Process description

H2 gas is supplied with a maximum supply pressure of 500 bar receding to 10 bar. Hydraulically driven booster compressors will then compress the gas in up to 4 stages with variable interstage pressures to a maximum of 1000 bar. The capacity of the H2 filling station is 20 kg/h at a supply pressure of < 10 bar, 35kg/h at a supply pressure of >30 bar and at 50 bar and above 45 kg/h. Assuming all buffers are filled at the start, it is possible to fill three LDV category B vehicles (≈4 kg) back-to-back with the 700 bar dispenser and simultaneously one HDV (≈30 kg) with the 350 bar dispenser.

Vehicles are filled from storage buffers, using a cascade system. The storage system consists of two pressure levels for 700 bar fills: 500 bar and 1000 bar. To fill vehicles as efficiently as possible, the FSS starts filling from the 500 bar buffer and afterwards the 1000 bar buffer.

The storage system for 350 bar fills consists of one pressure level: 500 bar. Here, the filling is also done using the cascade system.

For the 700 bar fills, three banks (buffers) of each pressure level mentioned above are included in the system. It is also possible to fill a vehicle from one 500 bar buffer, while the second is pressurized by the compressor in the meantime. This also applies to the 1000 bar buffer. For the 350 bar fills, the above is not possible, here a vehicle is either filled from the buffers or refilled by the compressor.

By integrating multiple safety loops into the software, it is not possible for the same buffer to be used simultaneously for filling and refueling.

Before the first compression stage and after each stage, the H2 gas is cooled back through interstage coolers. This prevents critical temperatures in the system and increases the density of the gas, resulting in a reduced number of compression stages. These interstage coolers consist of part air cooling and part mechanical cooling using a glycol-based refrigerant.

Before maintenance is performed, the entire system can be flushed with N2. In this way, an explosive environment in the piping is prevented and maintenance can be carried out safely.

The dispenser includes a mass flow meter and a flow control valve. Using a separate control unit with input from various instrumentation, the flow control valve is controlled in accordance with the SAE J2601-1 protocol for 700 bar refills and the SAE J2601-2 protocol for 350 bar refills. For the dispenser, the gas is cooled according to the T40 protocol for vehicles to be filled using the SAE J2601-1 protocol. The station offers a refueling solution for communicating and non-communicating vehicles it has one dispensing column for 350 bar and one for 700 bar. This depends on the configuration.

Process safety is ensured through various control loops and mechanical safety valves. All safety valves and discharge lines are bundled into a common vent line.

Throughput H2 plant

Based on the standard capacity of the FSS (20 kg/h or 45 kg/h), the total H2 throughput per day (24h) is 480 kg or 1080 kg which can be spread over 350 bar filling and 700 bar filling as pleased. Depending on the maintenance intervals, the total throughput per year must be determined.

Consolidation (Option)

The optional consolidation function can be applied in case the hydrogen supply to the station is limited. As an example, the application of a 500kW electrolyser (~8 kg/hour), which does not match with previously mentioned compression capacity. It would result in a limitation for continuous filling of vehicles. (Regularly a tube trailer is often applied, where the supply exceeds the station compression capacity)

By applying an additional storage volume (consolidation storage), a temporary high supply to the FSS can be generated in situations of high station utilization intensity. For this purpose, this storage is filled during off-peak hours and used as supply at peak times.

A fully automated feature that efficiently enables the deployment of a 24/7 electrolyser.

Storage of H2 700 bar fill (SAE-J2601-1 Cat B (7 kg)):

Quantity buffers	Banks	Type	Working Pressure	Volume each (bank)	Total volume	Total stored Hydrogen (approx. @ 15°C)
6	3	Steel	520 bar	300 liters (6*50 liters)	900 liters	29 kg
6	3	Steel	950 bar	300 liters (6*50 liters)	900 liters	43 kg

Storage of H2 350 bar filling (SAE-J2601-2 @ 30kg capacity):

Quantity buffers	Banks	Type	Working Pressure	Volume each (bank)	Total volume	Total stored Hydrogen (approx. @ 15°C)
18	3	Steel	520 bar	900 liters (18*50 liters)	2700 liters	86 kg

**"Storage H2 350bar" is based on 1 fill of 30kg; if multiple fills are desired in succession, the 350bar storage module can be placed multiple times.*

Storage of H2 Consolidation storage (optional)

Quantity buffers	Banks	Type	Working Pressure	Volume each (bank)	Total volume	Total stored Hydrogen (approx. @ 15°C)
3	1	Type 1-2-3-4	300 bar	3x 1700 liters	5100 liters	107 kg

**"Storage H2 consolidation can be further expanded depending on targeted peak mobility demand."*

Piping installation

Type of piping	Connection	Material	Internal diameter
T3-140/80-21	Compressor -> 500 bar storage	SS316	8 mm
T3-140/80-21	Compressor -> 1000 bar storage	SS316	8 mm
T3-140/80-21	Storage 350 bar -> Dispenser 350 bar	SS316	8 mm
T3-140/80-21	Storage 700 bar -> Dispenser 700 bar	SS316	8 mm
xxx	H2 supply -> Compressor	SS316	*To be determined, depending on configuration and spacing.*

Vent leadership must be arranged in coordination with the customer's supply scope.

Coolant

Type		Weight
R290	Propane	22.4 KG
R1270	Propene	12.8 KG

Modules FSS

The modules of the FSS consist of a compression module, cooling module, hydrogen storage and a dispenser for 350 bar refueling and a dispenser for 700 bar refueling.

Module	Dimensions (lxw)	Note
Compressor	6093 x 2819 [mm]	20 ft. HC Container
Cooling module	5500 x 2400 [mm]	
Storage H70	2500 x 2500 [mm]	Frame with plating
Storage H35	2500 x 2500 [mm]	Frame with plating
Additional Storage H35 (Option)	2500 x 2500 [mm]	
LP Supply storage 50m3 (Option)	12400 x 2600 [mm]	
Consolidation storage	6500 x 800 [mm]	(Estimate, subject to verification and changes)
Dispenser 350 bar	650 * 750 [mm].	
Dispenser 700 bar	650 * 750 [mm].	

- *<u>Remark:</u> Modules are still in the R&D phase therefore dimensions are not yet final and minor changes are reserved.*
- *<u>Remark:</u> Storage H70 and H35 face each other, footprint of the entire storage module is therefore 5000 x 2500 mm*