

USCAR Hydrogen Fuel System Component Working Group (H2FSC WG) - Targets for a High Pressure Regulator Unit on a light-duty fuel cell vehicle

The purpose of this document is to promote common requirements and designs for use by the H2FSC WG.

The 700 bar regulator unit shall reduce the hydrogen gas pressure in one or more stages from the tank maximum operating pressure (inlet) to a reduced delivery pressure (outlet) for the fuel cell system.

Characteristic	Target – Low Outlet Pressure Regulator	Target – High Outlet Pressure Regulator	Reference/Source*
Fuel	Hydrogen per ISO 14687		ISO 14687 (ref. SAE J2719)
Hydrogen Compatibility	Evidence of Hydrogen Compatibility		ANSI HGV 3.1-2015 SAE J2579 Appendix B
Nominal Working Pressure	700 bar		H2FSC WG
Maximum Operating Pressure	875 bar (1.25x NWP)		ANSI HGV 3.1-2015
Burst Pressure (inlet side)	1750 bar (2.5x NWP)		ANSI HGV 3.1-2015
Burst Pressure (outlet side)	2x Pressure Relief Valve (PRV) Activation Pressure		ANSI HGV 3.1-2015
Minimum Inlet Pressure – full performance within output pressure tolerance from minimum to maximum outlet flow	25 bar	30 bar	H2FSC WG
Minimum Inlet Pressure – full performance within output pressure tolerance from minimum to maximum average outlet flow	15 bar	20 bar	H2FSC WG
Minimum Inlet Pressure – reduced performance (per OEM feedback) below the output pressure tolerance although still able to flow through regulator	5 bar	5 bar	H2FSC WG
Normal Outlet Pressure (delivery pressure minimum to maximum outlet flow, including lock-up)	7 +2 / -2 bar	11 +3 / -2 bar	H2FSC WG
PRV Activation Pressure	15 +/- .75 bar Full Open: 16.5 bar Reclosing: 13.5 bar	20 +/- 1 bar Full Open: 22 bar Reclosing: 18 bar	ISO 12619-9 ISO 4126-1
Maximum Outlet Pressure Limit (allowable pressure limit during PRV activation to protect against fully open regulator failure. OEM fault strategy may be used to limit this pressure limit exposure.)	17.5 bar	23 bar	H2FSC WG
Maximum Outlet Flow (includes pulse conditions per OEM feedback)	3 g/s**		H2FSC WG
Maximum Average Outlet Flow	1.5 g/s**		H2FSC WG
Minimum Outlet Flow	0 g/s		H2FSC WG

Transient Response Rate (from minimum to maximum outlet flow)	<500 milliseconds	H2FSC WG
Maximum Service Temperature (ambient and operation)	85°C (Maximum environmental ambient is 50°C)	ANSI HGV 3.1-2015
Minimum Service Temperature	-40°C	ANSI HGV 3.1-2015
Maximum Outlet Gas Temperature	100°C	H2FSC WG
Maximum Inlet Gas Temperature	85°C	H2FSC WG
Minimum Inlet Gas Temperature	-60°C	H2FSC WG
Endurance Test (pneumatic)***	75,000 Cycles (1.5x 50k duty cycles) (1.5x was selected to align with the tank valve requirement in EC/79/2009)	EC/79/2009
Pressure Cycle Test (hydraulic)***	150,000 Cycles (3x 50k duty cycles)	EC/79/2009
Flow Cycle Life (interfacing to a fuel injector that varies between the max avg. and min. flow at a frequency and buffer volume as specified by the OEM between the regulator and injector at various inlet pressures to the regulator)	> 6 x 10 ⁷ Cycles	H2FSC WG
Maximum External Leakage	< 10 Ncm ³ /h (end of life)	ANSI HGV 3.1-2015
Maximum Internal Leakage (at lock-up condition or no flow)	< 10 Ncm ³ /h (end of life)	ANSI HGV 3.1-2015
Component Certification Requirement	ANSI HGV 3.1-2015 (USA) EC/79/2009 (Europe) or UN R134 (Europe) Must comply with applicable local and national regulations in which deployment will occur per customer (above are typical references)	H2FSC WG
System Certification Compliance (system criteria awareness)	UN GTR No. 13 UN R134 SAE J2579	H2FSC WG
NVH Requirement	No subjectively disturbing noises are allowed at any normal vehicle operating conditions per OEM feedback and assessment Needs to be robust to shock loads and vibrations exposed to during normal operation as determined for the specific customer and vehicle application	H2FSC WG
Corrosion Protection***	144 hours salt spray	ANSI HGV 3.1-2015
Water Ingress Protection***	IPx6 (high-pressure, heavy spray) IPx6K (extreme high pressure spray)	ISO 20653
Thermal Endurance***	At minimum, perform 100 temperature cycles between minimum and maximum service temperature in 5 minutes with a 30 minute hold at temperature For complete endurance assessment, needs to be robust to thermal fatigue and degradation that is caused by temperature change. Perform a customer defined thermal cycle profile	H2FSC WG (ref. IEC 60068-2-14)
Required Integration Functionality	Pressure Relief Valve on outlet Filter (10 µm) on inlet	H2FSC WG

Optional Integration Functionality (examples of integration but not limited to this list per customer design)	High Pressure Ports or Sensors Low Pressure Ports or Sensors Shut-off Valve on inlet Service Interface on outlet for defueling	H2FSC WG
Weight	< 2 to 3 kg depending on level of integration	H2FSC WG
Lifetime	15 years	H2FSC WG
Service Criteria	Shall not require any scheduled maintenance involving disassembly and/or replacement of parts to maintain proper function over lifetime	H2FSC WG
Inlet Fitting Interface	Female cone end-connection per ISO 2974 (6 mm OD tubing interface)	H2FSC WG
Outlet Fitting Interface	O-ring face seal per SAE J1453 and ISO 8434-3 (10 mm OD tubing interface)	H2FSC WG
PRV Interface	O-ring face seal per SAE J1453 and ISO 8434-3 (10 mm OD tubing interface) Other options may be specified by OEM	H2FSC WG
Sensor Port Interfaces (optional feature although design should consider accommodating)	Port interfaces as specified by OEMs Options to consider: 7/16"-20 UNF SAE J1926 (-4 size) 1/2"-20 UNF with port for $\varnothing 7.7$ mm stud seal	H2FSC WG
Electrical considerations for optional electronic regulator designs	Single electrical connector shall be directly attached to the unit in agreement with OEM Voltage supply shall be 12 +4/-5 VDC with full function in this range at any operating condition (supply current in agreement with OEM)	H2FSC WG
Electrical considerations for optional pressure sensors (either separate sensors or integrated directly into regulator)	Single electrical connector shall be directly attached to the unit in agreement with OEM Voltage supply shall be 5 +/- .25 VDC with full function in this range at any operating condition (supply current in agreement with OEM) Output signal shall be 0.5 to 4.5 VDC radiometric (other outputs may be specified by OEM)	H2FSC WG
Restricted Materials	Must avoid use of hazardous substances (for example, parts containing lead, mercury, cadmium, hexavalent chromium, etc.) per government regulations, environmental goals, and vehicle manufacture list of prohibited substances (suppliers are required to report)	H2FSC WG (ref. EPA TSCA Inventory, EU Directive 53/2000, other applicable national and OEM restrictions)

*Reference/source information provide the foundation or additional information for the requirement. The "H2FSC WG" notation indicates the requirement was developed by the Hydrogen Fuel System Component Working Group rather than another source.

**Flow rates are based on a light duty fuel cell vehicle (~80 to 100 kW) and will increase for higher power fuel cell vehicles.

***At the completion of the test, the component shall comply with the external leakage, internal leakage, and burst pressure requirements.

NOTE: This list of targets represents the core requirements for the basic design while a series-production product will have additional criteria per vehicle manufacture such as but not limited to:

- design validation for lifetime robustness in vehicle environmental conditions
- electromagnetic compatibility (EMC) requirements for electrical components
- quality control, reliability and production part approval process requirements
- suitable materials and lubricants to prevent fuel cell contamination
- material requirements including recyclability and recoverability