TECHNICAL BULLETIN

Prepared by WG-11 TB 51/24 – April 2024

Hydrogen Interface for Trailer to Hydrogen Refueling Station

Hydrogen refueling stations (HRS) are being deployed out of the industrial environment where Industrial Gas Companies are used to operate trailers. It is foreseen that a significant increase in number of deliveries to HRS will be required to support the growth of Hydrogen mobility applications. The connection between Gaseous Hydrogen (GH2) trailers and HRS are typical industrial connectors but there is a lack of harmonized standardization of physical connectors and relevant safety systems for interoperability. The aim of this document is to represent EIGA recommendations on this topic.

The scope of the document covers GH2 trailer usage in Europe, however most of the functional requirements can be extended and adapted for other geographies.

The requirements of this document only apply for new installations.

Definitions

Transfer panel

An interface device, between the GH2 trailer and the HRS. The transfer panel receives hydrogen from the source (e.g tube trailer or Multiple Element Gas Container MEGC) and transfers Hydrogen to the HRS, regardless of the source pressure. The transfer panel can include process equipment and safety functions such as sensors, valves, pressure reducers, check valves, pressure safety valves, vent line, grounding cable etc. It includes connectors for hydrogen and optional instrument gas supply for trailers. One HRS can have one or more transfer panels. This transfer panel can be part of the station or the supply chain.

Working Pressure

The settled pressure of a compressed gas at a uniform reference temperature of 15 °C (see EN ISO 10286).

Maximum Allowable Working Pressure of the HRS

The Maximum Allowable Working Pressure (MAWP) is maximum pressure permissible in a system at the temperature specified for the pressure (see ISO 19880-1).

Developed Pressure of the trailer

Developed pressure is a common term used across gas cylinders, bundles and other packages within the scope of EIGA TB 22. It is a pressure developed in a package during filling as a result of filling pressure and temperature generated due to compression.

Hydrogen Refueling Stations (HRS)

Facility for the dispensing of compressed hydrogen vehicle fuel, often referred to as a hydrogen refueling station (HRS) or hydrogen filling station, including the supply of hydrogen, and hydrogen compression, storage, and dispensing systems (see ISO 19880-1).

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Risk management of interfaces between trailers and HRS (example for 200 bar and 300 bar trailers)

For safe operation of the interface between a GH2 trailer and HRS, the following points shall be considered:

1. Compatibility of trailer and HRS connections for gaseous hydrogen, instrument gas, process signals (if applicable).
2. Gas transfer from GH2 trailer to HRS can be performed (valves, sensors, procedures, etc.).
3. Functionalities and devices for safe gas transfer operation (emergency-stops, overpressure protection, vent system, grounding, anti tow-away, etc.).

Main hazards are shown in figure 1.

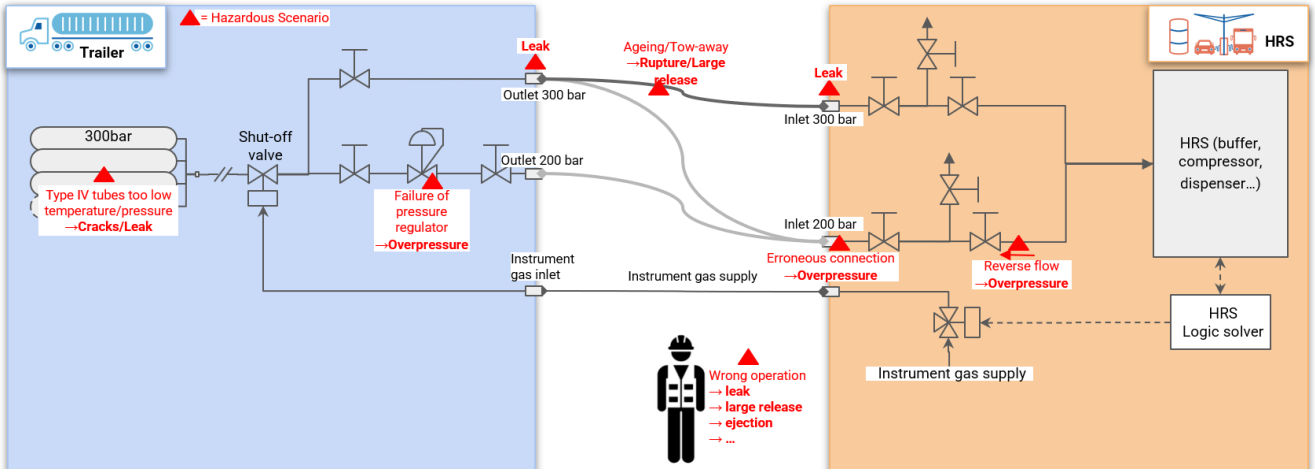

Figure 1: Main hazards at interface between a GH2 trailer and HRS (example for 200 bar and 300 bar trailers)

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Hazardous events	**Causes**	**Consequences**	**Examples of Safeguards**
H2 leak on GH2 flexible hose coupling	Various	H2 release / Fire / Explosion	**HRS:** Gas detection safety function= Detection → HRS shutdown + trailer shutdown (Shutdown of Instrument Gas (IG) supply from HRS → closure trailer shut-off valve OR trailer E-stop activated by HRS e-stop function) **Trailer:** Trailer shut-off valve is a normally closed valve (no IG supply from HRS closes it)
Rupture of GH2 flexible hose	Aging, trailer tow-away, etc.	H2 release / Fire / Explosion	**Trailer:** Anti-tow away device (various designs) **Trailer:** Restricted flow orifice to mitigate consequences
Overpressure at HRS 200 bar inlet	Trailer outlet 300 bar connected to HRS inlet 200 bar	Potential pipe rupture / Process equipment rupture on HRS inlet panel H2 release / Fire / Explosion	**Trailer:** Specific coupling 300bar, specific coupling 200 bar **HRS:** Specific coupling 300bar, specific coupling 200 bar
Overpressure at HRS 200 bar inlet	Failure of trailer pressure regulator 300 bar / 200 bar	Potential pipe rupture / Process equipment rupture on HRS inlet panel H2 release / Fire / Explosion	**Trailer**: Safety function: Pressure Switch High (PSH) → closing of trailer shut-off valve **HRS:** Pressure Safety Valve (PSV) on inlet panel (200 bar inlet equipment)
Low temperature of the trailer tubes (type IV)	Too high unloading flow rate combined with low ambient temperature	Potential cracks / Leak of tube liner (type IV). H2 release / Fire / Explosion	**Trailer:** Safety function: Trailer shutdown at low temperature. **HRS:** Safety function: Trailer shutdown at low temperature.
Low pressure in the trailer tubes (type IV)	Too much unloading below required residual pressure. Leakage in the system.	Potential cracks / Leak of tube liner (type IV). H2 release / Fire / Explosion	**Trailer:** Safety function: Trailer shutdown at low pressure. **HRS:** Safety function: Trailer shutdown at low pressure.

Table 1: Main hazards and example of safety barriers

Note: This risk assessment can be adapted to other pressures.

Recommendations and requirements

For safe operation of the interface between a GH2 trailer and a HRS, the following points shall be considered:

General

- The HRS operator shall ensure that the specific characteristics of all trailers connected to his system are reflected in the risk assessment of the interfaces.
- To avoid collision with a trailer the transfer panel shall be protected against impact (e.g. by bollards, bumb stop, kerbs, etc.).
- The unloading area shall be naturally ventilated and designed to prevent any hydrogen accumulation. The unloading area shall be paved or concreted. Sand and gravel shall be avoided.
- Tow-away during unloading shall be prevented by using an anti-tow-away device such as wheel chocks, barriers, electronic or pneumatic devices or others.
- Purging gas shall be vented through the stationary vent line, not through the trailer vent line (if any).
- For new installations the HRS maximum allowable working pressure shall be higher or equal to the maximum developed pressure of the trailer.
- Trailer safety devices such as Thermal Pressure Relief Devices (TPRD) are out of scope of this document.

Multi pressure and mating couplings

- The transfer panel can be designed to accept one pressure level or several different pressure levels. Each connecting point shall be designed to accept only one pressure level. Separate transfer panels can be installed at the HRS. In each case the overpressure risk shall be assessed and the relevant protection shall be integrated into the transfer panel.
- Risk of backflow shall be managed when multiple trailers can be connected simultaneously to one HRS via one or more transfer panels. This shall be done by the transfer panel. A secondary risk mitigation measure (such as a check valve) could be installed at the trailer.
- Some trailers are designed with multiple outlet connections delivering different pressures. Multiple reduction steps should be avoided. It is best practice to have the pressure regulator on the transfer panel and not on the trailer and use therefore the outlet connector corresponding to the trailer working pressure. If this is not possible, in case e.g a trailer delivering at different pressure levels, a specific risk assessment of the trailer to HRS interface shall be carried out.
- It is current practice to have transfer panels accepting 200 and 300 bar inlet pressure on one or separate transfer panels.
- HRS transfer panels could be designed to accept trailers with pressure above 300 bar.
    - 200 bar trailer unloading connections should comply with the connection standards at each geography (see examples in appendix A).
    - 300 bar unloading connections should comply with ISO 5145 number 38.

It is current practice to have male connectors on the trailer and the transfer panel side. Hose connectors are typically female to protect them against damage in case of getting dropped on ground. **Pneumatic valves of the trailer**

- The transfer panel shall be able to supply instrument gas to the trailer. The instrument gas system shall be designed for nitrogen and/or compressed air. The quality of the instrument gas shall be as follows:
    - Compressed air quality class 2 in accordance with ISO 8573-1
    - Nitrogen quality class with dew point ≤ -40°C
- The trailer shall have an instrument gas inlet connector for external supply if the trailer is equipped with pneumatic valves.
- The flexible hose for instrument gas shall be part of the transfer panel for new installations. As additional safety feature the flexible hose for instrument gas can be integrated into the hydrogen hose protection sleeve.

- The trailer instrument gas inlet connector shall be incompatible with the hydrogen connector so no erroneous connection is possible. The connector should be male on the trailer side and female at the hose (see examples in Appendix B) and shall comply with ISO 6150 or with local standards.
- The pressure of the instrument gas system shall be sufficient to activate the trailer pneumatic valves.
- The typical pressure range of the instrument gas is 7 to 10 bara.

Emergency Stop of the HRS and Shut-off of the trailer

In case of a GH2 flexible hose rupture or other release scenario on the trailer and on the HRS, the amount of the released hydrogen shall be limited. Current practice is:

- On the trailer connected to an HRS: An automatic shut-off valve (pneumatic or electric) which is isolating the hydrogen gas supply from the trailer. This valve can be activated by a stop push button on the trailer or by cutting off the instrument gas supply from the transfer panel and vent it. It is good practice to have stop push buttons or similar activation devices on the trailer which are easily accessible from various sides of the trailer. The shut-off system shall be tested regularly. If the trailer has no automated shut-off valve a specific risk assessment of the trailer to HRS interface shall be carried out.
- The HRS shall have an emergency stop function. This function can be activated manually (emergency push button) or automatically (e.g. detection of hydrogen leakages, fires etc.). The HRS should be able to close the trailer shut-off valve in case of emergency if an automatic shut-off valve is available.

The emergency shut off system of the HRS should be designed to avert automatic restart for example as described in ISO 13850. As an option for future installations the trailer shut-off-valve status should be communicated to the HRS.

Flexible Hose

- To mitigate the consequences of a tow-away the hydrogen flexible hose can be equipped with a breakaway coupling. A restricted flow orifice can be installed at the trailer side or in the flexible hose to limit the flowrate in case of rupture of the flexible hose. The restricted flow orifice should be sized to not limit the expected flow rate for normal operation (unloading).
- It is recommended to provide anti-whip protection to hoses at pressure above 40 bar (EIGA Document 42: Flexible connections in high pressure gas systems and ISO 14133 or equal requirements from local standards). The trailer and the transfer panel should have anchor points to attach an anti-whip protection.
- If the unloading hose is part of the transfer panel it should be compliant with ISO 16964 or ISO 14113.
- The hose length shall be appropriate to give enough space for manipulating during operation.
- The hose connections shall be protected against contamination (dust, water ingress, etc.) when the flexible hose is not connected to the trailer (e.g.: blind flange, plug, cap).

Grounding

- The trailer shall be protected from the static electric charge by a grounding device.
- The site shall have a dedicated grounding point with a resistance of equal or lower than 25 Ohms to ground. See NFPA 70 and CGA H-5, Standard for Bulk Hydrogen Supply Systems. The connection clamp shall be clean and free of rust.
- The grounding cable shall be a part of the transfer panel. The grounding terminal (earthing lug) shall comply to local regulations (e.g. NF E 86-302 or equivalent).
- At every delivery the connection of the grounding should be monitored on the HRS transfer panel or manually verified by a trained person.

Analysis

- Analysis of the hydrogen at the interface of between trailer and the HRS is typically not required as the trailer comes with an analysis certificate.
- If analysis of hydrogen is required for any reason it shall be done directly at the trailer.

Appendix A – Selection of GH2 connectors

Existing couplings (examples):

For 200 bar logistic:

- CGA 1350—1.00-11.5 NPS–LH–EXT for pressures up to 3500 psi at 70°F (24 130 kPa at 21.1°C) for ethane, ethylene, hydrogen, methane, and natural gas. See Connection No. 1350. See document CGA V-10 (2019) : High Pressure Gas Trailer Connections

- ISO TR 7470

- EU uses a variety of different non compatible connectors:
  - FR: NF E29-650 Type E (male)
  - IT: UNI 11144 (male)
  - DE & AT & PL & CZ & SK: DIN 477-1 Nr.1 (male)
  - CH: G1" (right-hand thread connection) (male)
  - BE & NL: Type B8 (same ref. DIN 477-1 Nr.1) (male)
  - UK & IR: BS341 BS2 or 4
  - ES & PT: ITC EP-6 Type E

For 300 bar

- ISO 5145 FTSC-Code 2170 connection number 38 equivalent to DIN 477-5 Nr. 57

- M36x2 LH (Male) cone seal (not a standardized connection)

For 380 bar

- M42x2 LH (Male) cone seal (not a standardized connection)

For 450 bar

- DKOS fitting (not a standardized connection)

For 500 bar

- M52 x2 conus seal 24° (not a standardized connection)

Appendix B – Examples of instrument gas connectors

List of instrument gas connectors typically used at H2 trailers (examples):

- NW7 (male)
- Staubli RBE06 (male)
- Swagelok SS-QC4-B1 (male)
- Swagelok SS-QF4-B6M0 (male)

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