PRHYDE

Protocol for heavy-duty Hydrogen refuelling

Deliverable D2.6

Requirements for a future refuelling protocol

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R E P O R T

Disclaimer

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TABLES

Acronyms and Abbreviations

BPCS	Basic Process Control System
CHSS	Compressed Hydrogen Storage System
FC	Fuel Cell
FCEV	Fuel Cell Electric Vehicle
HAZOP	Hazard and Operability Study
H_2	Hydrogen
H70	Indication for 70 MPa NWP hydrogen fuelling as defined in ISO 17268
HD	Heavy Duty
HP	High Pressure
HRS	Hydrogen Refuelling Station
HSSE	Health, Safety, Security and Environmental
IEF	Initiating Event Frequency
IrDA	Infrared Data Association
ISO	International Organization for Standardization
LD	Light Duty
LOPA	Layer of Protection Analysis
LP	Low Pressure
MAWP	Maximum Allowable Working Pressure
MD	Medium Duty
MVC	Measurement Validation and Comparison
NWP	Nominal Working Pressure
OEM	Original Equipment Manufacturer
OTV	On Tank Valve
PAER consequences	Incident consequences for People, Assets, Environment, and/or Reputation
PFD	Probability of Failure on Demand
PLC	Programmable Logic Controller
PRV	Pressure Relief Valve
PRR	Pressure Ramp Rate
SOC	State of Charge
TBC	To Be Confirmed
TPRD	Thermally-activated Pressure Relief Device

Executive Summary

This document gives engineering requirements for a protocol for gaseous refuelling of heavy duty vehicles to meet (mandatory requirements) as well as further recommendations (considerations, targets). It is based on the scope of the PRHYDE project, external input from the surveys conducted in the context of the first PRHYDE workshop and an analysis of deliverables D2.1-D2.5. Also, previous experience in developing refuelling protocols, brought in by the consortium members, has provided valuable input into the requirements.

This report also contains a description of the envisioned scope and output of this project and its limitations, in order to clearly focus and deliver useable results.

The requirements have been put into following categories:

- safety requirements
- scope requirements
- performance requirements

Additionally, a section on requirements towards the standardization was added, as it was noticed that several practical issues can only be addressed at the standardization level that will require harmonization with a number of existing or yet-to-be-developed standards. It is the intent to disseminate these additional requirements to the public, with specially targeting the standards development organization that will carry the results of this project further, most likely ISO.

1 INTRODUCTION, MOTIVATION AND METHODOLOGY

This deliverable serves to describe the requirements towards a refuelling protocol that the PRHYDE project will deliver. The basis of these requirements are the project objectives, but also the previous deliverables of work package (WP) 2, in which the current state of the art is analyzed and feedback from the wider industry is gathered and condensed into functional requirements.

It is recognized that there were a number of developments in the industry since the call was first written and the objectives formulated. The state-of-the-art analysis shows that there are basic solutions to address short term needs published or under advanced development in both SAE (H70, boundary conditions for H35), JPEC(H70) and CEP(H35HF). These short-term needs include e.g. filling busses and medium duty vehicles to H35 and H70 within the boundaries that the current hardware offers. Mentioned solutions, however, offer low performance (longer duration, non-optimized) fills that do not meet the required performance targets (see PRHYDE deliverable D2.1[1]) due to the underlying assumptions and limitations. Already existing protocols offer low performance (long duration) fills and it is not seen feasible to further speed those up based on their underlying approach, as well as philosophy followed.

From the consortium's perspective, there is no industry initiative that would have a comparable in-depth understanding of the state of the art of refuelling protocols and their shortcomings in terms of optimization and overall approach. Consequently, this project is uniquely positioned to define and excel in establishing a universal, public, and safe high-performance refuelling protocol, which is set as the aim of this project:

"The definition of a future refuelling protocol with more ambitious performance and functional targets, based on advanced communications and covering H35, H50 and H70 fuelling at commercially relevant[2] speeds, as well as extended functionality and flexibility for both the vehicle and station manufacturers." Advanced communications to transmit necessary safety critical information are thought necessary to enable appropriate safety of public filling of heavy duty (HD) vehicles within the performance targets outlined in D2.1.

This project will therefore focus on the « high performance » gap and deliver a protocol based on advanced communications to cover H35, H50 and H70 fuelling at commercially relevant (D2.1) speeds. The risk assessment in WP3 will also determine the possibility of using the PRHYDE approach with existing and future technologies, including communications.

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[1] All public deliverables can be accessed at the PRHYDE website: https://prhyde.eu/

[2] See PRHYDE Deliverable D2.1.

2 REQUIREMENTS FOR A FUTURE REFUELLING PROTOCOL

2.1 Desired Outcome

The desired output of the project is a flexible, advanced H35, H50, H70 protocol for commercially relevant fill speeds (given sufficient station design), based on advanced communications and taking into account flexibility for hardware development on the station and vehicle side.

The protocol will be able to run on a variety of station designs that will ultimately determine the performance, but, critically, gives a proven, safe, and optimized way to fill the applications` CHSS (within the constraints of the physical station design). The validity range of the protocol shall be such, that at least heavy-duty vehicles can be fuelled. An expansion to encompass a wider range of CHSS sizes can be done at any time, also after the project.

There are five main goals to determine a successful outcome:

- fuelling control,
- proof of concept,
- performance benchmark,
- design impact, and
- recommendations for standards organization.

Fuelling Control:

The project will deliver one or several methods of providing the fuelling control that meet the requirements in the document below.

The suggested protocol(s)

- shall clearly state the assumptions and validity ranges. This includes process limits, flexibilities, and target values.
- shall define which parameters are used for initial conditions (ambient temperature, initial pressure,...)

  A list of variables in the fuelling concept will need to be defined as well as where these values are obtained (e.g. sensors, design data, ...)
- shall define how the refuelling rate is established.
- shall define the ultimately responsible party for controlling the fill (station/vehicle) and how the responsibility is assigned and agreed between the two sides of the interface.
- shall describe the conditions under which refuelling is stopped and the means of stopping the fill (e.g. transmitted signals, etc.).
- shall describe process limits related to refuelling control.

- One set of process limits should describe the limits of a successful fill (e.g. reaching 100% SOC, not exceeding the design temperature of the CHSS,...).
- Another set of process limits should describe a means to keep the fuelling conditions in reasonable borders (e.g. abort when the fuelling gets too slow, there is no way to keep within the temp limits, etc.)

- should give considerations on fueling circumstances (intended non-fuelling events, maximum start-up mass), while leaving the requirements on these to further standardization activities.
- **shall be supported by flow charts to show sequence of logic checks and calculations.**

Proof of concept

The PRHYDE project

- shall allow refuelling predictions by simulations by the end of the project.
- shall be able to demonstrate the fuelling concept by field testing at practical/reasonable conditions. The verification of extreme conditions is a nice to have.
- **shall devise a plan and test fuelling concept within the constraints of current technology (run tests using existing hardware and verify simulation results, giving confidence to the models in order to anticipate results with future hardware).**

Specific (quantitative) requirements will be set forth in following sections

2.2 Safety Requirements

One key requirement for a future refuelling protocol is to ensure a save refuelling process. Table 1 lists the key safety requirements and process limits.

Table 1: List of Safety Requirements/Process Limits

ID	Title	Priority	Requirement	Comment
Safety_001	Overall	Mandatory	Protect station, vehicle, and customer from damage	Qualitative but this may be the only one allowed
Safety_002	Maximum CHSS density	Target	Prevent fuelling above 100% SOC	-
Safety_003	Maximum safe CHSS density	Mandatory	The safety stop shall be set at max. 115.0% SoC (to be confirmed by the risk assessment in WP3)	-
Safety_004	Maximum CHSS allowable working pressure	Mandatory	$P_{vehicle} \leq$ 125% NWP (H70: 87.5 MPa, H50: 62.5 MPa, H35:43.75 MPa)	-
Safety_005	Maximum CHSS temperature	Mandatory	$T_{vehicle} \leq$ 85°C for CHSS certified to GTR 13	-
Safety_006	Maximum CHSS temperature flexibility	Target	Allow $T_{vehicle} >$ 85°C for CHSS rated above GTR 13 temperatures	-
Safety_007	Ambient temperature range	Target	Prevent refuelling if -40°C $\leq T_{amb} \leq$ 50°C is not met	-
Safety_008	Minimum fuel delivery temperature	Mandatory	-40°C $\leq T_{fuel}$	-
Safety_009	Maximum fuel delivery temperature	Target	$T_{fuel} \leq$ 50°C (to be confirmed by the risk assessment in WP3 for applications today)	-
Safety_010	Minimum initial CHSS pressure	Target	Prevent refuelling if 0.5 MPa $\leq P_{initial}$ is not met	-

ID	Title	Priority	Requirement	Comment
Safety_011	Maximum peak flow rate	Target	For the newly developed nozzle/receptacle connection, which is to be used for HD applications: H35: Flow rate ≤ 300 g/s* H50: Flow rate ≤ 300 g/s* H70: Flow rate ≤ 300 g/s (* to be confirmed by the risk assessment in WP3) The peak flow rates are to be linked to the nozzle/receptacle connection (e.g. 60 g/s if a LD nozzle/receptacle is used), the protocol shall give a safe option based on precooling and flow limitations.	Impacts other standards

2.3 Scope Requirements

Different “Nice-to-Have” (targets and considerations) and “Must-Have” requirements (mandatory) with regard to the scope of the future refuelling protocol are listed in Table 2.

Table 2: List of Scope Requirements

ID	Title	Priority	Requirement	Comment
Scope _001	Tank capacities	Target	Cover wide range of MD/HD Tank Capacities: 10 – 120 kg	-
Scope _002	Reaction to changing pre-cooling	Target	Allows for the modification of fueling rate as pre-cooling temperature changes	Qualitative
Scope _003	Reaction to station design	Target	Protocol must allow for a flexible fueling rate, based on the station design	Qualitative
Scope _004	Pressure levels	Manda-tory	Refuelling solutions for H35, H50 and H70 applications	-
Scope _005	Protocol variables	Target	Protocol must allow for variables to be input, in order to be flexible for design intent. This can e.g. be achieved by having station side and vehicle side variables that can tweak the overall optimization of the resulting	Qualitative

ID	Title	Priority	Requirement	Comment
			protocol. On the vehicle side these can be e.g. T_{final} tables, on the station side these can be variables representing precooling capacity, HP storage capacity, etc. Examples: • Allow designs focusing on meeting fossil parity criteria. • Allow designs focusing on fastest possible filling under safe conditions. • Allow designs focusing on particularly hot/cold climate, e.g. a station that works in moderate climate can be designed to -10 to +30°C and will not need to cover the entire possible range.	
Scope _006	Station side pressure consideration	Conside r-ation	The protocol shall allow for station designs that have onsite stored pressure lower than the pressure class of allowed vehicles, i.e. using direct compression filling to finish the fuelling event.	-
Scope _007	No corridors	Conside r-ation	The protocol shall not prescribe a temperature window or a PRR corridor	-
Scope _008	Ambient conditions	Target	The protocol shall be able to take into consideration the ambient conditions	-
Scope _009	Design envelopes	Target	Performance based upon actual station and vehicle criteria and not based upon worst case vehicle assumptions	Qualitative
Scope _010	Future proofing	Conside r-ation	Must allow for future development of technology, both on vehicle-side and station-side, including: • advancing CHSS designs (e.g. non-cylindrical tanks, changes in conductivity, Type V tanks, etc.) • different station side component designs (e.g., nozzle) and higher flow rates • non-constant temperature precooling (e.g. station side precooling curves/functions, such as expansion turbine cooling)	Qualitative

ID	Title	Priority	Requirement	Comment
			• a mix of vessel sizes, forming a CHSS on the vehicle shall be possible • type V tanks and other vessels with other thermodynamic properties	
Scope _011	Advanced communi-cations	Conside r-ation	The protocol must adopt advanced communications input	Qualitative
Scope _012	Communi-cations design assumption	Conside r-ation	The protocol shall assume advanced, bi-directional and secure data communication is available	-
Scope _013	Target CHSS temperature	Target	The protocol shall take into account the possibility to fill to higher CHSS design temperatures than 85°C (where it can be shown that the CHSS is indeed designed to >85°C)	-
Scope _014	Design margins	Conside r-ation	The protocol shall make better use of existing tank temperature and design margins	-
Scope _015	Future proofing II	Conside r-ation	The protocol shall make it possible to use technical improvements on the CHSS for performance improvements (higher filling speed, more relaxed precooling, etc.) by utilizing the design information of the vehicle	Qualitative
Scope _016	Testing and validation	Conside r-ation	The protocol should be developed together with a validation document that it can be tested against	-
Scope _017	Consecutive fuelling	Target	The protocol shall include a safeguard for consecutive refuelling at different pressures	Qualitative
Scope _018	Unsafe pressure gradient lockout	Manda-tory	A refuelling point shall not be able to fill a lower pressure rated vehicle, i.e. H70 shall not be able to fill an H35 NWP vehicle	-
Scope _019	Safe pressure gradient support	Target	A refuelling point shall be able to safely fill a higher rated vehicle where a connection is possible. NOTE: H70 T_{final} tables can be used to safely refuel a vehicle to H35, in a non-optimized way, should the approach use T_{final} tables.	-
Scope _020	No precooling	Conside r-ation	The protocol shall offer a way to conduct a refuelling without precooling (e.g. during a precooling system failure)	-

ID	Title	Priority	Requirement	Comment
Scope_021	Flow metering	Conside-ration	Should the protocol rely on accurate flow metering, the accuracy of the flow meter must be known, implemented and the meter available	-
Scope_022	Early target	Target	The protocol shall allow for early termination of the fill based on a target vehicle SOC different to 100% SOC, in order to let the user determine the amount of fill (Note: user inputs resulting in less than 100%SOC shall not be recorded as a non-successful fill)	-
Scope_023	Cooling adaptation	Target	The protocol shall allow for a decrease of refuelling performance if cooling drops below the target performance range	-
Scope_024	HP capacity limits	Target	The protocol shall allow for a decrease of refuelling performance if HP capacity is not sufficiently available during the fill	-
Scope_025	Minimizing lookup	Nice-to-Have	minimize the use of lookup tables for fueling parameters, decrease their number where possible	-
Scope_026	H_2 up to ambient temperature	Nice-to-Have	Enable fueling with the hydrogen delivery temperature up to ambient temperatures	-
Scope_027	Vehicle data	Target	Use vehicle tank temperature for active control of the fill	-
Scope_028	Intermediate IrDa	Target	The protocol can allow IrDa input as a transitional approach	-
Scope_029	Complexity	Conside-ration	The protocol should be less complex than the table-based protocols	-
Scope_030	Performance basis	Conside-ration	The protocol should be more performance based and less prescriptive	-
Scope_031	Actual properties	Conside-ration	The protocol should take into account the real thermodynamic CHSS properties	-
Scope_032	Validity range and scope	Conside-ration	The protocol introduction (in the standard) should be very specific when describing scope and validity range	-
Scope_033	Vehicle control consideration	Conside-ration	The protocol should evaluate the vehicle controlling the fill, and document any decisions around that	-

ID	Title	Priority	Requirement	Comment
Scope _034	Size match	Consideration	The protocol should offer a way to match small stations to vehicles with large CHSS and provide information about the possible fill	-
Scope _035	Desired amount	Target	The protocol should allow for setting a target fill amount (e.g. 10 €, 50% SOC, 25 kg, etc.), in addition to 100%SOC target	-

2.4 Performance Requirements

Although the project partners are aiming to have an universal equation to describe all combinations of pressure class, tank volume, fuel delivery temperature, hardware spec, etc., the first year of PRHYDE project has provided internal preferences and feedback from external, which allows to narrow which combinations are most interesting, hence which combinations we should set a performance requirement (see Table 3).

Table 3: List of Performance Requirements

ID	Priority	Requirement	Comment
Performance_001	Mandatory	Fuelling simulations for H35 fills according to section 3 shall be possible within the performance targets	-
Performance_002	Mandatory	Fuelling simulations for H70 fills according to section 3 shall be possible within the performance targets. Benchmark is the 80 kg in 10 min fill.	-
Performance_003	Target	Protocol needs to minimize refuelling time, given the constraints it has to deal with, e.g. by returning the flow limit at which 100% SOC can still be met or another limit the protocol runs into	-
Performance_004	Target	Protocol must allow the station to achieve 95-100% SOC repeatedly and consistently, based on the protocol architecture and information that the protocol is fed by the vehicle and station	-
Performance_005	Target	Where a station is designed for high pre-cooling levels, such as T40, the protocol must deliver better refuelling times that table based protocols, such as SAE J 2601	-

ID	Priority	Requirement	Comment
Performance_006	Consideration	Where a station is designed to meet comparable refuelling times to a station running table-based protocols, the protocol must achieve more relaxed precooling conditions	-
Performance_007	Consideration	The protocol must allow for cheaper station design by allowing for a more relaxed precooling temperature handling compared to the T-classes to date	-
Performance_008	Target	The protocol must differentiate between type III and type IV tanks as a minimum and ideally be based on real thermodynamic CHSS data, and materialize on the refuelling time/precooling advantages	-
Performance_009	Target	The protocol shall allow for using different precooling temperatures, depending on ambient conditions, e.g. less precooling in winter, possibly steered by a target refuelling time	-

2.5 Requirements towards the Standard

Finally, Table 4 lists the requirements for translating the developed protocol into a standard.

Table 4: List of Requirements towards the Standard

ID	Title	Priority	Requirement	Comment
Standard _01	Out of bounds response	Manda-tory	The standard must define actions taken, if the refuelling parameters are exceeded by a defined margin for a defined time	
Standard _02	Exceeding process requirements	Consider-ation	Have means of terminating fuelling within 5 seconds if process requirements are exceeded	
Standard _03	Deviating process requirements	Consider-ation	Have means of mitigating fueling within 5 seconds if process requirements are deviated by an allowable amount	
Standard _04	Maximum initial CHSS pressure	Consider-ation	In non-communication events, $P_{initial}$ < NWP dispenser	

ID	Title	Priority	Requirement	Comment
Standard _05	Maximum peak flow rate	Target	For the newly developed nozzle/receptacle connection, which is to be used for HD applications: H35: Flow rate ≤ 300 /s* H50: Flow rate ≤ 300 g/s* H70: Flow rate ≤ 300 g/s (confirmed) (* to be confirmed by risk assessment in WP3) The peak flow rates are to be linked to the nozzle/receptacle connection (e.g. 60 g/s if a LD nozzle/receptacle is used)	
Standard _06	Maximum mass of hydrogen allowed during startup	Target	Total H_2 mass prior to start of fueling < X g (to be determined)	
Standard _07	Cycles per fueling	Target	Maximum number of 10 on/off cycles (below 0.6 g/s) per fuelling, including leak checks	
Standard _08	CHSS range	Target	Initial validation range for the protocol shall be: 250 L (10 kg at H70) ≤ CHSS Capacity ≤ 3000 L (120 kg at H70)	
Standard _09	Miscom-munication	Consider-ation	The protocol risk assessment shall cover the risk of receiving (electronically) incorrect vehicle data (e.g. due to malfunction of a CHSS OTV, making the CHSS smaller than anticipated)	
Standard _10	Communi-cations	Consider-ation	The protocol must allow for the data-based, secure transmission of the CHSS tank size	
Standard _11	Share of responsibilities	Target or Consider-ation	The protocol shall clearly define the responsibilities of vehicle / fuelling station for the process. If, e.g., vehicle data is used for process control by the fuelling station, it shall be clearly defined for which purpose the data is used and which safety requirements (e.g. ASIL level) arises from that.	

ID	Title	Priority	Requirement	Comment
Standard _12	No freeze on	Consider-ation	The protocol shall identify a way to prevent (or resolve) freeze-on issues, e.g. by flowing warm hydrogen for last part of the fill	
Standard _13	Station performance rating	Consider-ation	Station performance ratings need to be developed, e.g. a “gold star” or “silver star” station rating could be used	
Standard _14	Nomenclature	Manda-tory	The protocol shall be named independent of its intended field of use (e.g. “heavy duty vehicles”, “trucks”, “road transport”, etc.) for future possibility to expand scope without running into title issues	
Standard _15	Startup sequence	Target	The startup sequence shall not bring the CHSS over the temperature assumptions in modelling (in case dynamic data is not transferred)	
Standard _16	Protocol standard	Consider-ation	The protocol shall be (co-)developed according to a protocol development standard (Note: this is relevant only during standardization, which will follow after the completion of the PRHYDE project and is outside the scope of PRHYDE)	

3 BASE CASES FOR CALCULATING PERFORMANCE OF A SAMPLE STATION RUNNING THE PRHYDE PROTOCOL - PROTOCOL PERFORMANCE TARGETS

3.1 Vehicle Sizes

Deliverable D2.1 Table 1 examined different vehicle segments, including road, rail, and sea-based transportation. The work package members estimated the CHSS capacity, fueling times, and average flow rate for each of these segments. However, the PRHYDE partners agreed to focus validation of the initial protocol on road transportation, and, specifically, the vehicle segments listed in Table 5 below.

Table 5: Generic use cases and estimations for associated refuelling performance metrics as a benchmark for hydrogen refuelling (from PRHYDE Deliverable D2.1 Report)

Vehicle segment	CHSS capacity [kg]	Fuelling time [min]	Corresponding max. anticipated average H_2 flow [kg/min]
N2 - commercial vehicle	10-40	10	4
N3 - commercial vehicle	40-80	10	8
M2 - passenger carrier	10-40	8	5
M3 - passenger carrier	30-100	12	8

3.2 Station Sizes

Estimated station sizes and required compressor capabilities suggested for the three different pressure classes are listed in Table 6.

Table 6: Estimated station sizes and capabilities

Station Size	Pressure Class	Total HP Storage (@95MPa, ton)	Compressor Capability [kg/min]
Small	H35	0.5	2
Small	H50	0.5	2
Small	H70	0.5	2
Medium	H35	1	4
Medium	H50	1	4
Medium	H70	1	4
Large	H35	2	6
Large	H50	2	6
Large	H70	2	6
X-Large	H35	3	8
X-Large	H50	3	8
X-Large	H70	3	8
XX-Large	H35	4	10
XX-Large	H50	4	10
XX-Large	H70	4	10

3.3 Reference Fuelling Conditions

The PRHYDE partners agreed on a reference fuelling case for H35, H50, and H70. The performance targets will be based upon the conditions listed for each main pressure class in Table 7 below. The reference conditions are based upon the starting and ending conditions of the CHSS, as well as the ambient temperature because it has a strong impact on fueling time.

Table 7: Reference fuelling conditions

Baseline	Initial Pressure [MPa]	SOC	$T_{ambient}$ [ºC]
H35	5	100%	15
H50	7.5	100%	15
H70	10	100%	15

Since fuelling times can slow down significantly during hot days, the PRHYDE partners also introduced and considered a "Hot Case" where the ambient temperature is at 35ºC. The fueling protocol(s) will not be judged against this Hot Case, but it adds another reference condition to compare fueling times under conditions which could significantly impact users.

Table 8: Hot case reference fuelling conditions

Baseline	Initial Pressure [MPa]	SOC	$T_{ambient}$ [ºC]
H35 Hot Case	5	100%	35
H50 Hot Case	7.5	100%	35
H70 Hot Case	10	100%	35

Table 9 gives recommendations for multi-tank testing. The minimum Kv values given there must be used for simulations and for testing.

Table 9: Recommended minimum fuelling line Kv value

	Multiple Tank Testing
H35	0.46
H50	0.49
H70	0.53

Note: These recommended Kv values above are assumed for the entire line and therefore the Kv values of the receptacle and nozzle and other components in the fueling line should be higher than these values.

3.4 Target Fueling Times

The fill target and average flow rates are estimated based on the CHSS capacity and target fill times from Section 3.1 and the reference condition listed in Section 3.3. The CHSS capacity for the H70 pressure class is the largest CHSS capacity for the vehicle segment inTable 5. The CHSS capacity for the H50 pressure class is 75% of the H70 CHSS capacity, and H35 pressure class is 50% (see Table 10).

Table 10: Estimated fuelling times based on reference conditions

Vehicle Segment	Pressure Class	Max CHSS Capacity [kg]	Fill Target [kg]	Target Fill Time [min]	Average Flow [kg/min]
N2	H35	20	17	10	1.7
N2	H50	30	26	10	2.6
N2	H70	40	34	10	3.4
N3	H35	20	17	10	1.7
N3	H50	30	26	10	2.6
N3	H70	40	34	10	3.4
M2	H35	20	17	8	2.1
M2	H50	30	26	8	3.2
M2	H70	40	34	8	4.3
M3	H35	50	43	12	3.6
M3	H50	75	64	12	5.3
M3	H70	100	86	12	7.1

The comparison of the station sizes to the target fueling times in Section 3.2 shows that the smallest station can meet the fuelling times and average flow rates of the smallest vehicles with the lowest pressure classes. The largest stations can meet the requirements of the largest vehicles.

Performance simulation shall take into account back-to-back filling and evaluate the station performance with non-full HP storage buffers. Also, a run with depleted (empty) HP storage buffers shall be considered. This can also be used to assess the capability of the protocol to control direct fills.

What is PRHYDE?

With funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (FCH 2 JU), the PRHYDE project is aiming to develop recommendations for a non-proprietary heavy duty refuelling protocol used for future standardization activities for trucks and other heavy duty transport systems applying hydrogen technologies.

Based on existing fuelling protocols and current state of the art for compressed (gaseous) hydrogen fuelling, different hydrogen fuelling protocols are to be developed for large tank systems with 35, 50, and 70 MPa nominal working pressures using simulations as well as experimental verification. A broad industry perspective is captured via an intense stakeholder participation process throughout the project.

The work will enable the widespread deployment of hydrogen for heavy duty applications in road, train, and maritime transport. The results will be a valuable guidance for station design but also the prerequisite for the deployment of a standardized, cost-effective hydrogen infrastructure.

Further information can be found under https://www.prhyde.eu. For feedback on the PRHYDE project or the published deliverables, please contact info@prhyde.eu.

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