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CEP Requirements for Hydrogen Refuelling Stations fuelling at Ambient Temperature

Dear Madam, Sir,

The development of a hydrogen society is taking momentum. It becomes more and more evident that hydrogen will play an important role towards decarbonisation of transport and will contribute to the economic recovery in many countries. Hydrogen has a significant advantage compared to electricity as it can be transported and stored in large quantities over long time periods. Therefore, all kinds of fuel cell electric vehicles such as passenger cars, trucks, buses and light commercial vehicles have been deployed in Europe during the last years.
Obviously, in order to solve the chicken and egg problem, these vehicles will need to be fuelled at hydrogen refuelling stations (HRSs) that are currently being developed and deployed by many HRS manufacturers.
For passenger car vehicles, most of these HRSs are fuelling the vehicles at 70 MPa and at a temperature of -33°C to -40°C to meet the customer requirement of fast fuelling.
However, the CEP has noticed that more HRSs are being deployed at lower pressures (35 MPa) and fuelling at ambient temperatures because they are much cheaper to produce.
CEP recognizes that some customers are willing to purchase such kind of stations. As there is no available standard at this moment to fuel at ambient temperature, the CEP has set up a list of requirements to ensure safe and reliable fuelling of vehicles from Audi, BMW, Daimler, Honda, Hyundai and Toyota. See next pages for the requirements and the reason why these requirements were set in place.
As CEP we all wish you a good and prosperous hydrogen future.

Best regards

Clean Energy Partnership (CEP)

Jörg Starr
(Chairman)

Rev 1.2

1. Requirements for fuelling passenger car FCEVs using ambient temperature fuelling stations

#	Requirement	Background
1	Buffer fuelling according to SAE J2601(2010) for non-comm fuelling and Toyota/CEP H35 protocol for comm fuelling	The old D35 table from SAE J2601(2010) is possible to use, but fuelling is slow. The Toyota/CEP protocol provides faster fuelling at H35, but works only with communication fuelling See next page for the Toyota/CEP H35 protocol.
2	Maximum 10x opening and closing of the check valve during one refuelling.	This is the same requirement as SAE J2601 and mandatory in Europe as it is part of EN17127.
3	Hydrogen flow <60 g/s	This is the same requirement as SAE J2601 and mandatory in Europe as it is part of EN17127.
4	<85°C inside each tank	This is the same requirement as SAE J2601 and mandatory in Europe as it is part of EN17127.
5	Max 100% $SOC_{vehicle}$	This is the same requirement as SAE J2601 and mandatory in Europe as it is part of EN17127.
6	End pressure target= <100%SOC	If the station stops at P_{target}, it should stay below 100% SOC
7	Nozzle with IR communication	For H70 this is already mandatory as EN17127. For H35, the CEP also requests a communication nozzle, even if the fuelling is according to non-comm table D35 from SAE J2601(2010). This will enhance safety as the vehicle is able to send an abort signal towards the station in case something goes wrong.
8	Minimum ramp rate: >1MPa/min	This is also the stance from SAE J2601 as of 2014. Below 1MPa/min there is a chance for chattering of the check valves.
9	Use “flow and pause” approach in case of compressor fuelling.	In case you use direct compressor fuelling and >1 MPa/min cannot be reached, use a “flow and pause” approach. See figure1 on next page.
10	Pressure pulsation <±0.5 MPa/s	During the flow it is possible that there is a pressure pulsation towards the tank. This pulsation should be limited to <±0.5 Mpa/s to prevent impact of the check valve to its seat.

11	Prevent overheating due to consecutive fuelling of dual pressure stations	If your station has a dispenser of both H35 and H70 fuelling, there is a chance that the customer might fuel first at 35MPa and after that fuel at 70MPa. At the end of the first 35MPa fuelling there is a chance that the tank temperature is too high to start a H70 fuelling. This should be avoided.
12	H_2 quality according to EN 17124	This is mandatory in Europe as it is part of the Directive of Alternative Fuel Infrastructure.

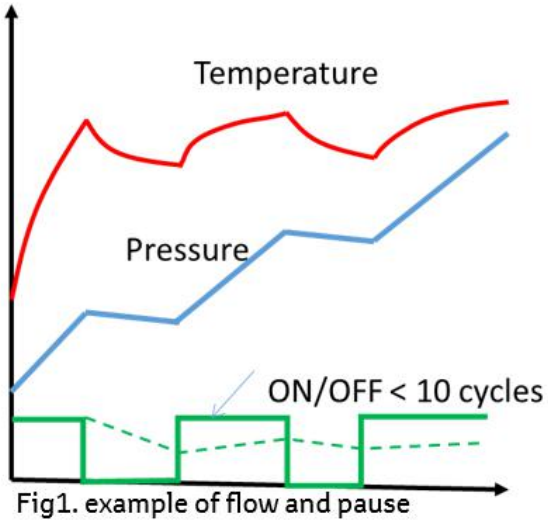

Fig1. example of flow and pause

2. Usage of H35 T_{amb} protocol from Toyota/CEP

Using the SAE J2601(2010) D35 table provides you with the possibility to fuel a passenger car vehicle with a tank size of up to 10 kg at ambient temperature. The ramp rate is however very slow and therefore fuelling time can be quite long. 20 minutes or longer is not an exception.
Using the Toyota/CEP protocol, the fuelling time can be reduced considerably. Continuous monitoring of the IR signal is however necessary to perform safely, and the initial tank temperature will need to be taken into account before fuelling the vehicle.
Below is shown a comparison table between SAE J2601(2010) D35 table and the Toyota/CEP H35 table. The orange area is out of scope of the CEP approval and not recommended, unless you use a pause and flow approach with where the flow never goes below 1 MPa/min. This will result in limitations if you fuel at high ambient temperatures:
SAE J2601(2010) D35 table: T_{amb}^{max} = 28.7°C
Toyota/CEP H35 table: T_{amb}^{max} = 44.1°C

$T_{ambient}$	SAE protocol	Toyota protocol		
	APRR	APRR	Max average flow rate	$T_{ini}CHSS_{max}$
45 °C	0.3 MPa/min	0.9 MPa/min	60 g/min	45 °C
40 °C	0.5 MPa/min	1.5 MPa/min	100 g/min	40 °C
35 °C	0.7 MPa/min	1.6 MPa/min	110 g/min	40 °C
30 °C	0.9 MPa/min	2.0 MPa/min	130 g/min	36 °C
25 °C	1.3 MPa/min	2.5 MPa/min	170 g/min	33 °C
20 °C	1.8 MPa/min	3.1 MPa/min	210 g/min	30 °C
10 °C	3.4 MPa/min	4.3 MPa/min	290 g/min	25 °C
0 °C	6.4 MPa/min	7.5 MPa/min	510 g/min	15 °C
-10 °C	10.4 MPa/min	-	-	-
-20 °C	15.1 MPa/min	-	-	-
-30 °C	15.1 MPa/min	-	-	-
-40 °C	15.1 MPa/min	-	-	-

Note

1. Station type: H35 Non-precooling
2. Initial pressure: 0.5MPa MIN
3. Target pressure: 35MPa MAX
4. Maximum flowrate: 60g/sec
5. Cyclic control: 10 times max per a fueling of under 0.6g/sec
6. No top-off fill at H70 station within 60minutes
7. No fill over 44.1°C ambient, below -40C
8. Fueling shall be controlled by APRR (Average Pressure Ramp Rate) or Flow rate shown above table.

3. Slow Filling and Ambient Temperature Stations Fuelling Light Duty Vehicles

In order to have an ambient temperature station being approved by the CEP,
it shall meet the CEP requirements mentioned above in chapter 1
The H2 quality shall meet the EN 17124 standard
The connection shall meet the EN ISO 17268 standard

AND

PUBLIC HRS*	NON-PUBLIC HRS*	
Fuelling protocol complies with EN 17127, therefore: - FAT report of each station type - SAT report of each station	Request approval from the OEMs of each vehicle that fuels at that refuelling point (This is obviously **not** a CEP approval, but you can get approval from some OEMs.)	Trilateral agreement between HRS manufacturer/operator, CEP and CEP recognized 3rd party. (e.g. TÜV-SÜD, Bureau Veritas, … TBC)
	Details of report and tests to be performed will be discussed with each individual OEM.	Details of report and tests to be performed will be discussed with 3rd party.

*Definition of public station in AFIR: (38) 'publicly accessible' alternative fuels infrastructure, means an alternative fuels infrastructure which is located at a site or premise that is open to the general public, irrespective of whether the alternative fuels infrastructure is located on public or on private property, whether limitations or conditions apply in terms of access to the site or premise and irrespective of the applicable use conditions of the alternative fuels infrastructure;