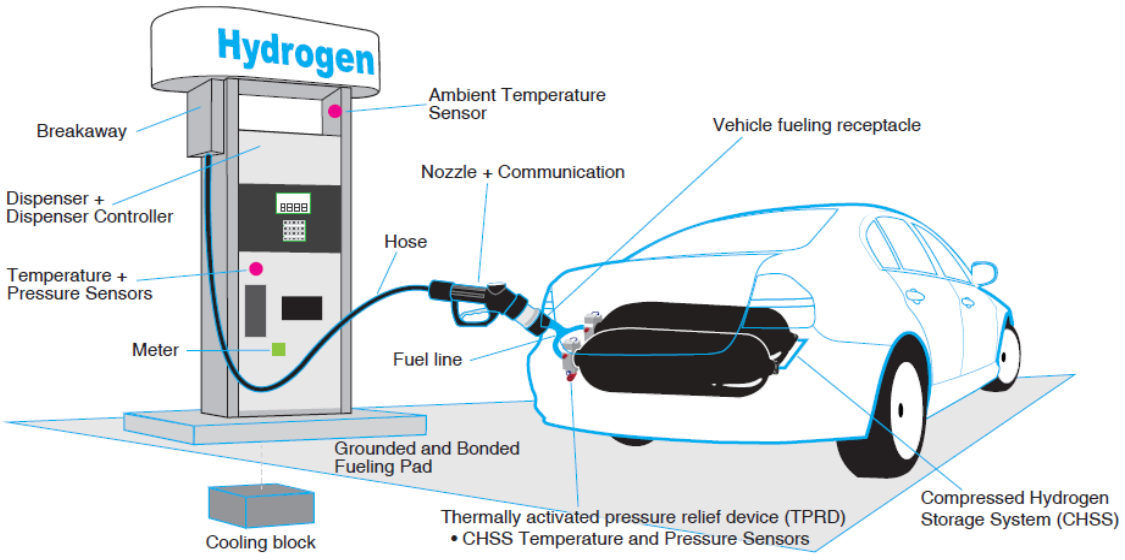
L. Critical Interoperability Considerations

1. Principal Interoperability Elements

163. Hydrogen-fueled vehicle safety depends on hydrogen dispenser operation and hydrogen fueling station (HFS) controls during the vehicle fueling process. It is thus important to highlight the considerations critical for understanding and taking into account interoperability between the HFS and a hydrogen-fueled vehicle.

164. Figure 9 below describes an example of the key components of the fueling station dispenser including the hydrogen-fueled vehicle high pressure hydrogen system, comprising amongst others, the receptacle and compressed hydrogen storage systems (CHSS) with sensors as well as pressure relief device(s). The CHSS has a thermally activated pressure relief device(s) to protect against overpressure due to a fire. On the station side, there is an automated dispensing control system (e.g. through a PLC) for performing the fueling (using an acceptable fueling protocol such as SAE J2601), as well as fault detection and management procedures. The station also has an over pressure protection device such as a pressure relief device(s) or equivalent to protect against over pressurization of the dispenser and the vehicle.

Figure 9 - Example of the fueling station dispenser key components including the vehicle high pressure hydrogen system



165. The dispenser at a public fueling station for light duty vehicles is typically designed with separate nozzles to fuel vehicles to 35 MPa and/ or 70 MPa nominal working pressures. The station fueling nozzle may contain a communications receiver and the vehicle may contain a communications transmitter (such as SAE J2799). The vehicle IrDA communications system may use the SAE J2799 protocol to transmit the measured temperature and pressure of the compressed hydrogen storage system on the vehicle to the hydrogen dispenser. The station dispenser controller may use this data for the control system to manage the fueling process.

166. A detailed guidance on general requirements for a hydrogen fueling station (HFS) interoperability with a GTR 13 compliant hydrogen-fueled vehicle can be found in ISO 19880-1:2019 standard (ISO for short). An ISO-complaint HFS makes the following critical assumptions in regards to a hydrogen-fueled vehicle:

(a) The receptacle pressure rating matches vehicle CHSS pressure rating (ref. Clause 5.2.1.1 of the GTR 13)
(b) The receptacle mounting is able to withstand the breakaway force specified in a proper standard (ref. ISO 19880-3 and ISO 19880-1)
(c) Vehicle's CHSS is able to safely be depressurized to a pressure of 0.5 MPa (ref. SAE J2601 and ISO 19880-1), and
(d) Vehicle's CHSS is able to safely accept at least 10 pauses during fueling where the fuel rate drops below 0.6 g/s (ref. SAE J2601 and ISO 19880-1).

2. Description of SAE J2601

167. SAE J2601 defines the protocols and process limits for hydrogen fueling of light duty vehicles, which meet the requirements of the GTR 13.

168. The fueling protocols in SAE J2601 are based on a set of boundary and initial conditions, which reflect CHSSs of current light duty vehicles and associated fuel delivery components in the vehicle and filling station that affect the fill.

169. SAE J2601 defines fueling protocols based on either a look-up table approach utilizing a fixed pressure ramp rate, or a formula based approach utilizing a dynamic pressure ramp rate continuously calculated throughout the fill. The table-based protocol provides a fixed end-of-fill pressure target, whereas the formula-based protocol calculates the end-of-fill pressure target continuously. Both protocols allow for fueling with communications or without communications. For fueling with communications, SAE J2601 is used in conjunction with SAE J2799.

170. For hydrogen stations intended for the fueling of heavy duty vehicles, SAE J2601-2 is available.

3. Use of Vehicle-to-Station Communication

171. The use of vehicle-to-station communication enhances the fueling process by providing information about the CHSS being fueled, which the dispenser would not otherwise know, such as the CHSS nominal working pressure (e.g. H70, H35), the CHSS volume, the CHSS gas pressure, and the CHSS gas temperature. It also provides a fueling command signal, which informs the dispenser if it is "ok to fill" or if the fill should be aborted. Although these data provide an additional layer of safety, they are not used for primary control of the fueling process, as a reliability requirement has not been established for the vehicle data measurements and for the communication link. In SAE J2601, the data communicated to the station may be used for secondary confirmation of the CHSS nominal working pressure, for determining the CHSS volume, and for determining when to end the fill based on a target SOC of 95 to 100%. The data communicated does not influence the pressure ramp rate the dispenser utilizes – the pressure ramp rate is the same for communication fueling and for non-communication fueling for a given CHSS volume.

172. SAE J2799 utilizes one-way communication and provides error-checking that can identify faults with the data transfer. If a sufficient error in communication is detected, or if communication is lost, the dispenser control must either switch to the non-com fueling protocol or stop fueling.

4. Validation of the Fueling Protocol and Vehicle-to-Station Communication

173. It is important that the fueling station be validated that it is correctly applying the fueling protocol and vehicle-to-station communications. This validation can be conducted through the use of Factory Acceptance Tests, through the use of Site Acceptance Tests, or a combination of both. For validation of fueling stations employing SAE J2601 and SAE J2799, an approved validation standard, such as CSA HGV 4.3, should be used.

174. Validation of the fueling protocol is intended to test that the dispenser is:

(a) Applying the control parameters correctly
(b) Responding to process limit violations correctly
(c) Able to meet a certain level of fueling performance (i.e. completing fills without exceeding process limits and achieving an acceptable ending SOC in the CHSS.

175. Validation of the vehicle-to-station communications is intended to test that the dispenser:

(a) Receives and interprets the communicated data correctly
(b) Responds correctly to data values which are outside the allowed bounds

(c) Responds correctly to bad data packets
(d) Responds properly to data which should terminate the fill:
    (i) An “abort” command
    (ii) CHSS gas temperature equal to or greater than 85 C
    (iii) CHSS SOC ≥ 100%