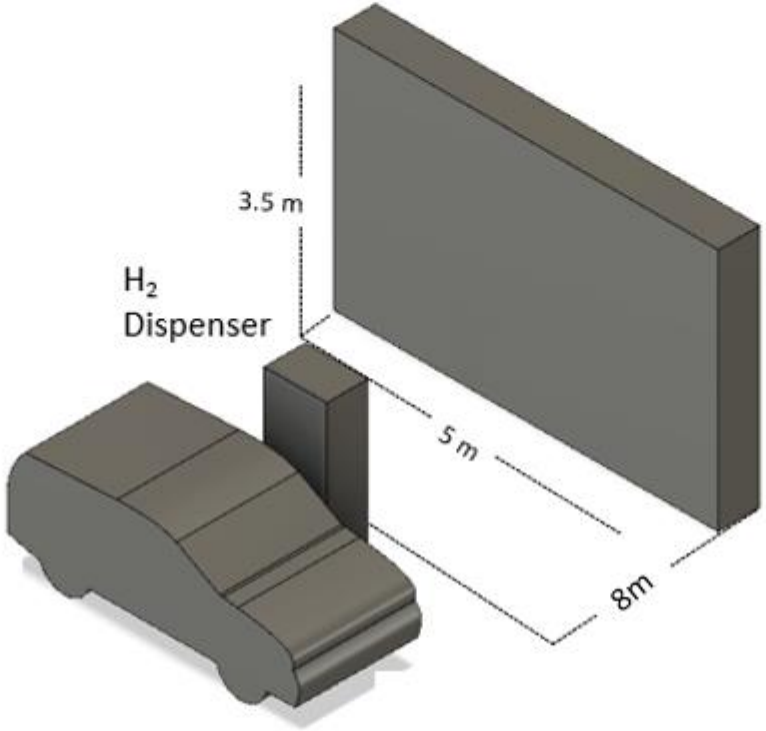
- A representative replica forecourt (refuelling pumps and infrastructure) will be required for the tests outlined in the 'Experimental work' slides.

The information considered for the forecourt design:

- Configurations proposed in workshop 1
- National & international standards
- Industry guidance
- Input from stakeholders
- Input from regulatory bodies

WP2.2 – Forecourt (ii)





WP2.2 – Discussion

Outline

- Would there be further considerations in relation to multi fuel forecourts ?
- In terms of local regulation – could the proposed data address questions you have?

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Research into permitting requirements (i)

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Preliminary extensive diagnosis of the existing rules, standards and best practices in the domain.

Goal

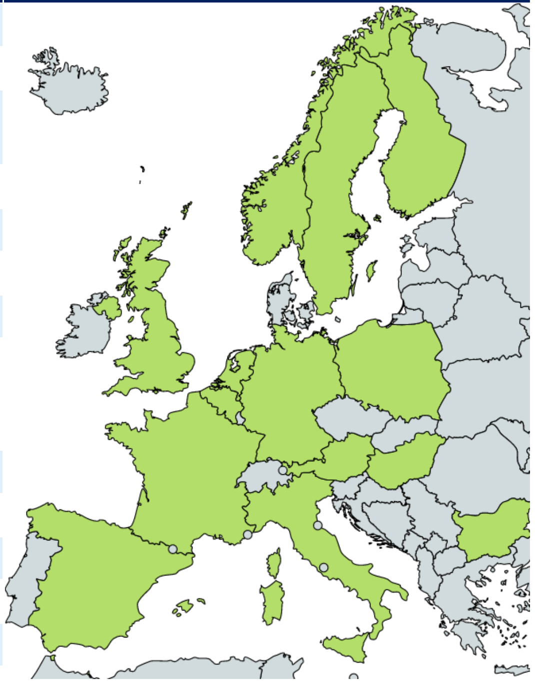
- Collect specific information on requirements, rules, conditions, standards applicable at national level in 14 European countries (Network of National Experts);
- Comparative assessment and gap analysis.

Scope of research

- Existing permitting requirements for HRS;
- Risk Assessment regulations/methodologies;
- Safety or separation distances;
- Intervals and content of equipment maintenance.

Network of National Experts

COUNTRY	ORGANIZATION	EU COVERAGE & REPRESENTATIVENESS
AT	Austrian Energy Agency	
BE	WaterstofNet vzw	
BG	Bulgarian Hydrogen, Fuel Cell and Energy Storage Association	
FI	VTT Technical Research Centre of Finland LTD	
FR	France Hydrogéne	
DE	ZSW	
HU	Hungarian Hydrogen & Fuel Cell Association	
IT	Italian National Agency for new technologies, energy and sustainable economic development and H2 Italy	
NL	NEN	
PL	NEXUS Consultants	
ES	Aragon Hydrogen Foundation	
SE	Hydrogen Sweden	
UK	ITM Power	
NO	Greenstat	



- D1.2 – Permitting requirements and risk assessment methodologies for HRS in the EU (first version)

Research into permitting requirements (ii)

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Main highlights:

- In most countries, no specific HRS regulation is found:
  - Conventional refuelling stations regulation + hydrogen safety in industry regulation
  - Conventional refuelling stations regulation + CNG regulation

- Placement of hydrogen dispenser next to other fuels (same island):
  - Allowed: DE, FR (as long as 5 m safety distance is respected)
  - Forbidden: ES
  - Not mentioned in regulation but often not allowed: AT

- Safety distances around and within the station:
  - Result of risk assessment exercise
  - Prescribed by regulation – unclear how they are defined

- D1.2 – Permitting requirements and risk assessment methodologies for HRS in the EU (first version)
- Ongoing work throughout the whole duration of the project to publish the final version

Thank you for participating!

Next steps:

- Workshop report will be sent on the 1st February
- Feel free to provide feedback on the document until the 8th February
- Should you have any other feedback: info@multhyfuel.eu
- Stay tuned at https://multhyfuel.eu/

Thank you for your attention!

info@multhyfuel.eu

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