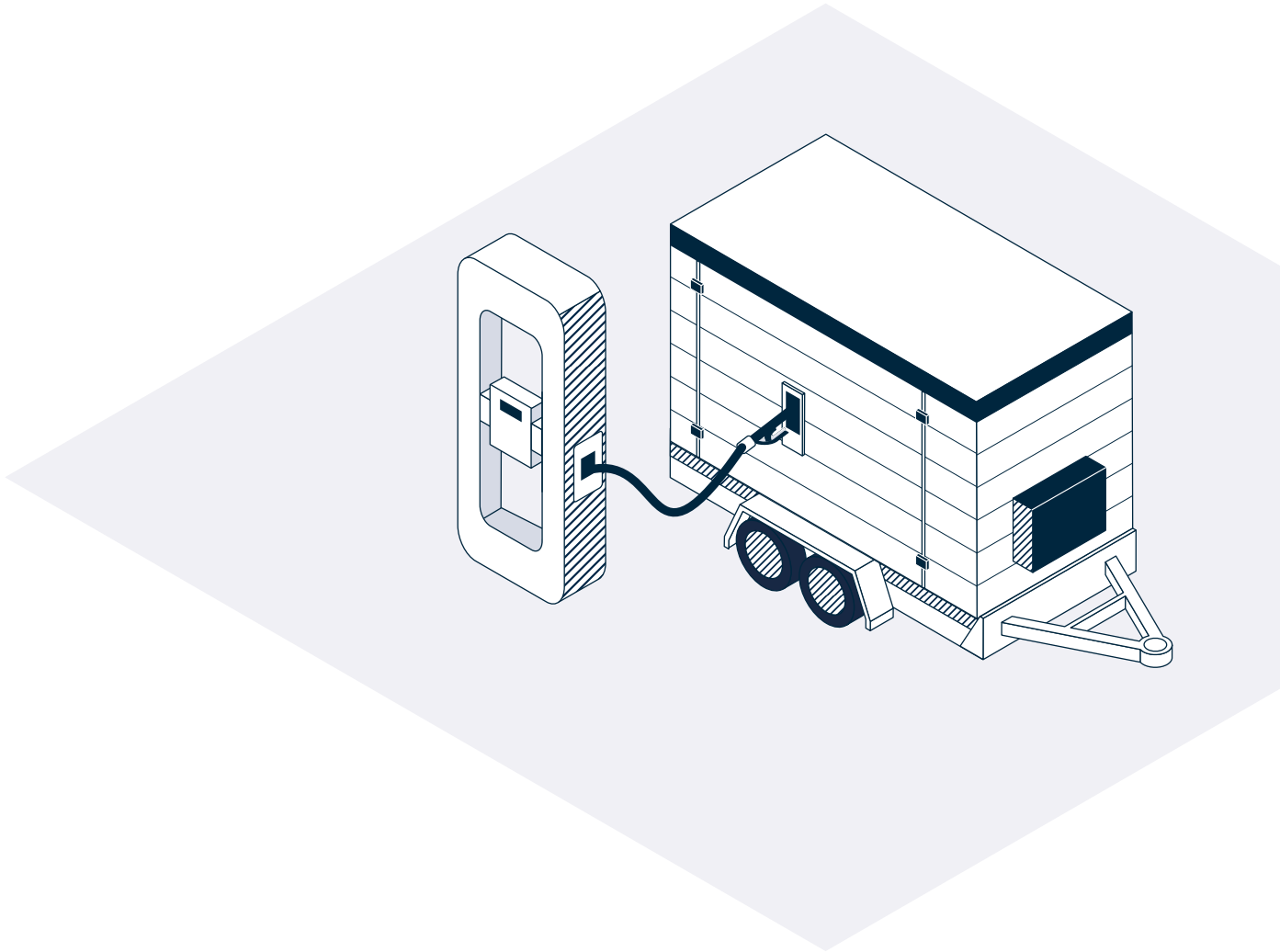
CEP-recommendation for designing test benches according SAE J2601



Contents

List of abbreviations and definitions

ADR	Accord européen relatif au transport international des marchandises Dangereuses par Route - European Guideline
CE	Communauté Européenne - European Guideline
CEP	Clean Energy Partnership
EU	European Union
FMEA	Failure Mode Effect Analysis
FS	Fuelling Station
Fuelling Line	Pipe between receptacle and vessel
HSTA	Hydrogen Station Test Apparatus
IR	Infrared
ISO	International Organization for Standardization
LFL	Lower Flammability Level (for Hydrogen)
NWP	Nominal Working Pressure at +15 °C
Nozzle	Hydrogen Fuelling Device / Pistol at station side
OEM's	Original Equipment Manufacturers (in this content Car Manufacturers) PLC Programmable Logic Controller (SPS)
PRR	Pressure Ramp Rate Receptacle Fuel nipple at vehicle side
shall	Binding requirements that must be satisfied by the contractor SAE Society of Automotive Engineers
SOC	State of Charge
TIR	Technical Information Report (Guideline)
TÜV	Technischer Überwachungsverein (German Technical Inspection Agency) USB Universal Serial Bus

Background

In March 2010 the SAE TIR J2601 was published as first document which set a worldwide guideline for 35 MPa and 70 MPa hydrogen fuelling process.
The use of a test bench for performing approval tests was introduced and requested with ISO 19880-1 and this document is an update and addition with the experiences gained so far. In terms of refuelling tests, the following standards shall be considered: SAE J2601, ISO 19880-1, ISO 19885-1,

The main focus of an HSTA is to simulate different configurations of a hydrogen vehicle fuel system. This includes the nozzle/receptacle mechanical interface as well as the communication interface.
This helps to perform the different approval tests of a fuelling station including the compliance to fuelling protocols like SAE J2601 and others.

Scope of the test device

The test devices targeted in this document are intended to cover tank sizes for refuelling light duty vehicles (2-10kg) and heavy duty vehicles (70kg recommended at 70 MPa). It must be suitable for both 35MPa and 70MPa refuelling operations. The devices should be capable to validate the implementation of the protocol at the dispenser as well as the performance of the station.

Certification and approvals for the HSTA

The HSTA (Hydrogen Station Test Apparatus) is intended for use within the European Union

A coherent safety concept in compliance with CE certification of the test system must be realized. For this a Declaration of Conformity is required, which must include both a risk analysis and a risk assessment considering explosion-proof (ATEX) and fire protection requirements. The design shall enable an easy transportation of the HSTA on public roads. The ADR provides rules for transportaiton in EU[1].

Depending on the specific approach for the design of the HSTA, the following UN classifications of the ADR might give guidance on this:

- UN 1956
- UN 1049
- UN 3164

Recommended list of components of the HSTA

The list shows the main components the HSTA shall at least include. The list is not a final component list.

- 70 MPa NWP rated and type approved pressure vessel(s) (corresponding to 87,5 MPa MOP Maximum Operating Pressure) with a total recommended storage capacity between 7kg to 10 kg for light duty refuelling or up to 60-80kg for heavy duty refuelling. The vessel type (II - IV) is selectable. If multiple vessels are used, individual vessels shall be isolatable to allow various test configurations.[2]

[1] Transport on public road with inert gas <2bar does not require specific measure by the ADR.

[2] Considerations on the required size of the HSTA for HeavyDuty refuellings can also be found here: **Recommendation for site acceptance tests (SAT) for heavy duty with small test benches**

Pressure equipment requirements

- The complete system shall be PED-approved (Pressure Equipment Directive 2014/68/EU).
- Cylinders, tanks, and vessels shall be compatible with the temperature and pressure range of R134, and if applicable SAE J2601.
- The use of R134-certified tanks is recommended. Alternatively, other qualified tanks compatible with R134 temperature and pressure ranges and proven long-term durability may be used. Valves, piping, and fittings shall meet harmonized standards according to R134 or PED requirements (see EU Regulation 2019/1616). Realization of back-to-back filling with the set of vessels might be considered in the vessel configuration
- Receptacles shall conform to ISO 17268-1 or ISO 17268-2, e.g., H70 F90, H35 F120, or H70 F300.
- Communication interface according to SAE J2799; future compatibility with upcoming ISO 19885-2 should be prepared.
- Shut-Off valve in fuelling line.
- Safety relief valve in fuelling line.
- Particle filter in fuelling line (≤ 5 µm), redundant filters are optional.
- Pressure sensor (0 to 100 MPa, accuracy ± 0.5 % max.) in fuelling line close to the receptacle.
- Temperature sensor (-45 to +85 °C, accuracy ± 1.0%) in fuelling line close to the receptacle located inside the piping directly into the gas stream. (See details below)
- Ambient temperature sensor (-45 to +55 °C, accuracy ± 1.0 %).
- Simulteouns refuelling and defuelling at the same time should be prevented.
- Flow limiter for defuelling according to vessel (see Chapter **„Hydrogen Chimney“**) manufacturer, to be accounted for depending on the desired defuelling rate.
- Hydrogen leakage detection for the HSTA.
- Emergency Shut-Off system, according to the risk assessment
- Grounding connection
- Data recording system for sensor data (pressures, temperatures, flow, and IR Data). Minimum sample rate 2 Hz (500 ms). Excel compatible data format, preferable in one file as a data transfer format. It is recommended on details for the file fomatting with the 3rd party which will use the data.

Test capabilities of the HSTA

The HSTA shall be used to verify fuelling station safety and performance per EN17127. Parameters and functions to be recorded include:

- IR-Communication according to SAE TIR J2799:
  - Real time parameter transmission
  - IR-blackout on request
  - Abort-Signal send out on request
  - Max. temperature signal send out on request
  - Max. pressure signal send out on request
- hydrogen temperature in vessel
- hydrogen pressure in vessel

Recommended adjustable data for initiating certain tests:

- Volume
- Temperature
- Pressure

Additional parameters from the fuelling station for information:

- pressure ramp rate
- target pressure
- flow limitation
- hydrogen precooling temperature
  - time for reaching the hydrogen precooling temperature window
  - monitoring of the hydrogen precooling window during the fuelling

Data recording

Following measurement data shall be recorded continuously during each fuelling and transferred into an Excel-compatible file format:

- Ambient Temperature
- H_2-Temperature (downstream receptacle inside the gas stream)
- H_2-Pressure after receptacle
- Vessel temperature and vessel pressure optionally
- SOC and H_2-Amount of storage vessels (measured or calculated)
- IR-Communication Data

General recommendations

The manufacturer should consider all handling aspects of the test bench, like

- Transport to and from the station.
- Installation at and removal from the station.
- Testing activities at the station.
- Storing between operation.
- Preparations for transport.
- Operation of the HSTA at any kind of Hydrogen Station.
- Appropriate power supply.
- Size and weight.
- Handling requirements
- Compliance with sustainability principles
- Requirement to develop a concept for a safe solution to perform the required 5 tests per dispenser considering public traffic and activities at other dispensers on multi-fuel stations and defueling the tanks between refuelling tests (see also chapter **„Hydrogen Chimney“**).
- Deflation of the HSTA vessels at the station without moving the HSTA.

Design values per SAE J2601 and J2601-5

The HSTA must meet all design values and tolerances specified in SAE J2601 (for light-duty vehicles) and SAE J2601-5 (for heavy-duty vehicles) in their latest version.
Future protocols from upcoming ISO 19885-3, e.g. Mid-Flow Twin Protocol, shall be considered in the design—especially regarding pressure drop limits in the instrumented fuelling line.

Hydrogen chimney

If a chimney is installed, the following recommendation should be considered and confirmed by a risk assessment accounting for the defuelling rate. The HSTA needs a hydrogen chimney for defuelling and safety valves. The exhaust opening of the chimney shall end at least 3.5 m above the ground. The construction shall be robust, rain protected, and noise optimized. The chimney should be integrated into the HSTA or designed as standalone system. For transportation the chimney shall be foldable to a maximum length of 2 meters. A conductive connection between HSTA and chimney is mandatory. The postioning and erecting of the external chimney shall be done with trained personell (e.g. befähigte Person after BetrSichV). Notified bodies should be contacted for further information.
For information: there might be the possibility to connect the HSTA to the chimney of the HRS. The availability of such a connection and the connection type needs to be clarified individually with the refuelling station manufacturer or operator.

Hydrogen temperature sensor

If a temperature sensor is implemented in the fuelling line, the hydrogen temperature sensor shall be located next to the receptacle. A quick response time of the temperature sensor shall be realized. A Thermocouple should be choice of high accuracy and located in a logical manner. The sketch below illustrates the mounting position of the temperature sensor which shall be realized. The location of the sensor element inside the fitting shall be located at a wider inner diameter of the fitting to ensure that the measuring results is not falsified by gas stream effects.

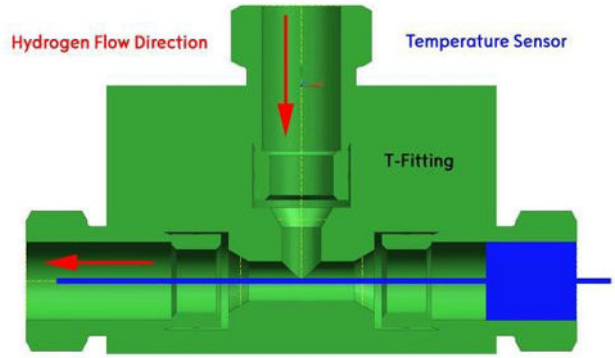


Figure 1 - Temperature Sensor Assembly Sketch in T-Fitting as example

Exemplary test sequence

Testing with the HSTA at the fuelling station typically follows the sequence below:

1. Inform HRS operator or relevant personell and fulfil neccessary paperwork according to local regulation
2. Ensure access to the dispenser is properly signalled and restricted.
3. Disable dispenser (no customer fuelling)
4. Place HSTA in front of FS dispenser
5. Connect earth connection clamp to station grounding
6. Connect power supply

7. Check and start data acquisition
8. Connect FS nozzle
9. Start fuelling according to test procedure
10. Disconnect HSTA in reverse order
11. Enable HSTA to be defuelled
12. Connect HSTA to defuelling chimney
13. Connect grounding and power supply
14. Defuel HSTA
15. Preparation for next test according test procedure

Automation requirements

Automation features of the HSTA shall include (but not be limited to):

- Monitoring of vessel parameters
- Close shut-off valve in fuelling line of HSTA and send ABORT signal with IR interface if limits from chapter XX (see above) are violated.
- If 20% Lower Flammable Limit (LFL), is detected, then send a warning signal to the HSTA operator. In addition, close shut-off valve and send IR abort signal.
- Send static and dynamic data via IR interface according to SAE J2799 to the FS. Set the fuelling command depending on the HSTA status and the HSTA mode.
- Enable IR data manipulation by user request (manual set of temperature, pressure and / or fuelling command signal) and IR deactivation during fuelling.
- Enable an automated defuelling of the HSTA to a target pressure level set by user and keep the HSTA in operating limits during defuelling.
- record data during fuelling and defuelling operation
- Count and record total pressure cycles of vessels. Vessels should not exceed cycling or usage from R134.
- Possibility to send simulated values for tank pressure, temperature and volume via IR.
- Possibility to send invalid checksum via IR.

Recommendation on documentation

The HSTA documentation should include at least:

- HSTA description
- CE-Certification
- Documentation of all used components and manufacturer documentation
- Piping and instrumentation diagram, including fitting specifications
- HSTA layout plan with metric dimensions
- Circuit and wiring diagram
- Maintenance and service plan and instructions
- FMEA, Safety Concept
- Safety and Ex zone definitions and plan
- Operation instruction
- ADR documentation, as applicable

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