Hydrogen Station Equipment Performance Device (HyStEP Device) Specification

Overview

Policies and technology solutions need to be developed and implemented to help reduce the time from when a new hydrogen station is completed to when the station has been approved by all of the fuel cell electric vehicle OEMs for customer fills. The current practice of station acceptance, which burdens vehicle OEMs with serial testing of stations because each OEM conducts their own testing and evaluation, can take months. This process is not practical or sufficient to support the timely development of a hydrogen fueling station network. This is especially true in the state of California where new stations are coming online currently and as many as 35 new stations are scheduled to be commissioned in the next year and half.

Ultimately, a hydrogen station test device that can be used to verify station fueling protocol according to the SAE J2601 standard, average daily and peak fueling capacity, and fuel quality would be desirable to commission new stations. In the near-term, a test device designed specifically to test station fueling protocol that is technically effective, safe, robust, and user friendly will accelerate the commissioning of CA stations. This device must be safe and robust enough to survive travel from station to station to be useful, but also simple enough to design, fabricate, assemble and implement quickly to meet the CA timetable. This project aims to develop such an alpha version device within six months of contract award, with the option to allow for later expansion to enable additional capabilities.

This device will initially include one or two Type IV 70 MPa tanks capable of storing a total of 4-7 kg H_2. The tank(s) will have a thermal pressure relief device and will be instrumented with pressure and temperature sensors. The tank will be connected to a 70 MPa receptacle equipped with pressure and temperature sensors and will have IrDA communications capability. All will be integrated with a data acquisition, analysis, and control system. A valve near the receptacle attached to a vent manifold will be used to both simulate a leak for fault detection tests and for controlled defueling. Additional temperature sensors will record ambient temperature near the receptacle and various external system temperatures.

The station test device will be capable of performing key tests defined in CSA HGV 4.3. These include IrDA communication tests, fault detection tests, and communication and non-communication fills at 70 Mpa (H70). Additionally, the device must be capable of carrying out communication and non-communication fill tests at 35 MPa (H35). All test parameters listed in HGV 4.3 Table I will be provided in an easily accessible data file.

Overall System Requirements

SAE J2601 includes fueling in ambient conditions from -40C to +50C and gas fueling temperature between -40C and +85C. The pressures for fueling are up to 87.5MPa or 1.25x NWP. However, as this is a test device to ensure the fueling meets SAE J2601, fault conditions may occur and the tank should therefore be rated above this maximum fueling limit. The tank(s) rating should follow SAE J2579 which includes cycling validation at a temperature range of -40 C to 85 C, testing up to 1.5X nominal working pressure (NWP) of 70 MPa, and a minimum 2.25X NWP burst pressure.

The following system requirements for the station test device apply to the entire system with the exception of the hydrogen storage tank(s)

Table 1: System Requirements

	Required
MAWP (MPa)	96.6
Ambient Temperature Range (°C)	-40 to 50
Tank Gas Temperature Range (°C)	-45 to 85
Maximum Flow rate (g/s)	≥ 60
Receptacle to Tank Pressure drop (MPa)*	≤ 20 (15 to 20 preferred)

* This pressure drop is defined according to J2601 as: When tank pressure is 10 MPa and fuel temperature is -15°C at the nozzle and mass flow is 1.5 x the average mass flow to fill the storage volume in 3 minutes

Primary Component List

- Type IV 70MPa rated tank(s) compliant with SAE J2579 with a H_2 storage capacity in the 4-7kg range (preferred 4.5-6.5 kg range). A single large tank is preferred.
    - (Option) Provide flexibility in the design and configuration of the device for additional tank(s) to be added in the future.
    - (Option) Provide additional tank(s) to allow for back-to-back fills and/or testing in the 7-10 kg range.
- Automotive-type in-tank valve that includes a check valve for fueling, a solenoid valve for defueling, and a thermal pressure relief device (TPRD) is preferred. Equivalent external components are acceptable.
- H70 rated SAE J2600 compatible receptacle
- Vehicle-side IrDA communications capability per SAE J2799
- IrDA control interface with the ability to simulate signals
- Leak valve near receptacle for fault detection tests
- In-line pressure relief valve and shut-off valve
- In-line particle filter (≤ 5μm)
- Vent manifold with flow limiter and interface for connection to station vent stack for defueling
- Standalone vent stack and tubing as alternative to station vent stack

- If the system is enclosed, venting must be provided to prevent the accumulation of hydrogen and a hydrogen leak detector must be mounted within the enclosed space
- Data acquisition and analysis system with minimum sampling frequency of 10 Hz
- Mobile Platform:
    - (Option 1) System should be mounted on a trailer towable by a half ton pickup truck. Trailer suspension must prevent damage to system from shock and vibration.
    - (Option 2) System designed to fit into standard ½ ton, full size pick up bed (4' X'8') inside wheel wells. Recommended maximum dimensions, approximately 36" W X 48"L X 36" H including nozzle receptacle. Must weigh no more than 750 lbs. and lifting and mounting features must be supplied to accommodate lift truck (below) and chain lift (above).
- All systems should be able to withstand road vibrations, wind, rain and other forces associated with transport and field use.
- All electronic systems should be Class 1, Division 2, Group B.

Materials of Construction

All components of the device exposed to hydrogen gas (tubing, fittings, valves, instrumentation, etc.) shall be fabricated from materials compatible with high pressure hydrogen using sound engineering practices. Metal alloys shall be limited the list provided in SAE J2579 Table B2 QUALIFICATION OF HYDROGEN COMPATIBILITY BASED ON USAGE CONDITIONS. This table lists 316 and 316L stainless steel as well as several high nickel content steels and several aluminum alloys. Non-metal parts (seals, valve seats, etc.) shall be screened to ensure performance under the conditions listed in Table 1. Guidance can be found in ISO/PDTR 15916 and NSS 1740.16 from NASA as well as CSA HGV 3.1and HPRD1.

Required Instrumentation

Sensor	Location	Measurement Range	Accuracy
Receptacle Pressure	In-line near receptacle	0 to 100 MPa	0.1% of full scale
Receptacle Temperature	In-line near receptacle	-45 to 100 °C	± 1 °C
Tank Gas Pressure	In-line at tank inlet. Must be representative of pressure inside tank.	0 to 100 MPa	0.1% of full scale
Tank Gas Temperature*	At least one sensor inside tank out of gas flow path. Multiple sensors preferred.	-45 to 100 °C	± 1 °C
Ambient Temperature	External near receptacle protected	-45 to 55 °C	± 1 °C

	from environmental effects		
External Tank Temperature	External mounted to the outside skin of tank with thermally conductive material	-45 to 55 °C	± 1 °C
H2 Flow Rate (Optional)**	In-line between receptacle and tank	1.5 to 75 grams/sec	± 2.5% of reading

* From CSA HGV 4.3: The HDTA shall have at least one tank temperature sensor used to accurately measure the gas temperature in the tank. The sensor shall be installed inside the tank in the same end as the hydrogen supply piping and shall protrude no more than 20 cm (8 in) into the vessel beyond the neck section of the tank. Sensor shall avoid contact with the wall and out of the incoming flow path.
** A hydrogen flow meter should be quoted as an option for the project team to consider

Test Requirements per CSA HGV 4.3

- Will perform Communication Tests 2.2.1 through 2.2.5
  - ABORT test, HALT test, data loss then ABORT, data loss and resumed fueling, and thermocouple fault
- Will perform Fault Detection Tests 2.3.1 through 2.3.3
  - Receptacle leak at start of fueling, high pressure leak during fueling, and full tank refusal
- Will perform Performance Tests 2.4.1 and 2.4.2
  - Communication fill and non-communication fill with Type IV tank under 7kg
- Will not perform Performance Tests 2.4.3, 2.4.4, and 2.4.5

Note: CSA HGV 4.3 is currently undergoing revision to be harmonized with the recently published SAE J2601 standard. Depending on timing, these test requirements may be changed to reference the new HGV 4.3 document.

Data Acquisition, Analysis and Reporting

The data acquisition system (DAQ) shall be designed to provide the test parameters listed in CSA HGV 4.3 Table I. These parameters will be either directly measured or calculated from directly measured quantities and saved in an Excel-compatible file format. The DAQ shall also be designed to accommodate up to 4 additional temperature sensors and 2 additional pressure gauges. A real-time data display capability shall be included that, at a minimum, will display tank pressure and temperature as well as safety-related parameters. An approved DAQ software shall be used that will allow the end user flexibility to modify calculated parameters, automated procedures and/or data acquisition rate.

Parameter	Description	Measured	Calculated
Tamb	Ambient temperature at the dispenser	X	
Pstart	Initial tank pressure	X	

Tstart	Initial tank temperature	X	
Pmax	Maximum observed tank pressure during fueling (average of ≥ 3 points)		X
Tmax	Maximum observed gas temperature in the tank during fueling (average of ≥ 3 points)		X
Fmax	Maximum fuel flow rate (Fuel flow rate will be estimated if a fuel flow meter is not included)	X (optional)	X
SOC	State of charge calculated 5 seconds after the end of fueling		X
FEtime	Fueling duration		X
Ptarget	Target fueling pressure		X
Pend tank	Final tank pressure (average of ≥ 3 points)		X
P5	Tank pressure 5 seconds after end of fueling	X	
GT5	Tank temperature 5 seconds after end of fueling	X	
SOC5	State of charge 5 seconds after end of fueling		X
P30	Tank pressure 30 minutes after end of fueling	X	
GT30	Tank temperature 30 minutes after end of fueling	X	
D30	Hydrogen density in tank 30 minutes after end of fueling		X
SOC30	State of charge 30 minutes after end of fueling		X
Tfuel	Fuel delivery temperature	X	
GT15	Fuel delivery temperature 15 seconds into fueling	X	
APRR15	Average pressure ramp rate (averaged over 15 second intervals)		X
APRRaverage	Overall average pressure ramp rate		X
APRRtarget	Target APRR based on SAE J2601 tables		X
DP	Pressure drop from receptacle to tank		X
PPulse	Initial pressure pulse mass		X

Post processing of the data will be required to verify compliance with SAE J2601 and NFPA 2 leak and hose checks. Data shall be available to verify the following:

Parameter	Definition	Criteria
LC	Leak check at beginning of fill	Verify pause, t < 15 sec.
LCP20	Leak check at 20MPa intervals	Verify pauses and pause times
NFZ	No fueling zone	Tank is not filled if start conditions are in “no fueling” zones of J2601 tables

Ppulse	Number of fueling pauses (≤ 10)	Verify # pauses < 10

Validation Testing

Prior to acceptance, the system shall be tested to ensure operability. The following tests shall be carried out at a minimum:

By the device supplier:

- Leak check: Verify the system is leak tight at 87.5 MPa. Pressure drop shall be less than 10% over a 6 hour hold.
- Fitting tightness check: Torque check on all bolts/fasteners
- Communications check: Verify the IrDA transmitter and control unit operate as expected
- Safety checks: Verify the operation of all passive and active engineered safety controls and document.

Final validation testing of the device will be carried out at the NREL Energy Systems Integration Facility (ESIF). The device supplier shall provide technical support and training on device operation at ESIF for a duration of one week following delivery of the device. The goal of this testing is to verify that it meets the requirements of this specification.

- Testing will be carried out at the ESIF facility with a research dispenser equipped for 70 MPa fueling with -40 C pre-cooling (H70-T40). All of the required tests will be carried out and test procedures will be verified per CSA HGV 4.3. Measured and calculated parameters will be recorded and checked for completeness and accuracy. All required tests will be performed multiple times to satisfy the requirements of a Gauge R&R study.
- The device must complete all of the required tests and produce the required data to be considered acceptable.

Documentation

Documentation shall be included with the device and shall include the following:

- A user manual including operating instructions and a troubleshooting guide will be provided upon completion of the device and prior to final validation testing.
- A maintenance schedule and instructions document will be provided upon completion of the device and prior to final validation testing.
- A final piping and instrumentation diagram that must accurately represent the as-built device
- Dimensioned drawings of the overall system
- An electrical wiring diagram
- The data acquisition software code, description, and instructions for modification
- A report summarizing the results of the HA/FMEA

- An individual component parts list (Bill of Materials) and the manufacturer's documentation (if applicable) for all components
- All component certifications received by the contractor
- Leak and pressure tests of individual components and/or the entire device manifold should be documented and certifications provided.

Training

The device supplier shall provide technical support and training on device operation at NREL for a duration of one week following delivery of the device. Project team members will be trained on the operation of the device including troubleshooting and maintenance. Supplier representative(s) will also support initial H70-T40 tests at ESIF.

Spare Parts

To help ensure maximum up time in the field, the device should be delivered with a minimal amount of common, and if possible, long lead time, wear-related spare parts such as o-rings, valves, etc. Also, a list of specific tools required to repair and/or maintain the device should be included (type of torque wrench, metric tools, etc).

Piping and Instrumentation Diagram

Figure 1 shows a reference P&ID for the station test device. The diagram shows an example configuration with many of the key components required. The supplier shall create their own detailed P&ID diagram during execution of the project.

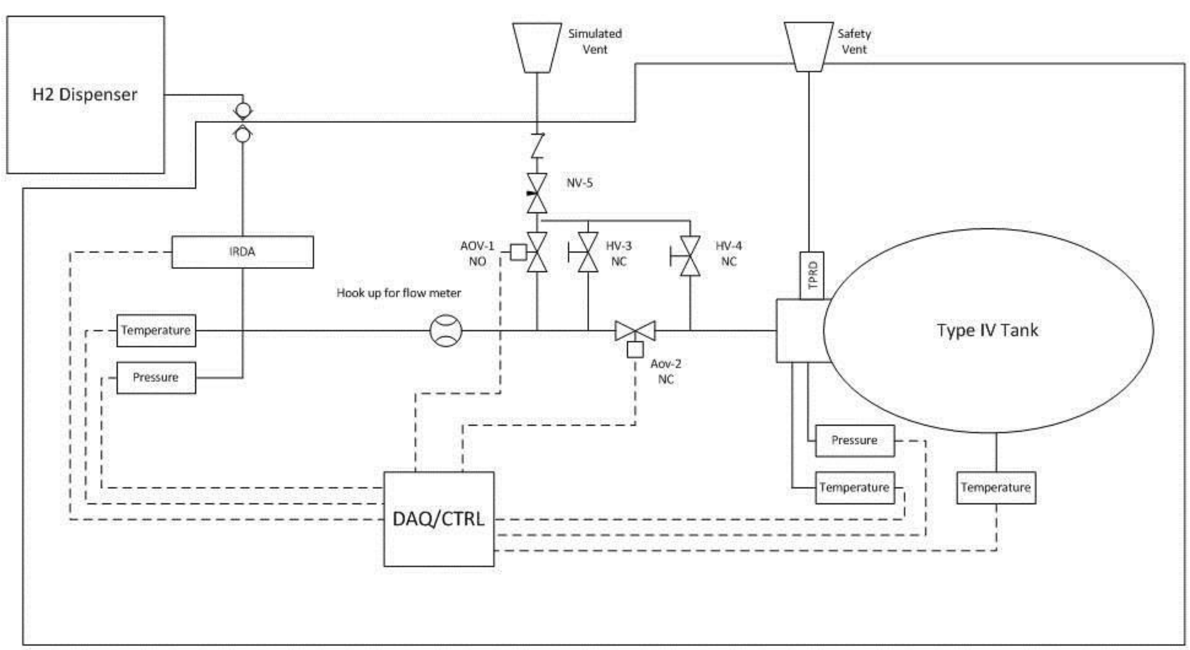

Figure 1. Reference piping and instrumentation diagram.