



# Hydrogen Rules 2027

**version 1.0, 02.10.2027**

## **Preface & Foreword**

This version of the Hydrogen Rules 2027 was published after the second season with Formula Student vehicles powered by hydrogen on track to improve the wording and clarify some rules. This document replaces the Hydrogen Rules 2026 Version 1.2.

In case of rules question or any other hydrogen-related topics please send a mail to:

[hydrogen@fs-world.org](mailto:hydrogen@fs-world.org)

In order to give an indication of where changes are most likely to be made for 27/28, these rules are labeled: TBD= to be discussed.

# Changelog

| Rule    | Version | Change                                                               |
|---------|---------|----------------------------------------------------------------------|
| G1.1.5  | 1.0     | Removed “From 2007”                                                  |
| G3      | 1.0     | Removed whole chapter about Hydrogen Concept Challenge               |
| G3      | 1.0     | Added new chapter about Whitelist Addition Request Form              |
| G4.1.2  | 1.0     | Updated deadline, same as for other documents like SES, ASES, IAD... |
| G4.1.4  | 1.0     | Changed consequences for late submission of H2SF                     |
| G4.1.5  | 1.0     | Added reference to FS rules                                          |
| G5      | 1.0     | Removed whole chapter about VSV, now same as in FS Rules             |
| G5.1.4  | 1.0     | Added rollover protection envelope to SES3D                          |
| F1.1.2  | 1.0     | Updated wording                                                      |
| F1.1.3  | 1.0     | Removed rule about fuel supply                                       |
| F2.1.1  | 1.0     | Changed considered parts to critical components                      |
| F2.1.1  | 1.0     | Added exception for vent line according to S5.1.2 from this rule     |
| F2.1.3  | 1.0     | Updated wording and added tube equivalent underneath hydrogen tank   |
| F2.1.7  | 1.0     | Changed requirements for holes in perforated shielding               |
| F2.1.8  | 1.0     | Added triangulated to existing wording                               |
| F2.1.9  | 1.0     | Added exception for [H2CV] & [H2HY]                                  |
| F2.1.10 | 1.0     | Prohibited combined attachment points and defined distance           |
| F2.1.10 | 1.0     | Removed titanium bolts, already covered by T10 and T3.16 of FS Rules |
| F2.1.11 | 1.0     | Added new rule                                                       |
| F3.1.1  | 1.0     | Allowed only hydrogen tanks from Hydrogen Tank Whitelist             |
| F3.1.2  | 1.0     | Removed all not vehicle design relevant parts of old wording         |
| F3.1.3  | 1.0     | Changed distance from 50 to 25 mm                                    |
| F3.1.4  | 1.0     | Removed wording which does not add any further requirements          |
| F3.1.5  | 1.0     | Moved pressure gauge from F3.1.4 to new separate rule                |
| F3.1.7  | 1.0     | Added new rule                                                       |
| F3.1.12 | 1.0     | Added additional requirement                                         |
| F3.1.13 | 1.0     | Changed female Maximator 6M connection to female G1/4” connection    |

|         |     |                                                                          |
|---------|-----|--------------------------------------------------------------------------|
| F4.1.1  | 1.0 | Moved exceptions for fuel injectors to chapter C                         |
| F4.1.2  | 1.0 | Removed recommendation for fittings                                      |
| C1      | 1.0 | Updated deadlines to 2026-12-18 13:00 CET                                |
| C1.1.5  | 1.0 | Updated wording and add exceptions for fuel injectors                    |
| C1.1.7  | 1.0 | Allowed devices mitigating pressure pulsations                           |
| E       | 1.0 | Removed old chapters E2, E3, E4, E6 and E8, updated numbering            |
| E1.1.1  | 1.0 | Changed definition                                                       |
| E2.1.5  | 1.0 | Added power limitation of 100 kW                                         |
| E3      | 1.0 | Updated whole chapter about discharge circuit                            |
| E4.1.3  | 1.0 | Removed reference to FS rules, already covered by new wording in E.1.1.1 |
| E4.1.4  | 1.0 | Added exemption for unmodified OEM fuel cell system containers           |
| E5.1.1  | 1.0 | Changed requirements                                                     |
| E5.1.2  | 1.0 | Added exemption of EV4.1.2 for fuel cell stack                           |
| E5.1.4  | 1.0 | Added FCIRs                                                              |
| E7      | 1.0 | Removed fixture and changed requirements OEM FCSC                        |
| E10.1.1 | 1.0 | Added additional requirements                                            |
| E12     | 1.0 | Changed rules regarding OEM Fuel Cell System Container                   |
| E10     | 1.0 | Removed old rule E10.1.3                                                 |
| S1.1.6  | 1.0 | Limited HSO to students                                                  |
| S2.1.3  | 1.0 | Changed orange to neon pink                                              |
| S4      | 1.0 | Updated figure 4ch changed “HS” to “hydrogen”                            |
| S4.1.4  | 1.0 | Updated wording                                                          |
| S5.1.1  | 1.0 | Updated wording                                                          |
| S5.1.2  | 1.0 | Updated requirements for safe venting locations                          |
| S5.1.4  | 1.0 | Added active ventilation systems must push the air as soon as HSMS is on |
| S6.1.1  | 1.0 | Changed to all metal parts must be grounded                              |
| S6.1.2  | 1.0 | Updated wording                                                          |
| S7      | 1.0 | Removed all rules and made new S7.1.1                                    |
| S8.1.3  | 1.0 | Relaxed rule                                                             |
| S9.1.2  | 1.0 | Removed whole old rule                                                   |

|           |     |                                                                       |
|-----------|-----|-----------------------------------------------------------------------|
| S9.1.3    | 1.0 | Removed accompanying a hydrogen-powered vehicle by an official        |
| S9.1.4    | 1.0 | Splitted old rule into different rules, allowed handcarts with a roof |
| S10       | 1.0 | Removed old S10.1.4 and S10.1.6                                       |
| S10.1.1   | 1.0 | Added excess pressure in the fuel cell hydrogen supply line           |
| H2.1.4    | 1.0 | Added possibility to have only one Rain Test                          |
| H2.1.7    | 1.0 | Added H2SMD bypass                                                    |
| H3.1.1    | 1.0 | Updated what teams have to bring to Hydrogen Scrutineering            |
| H5 and H6 | 1.0 | Removed whole old chapter                                             |
| H5.1.3    | 1.0 | Changed to non-reusable seals                                         |
| D2.1.2    | 1.0 | Removed rule about endurance distance                                 |
| D3.1.3    | 1.0 | Updated formula and wording for fuel efficiency                       |
| D3.1.4    | 1.0 | Changed 40% to 50% and value at the example                           |
| D3.1.5    | 1.0 | Added new rule to make sure not affecting EV category to much         |
| J2.1.3    | 1.0 | Removed rule about old prices in BOM                                  |
| J3.1.1    | 1.0 | Updated wording                                                       |
| J3.1.2    | 1.0 | Removed rule about Hydrogen Judges                                    |

# Abbreviations

| Shortcut | Full name                           |
|----------|-------------------------------------|
| BOM      | Bill of Material                    |
| BOTS     | Brake Over Travel Switch            |
| BSPD     | Brake System Plausibility Device    |
| CRD      | Cost Report Documents               |
| CV       | Internal Combustion Engine Vehicle  |
| CVMD     | Cell Voltage Monitoring Device      |
| DI       | Direct Injection                    |
| EV       | Electric Vehicle                    |
| FC       | Fuel Cell                           |
| FCCU     | Fuel Cell Control Unit              |
| FCEV     | Hydrogen Fuel-Cell Electric Vehicle |
| FCSC     | Fuel Cell System Container          |
| FS       | Formula Student                     |
| HS       | Hydrogen System                     |
| HSMP     | Hydrogen System Measuring Point     |
| HSMS     | Hydrogen System Master Switch       |
| HSO      | Hydrogen Safety Officer             |
| HV       | High Voltage                        |
| H2CV     | Hydrogen Combustion Vehicle         |
| H2HY     | Hydrogen Combustion Hybrid Vehicle  |
| H2SF     | Hydrogen System Form                |
| H2SMD    | H2 Safety Measurement Device        |
| LHV      | Lower Heat Value                    |
| LVMS     | Low Voltage Master Switch           |
| LVS      | Low Voltage System                  |
| NWP      | Nominal Working Pressure            |
| OTD      | On Tank Device                      |

|        |                                          |
|--------|------------------------------------------|
| OTV    | On Tank Valve                            |
| PFI    | Port Fuel Injection                      |
| SDC    | Shutdown Circuit                         |
| SES    | Structural Equivalency Spreadsheet       |
| SHYTTA | Safe Hydrogen Tank Transfer Area         |
| TPRD   | Thermal Activated Pressure Relief Device |
| TS     | Tractive System                          |
| TSAL   | Tractive System Active Light             |
| TVSD   | Technical Vehicle System Documentation   |
| WARF   | Whitelist Addition Request Form          |

# G: General

## G1: Hydrogen vehicles

- G1.1.1** In addition to the existing CV / CV hybrid class and EV class categories, Formula Student vehicles powered by hydrogen are also allowed to participate.
- G1.1.2** Competition decides independently each year whether it will allow hydrogen-powered vehicles.
- G1.1.3** For the initial implementation of a hydrogen powertrain, each team is allowed to convert an existing CV or EV Formula Student vehicle to run on hydrogen. This rule can only be used once per team. Eligibility will be determined on a case by case basis. Contact the following e-mail: [hydrogen@fs-world.org](mailto:hydrogen@fs-world.org) as early as possible.
- G1.1.4** A hydrogen vehicle may be used for two years, counting from the first day onsite of its first hydrogen competition. The newest version of the hydrogen rules must be used for any part that falls under the scope of the hydrogen rules.
- G1.1.5** Chassis according to the rule G1.1.3 must not be older than 5 years.

## G2: Scope

- G2.1.1** For teams building a hydrogen-powered vehicle, the Hydrogen Rules and the FS-Rules apply, whereby the Hydrogen Rules take precedence in the case of a conflict.
- G2.1.2** The Hydrogen Rules are aimed at teams in only one of the following classes:
- Hydrogen fuel cell technology within the existing EV class - short: [FCEV]
  - Hydrogen combustion within the existing CV / CV hybrid class - short: [H2CV] / [H2HY]
- G2.1.3 TBD:** Vehicles powered by hydrogen may be scored in existing or separate classes at the competition organizers discretion.

## G3: Hydrogen Tank Whitelist and Whitelist Addition Request Form

- G3.1.1** Only hydrogen tanks which are on the final Hydrogen Tank Whitelist are allowed to use in the season 26/27.
- G3.1.2** In case a team is considering using a hydrogen tank not currently listed on the Hydrogen Tank Whitelist, they have to submit a Whitelist Addition Request Form (WARF). The WARF template is provided on the competition websites. Also the current version of the Hydrogen Tank Whitelist can be found on the competition websites.
- G3.1.3** The deadline for the submission of the WARF is Friday 2026-11-27 13:00 CET.
- G3.1.4** Submission for all competitions is done via the following e-mail: [hydrogen@fs-world.org](mailto:hydrogen@fs-world.org) in .pdf format
- G3.1.5** The final version of the Hydrogen Tank Whitelist for the season 26/27 will be published latest on Saturday 2026-12-19 13:00 CET.

## G4: Hydrogen System Form

- G4.1.1** All teams must submit a Hydrogen System Form (H2SF) using the newest H2SF template provided on the competition websites.
- G4.1.2** The deadline for the submission of the H2SF is Friday 2027-03-12 13:00 CET.
- G4.1.3** Submission for all competitions is done via the following e-mail: [hydrogen@fs-world.org](mailto:hydrogen@fs-world.org)

**G4.1.4** Contrary to A 5.4.2 of the Formula Student Rules, teams that do not submit documents until 24 hours after the respective deadline are not de-registered. Instead minimum 20 penalty points will be applied.

**G4.1.5** If the officials request a correction of the H2SF, A 5.3 of the Formula Student Rules applies.

## **G5: Structural Equivalency Spreadsheet**

**G5.1.1** The team must use the newest available Structural Equivalency Spreadsheet (SES).

**G5.1.2** Teams with a chassis according to the rule G1.1.3 or G1.1.4 are not allowed to use old SES-templates.

**G5.1.3** If a chassis according to the rule G1.1.3 or G1.1.4 is used the team has to explain in the SES the differences between the rules which have been used to build the vehicle and the current version of the Formula Student Rules. The team has to explain why their current design is a safe design or what must be updated in their vehicle.

**G5.1.4** The rollover protection envelope according to T1.1.16 of the Formula Student Rules must be shown as a 3D surface in the SES3D.

# F: Fuel and Fuel System

## F1: Fuel

- F1.1.1** The allowed forms of power in addition to those covered by the Formula Student Rules (Gasoline, E85 and Electric) are specified as Hydrogen Combustion Vehicle [H2CV], Hydrogen Combustion Hybrid Vehicle [H2HY] and Hydrogen Fuel-Cell Electric Vehicle [FCEV].
- F1.1.2** Only hydrogen in the form of compressed gas is provided at the competition with a maximum Nominal Working Pressure (NWP) of 350 bar. It is hydrogen according to ISO 14687: 2025 - at least grade D. Cryogen, liquid or cryo compressed hydrogen is not allowed.

## F2: Fuel System

- F2.1.1** Hydrogen tanks, pressure regulators and fuel cells are considered critical components according to T3.3.1 in the Formula Student Rules. All parts containing hydrogen under normal operating conditions must be located within the rollover protection envelope according to T1.1.16 in the Formula Student Rules. The end of the vent line according to S5.1.2 is excluded from this rule.
- F2.1.2** All parts containing hydrogen including the hydrogen tank must be located behind a firewall as defined in T4.8 in the Formula Student Rules.
- F2.1.3** Components considered as critical components in F2.1.1 that are less than 350 mm above the ground must be protected from impacts, see T3.15 in the Formula Student Rules. Impact protection must follow T3.16 when having bolted attachments. Hydrogen-containing tubing / piping / lines in front of the front hoop may alternatively be shielded by the front bulkhead support structure according to T3.14 in the Formula Student Rules. Impact Structures between the Front Hoop and Main Hoop are considered Side Impact Structures, see T3.15.1. Tubing between driver and hydrogen tank (where the side impact structure is normally located) must be equivalent to the Front Bulkhead Support tubing according to T3.2.1 of the Formula Student Rules. The hydrogen tank must be protected from direct ground contact by a triangulated structural protective element which must be equivalent to the Front Bulkhead Support tubing according to T3.2.1 of the Formula Student Rules.
- F2.1.4** If a structural side pod is used, a firewall must shield the driver both in a seated position and while exiting the vehicle. This side pod must be sufficiently ventilated. The formation of hydrogen pockets must be prevented. See chapter S5.
- F2.1.5** The hydrogen tank and other parts containing hydrogen must be shielded from any heat sources that can reach a temperature of more than 85 °C (e.g. brake discs or exhaust system) or the temperature rating of the hydrogen component - whichever is lower.
- F2.1.6** Accumulation of the hydrogen in insulation or shielding materials must be prevented (e.g. foam or other porous materials are prohibited).
- F2.1.7** The hydrogen tank, on tank device (OTD) and other parts containing hydrogen must be shielded from debris and other materials thrown up from the track and by the wheels. Shielding with a minimum thickness of 1 mm must cover any straight line between the wheels or the track and the aforementioned components. Shielding located less than 100 mm from the top of the firewall as defined in F2.1.4 must be perforated with a maximum hole diameter / size of 3 mm and a perforation area of at least 20 %. The difference between pitch and hole diameter / size must be greater than or equal to the sheet thickness.

- F2.1.8** The lowest point of any part of the hydrogen system may only be lower than the line between the lowest point of the main hoop and the lowest triangulated chassis member beyond the hydrogen system if it is protected from hitting the ground by a structure mounted directly to the chassis.
- F2.1.9** No excess volume in the hydrogen supply lines with the intent of buffering may be installed. An exception is specified in C1.1.7 for [H2CV] & [H2HY].
- F2.1.10** Wherever structural parts are attached to an existing primary structure (nodes from primary structure must be used for frames), a minimum of four attachments compliant to T3.16 of the Formula Student Rules must be used. These attachment points must not be combined and must be at least 200 mm apart, measured from the points located midway between the bolt centers of each attachment. Alternative joining methods may be used. Equivalency must be shown. Bonded joints are allowed according to T3.2.8 of the Formula Student Rules if peeling is prohibited.
- F2.1.11** All parts considered as primary structure or used to fulfill any intent of primary structure must be directly attached to the primary structure.

### **F3: Hydrogen Tank**

- F3.1.1** Only hydrogen tanks listed on the final Hydrogen Tank Whitelist are eligible for use in the 26/27 season. A hydrogen tank is only eligible to be added to the Hydrogen Tank Whitelist if it is ...
- ... designed and manufactured for at least 350 bar nominal pressure of hydrogen
  - ... and certified by an accredited body (typically in the country of origin)
  - ... and marked or stamped accordingly. e.g. according to the international automotive regulations UNECE GTR No. 13 – Hydrogen and Fuel Cell Vehicles (UN GTR No. 13) like UNECE Regulation No. 134 – Hydrogen and Fuel Cell Vehicles (UN R134) or GB/T 35544-2025 – Safety requirements for fuel cell electric vehicles (GB/T 35544-2025), CSA HGV 2 — Compressed Hydrogen Gas Vehicle Fuel Containers (CSA HGV-2) or the old EC Regulation (EC) No 79/2009 or comparable
- F3.1.2** Hydrogen tanks with visible defects, e.g. abrasion, cuts or chemical damage may not be used without clarification of the manufacturer. A questionable tank will be confiscated until the end of the competition or until there is a written clarification with the manufacturer.
- F3.1.3** The hydrogen tank must be securely mounted to the primary structure and must be assembled according to the manufacturer's specifications. The hydrogen tank has to be protected from mechanical stresses introduced by e.g. chassis deformation or engine vibration (e.g. flexible mounts). The hydrogen tank itself and its mounting to the chassis must adhere to T3.3.1 of the Formula Student Rules. Any components containing tank pressure must be mounted at a minimum distance of 25 mm from the inside of the surrounding outward facing parts of the primary structure except the floor.
- F3.1.4** The OTD must be mounted directly to the hydrogen tank and it must include both an on tank valve (OTV) and a thermal activated pressure relief device (TPRD). All these must vent to a “safe venting location”, see S5.1.2. The hydrogen tank may be certified according to ISO 19881, which covers only the design validation and type testing of the tank itself. ISO 19881 does not cover the approval of the OTD, nor the approval of the combined assembly of hydrogen tank and OTD/OTV. Therefore, if the hydrogen tank holds only an ISO 19881 certification, the tank–OTD/OTV combination must undergo separate testing and approval according to the applicable requirements of e.g. UN Regulation No. 134. In standard practice, the hydrogen tank and the OTV are tested together as a combined unit in the configuration required by e.g. R134 and are certified accordingly.

- F3.1.5** An analogue pressure gauge must be installed between the OTD and the pressure regulator.
- F3.1.6** A pressure regulator must limit the downstream pressure of the hydrogen to a maximum of 40 bar or the maximum operating pressure of the lowest rated component and must be mounted as close as possible to the OTD. The pressure regulator must be rated and suitable for mobile applications. Every pressure level in the system must be protected against overpressure by mechanical means (e.g. burst plate venting to a safe venting location see S 5.1.2). Excess pressure must also trigger the Shutdown Circuit using a N/C switch.
- F3.1.7** The output pressure of the pressure regulator must be mechanically limited to a maximum of 40 bar and must not be adjustable. Additional pressure regulators are permitted downstream of this regulator and are not subject to the restrictions in this rule.
- F3.1.8** The hydrogen tank must be equipped with a connector that is designed to be repeatedly reconnected. This has to be installed after all tank mounted components, see F3.1.4 to F3.1.6.
- F3.1.9** The hydrogen tank must be protected against subcooling, if the temperature in the hydrogen tank falls below -40 °C due to gas extraction. If the temperature falls below this value, the OTD must close.
- F3.1.10** Each hydrogen tank must be equipped with structurally sound means to be lifted from the vehicle by two people with both hands each (e.g. handles or easily accessible structural tubes). These means may be removable without tools. Gripping surfaces have to be clearly marked in neon pink.
- F3.1.11** Access to the OTD must be possible without tools. It must **NOT** be possible to operate the OTV without tools. A label must be placed next to the access point indicating which tool is required and indicate the direction to close the OTV with an arrow.



**Figure 1:** Example: A 6 mm Allen key is needed to close the OTV clockwise

- F3.1.12** The hydrogen tank system must be able to be bled down to the lowest pressure allowed by the manufacturer. This must be possible with the hydrogen tank system removed from the vehicle and must be conducted using a dedicated device designed for this purpose.
- F3.1.13** For bleeding the hydrogen tank a manual valve and a female G¼" connection must be provided after the primary pressure regulator. The port must be fully sealed with a pressure rated cap when not in use. This device may be removed from the vehicle during normal operation. A valve block with a manual valve and a port for the connector between the hydrogen tank and the vehicle is recommended, see F3.1.8. Bleeding the tank must be possible with the hydrogen tank mounted to the vehicle (not using any lifting devices) or the transportation cart as well as by itself.
- F3.1.14** A grid independent power supply for all non manual valves in the hydrogen tank system must be provided by the team. For electrically actuated valves the use of a lead acid battery with a fuse, waterproof container and connectors is highly recommended.

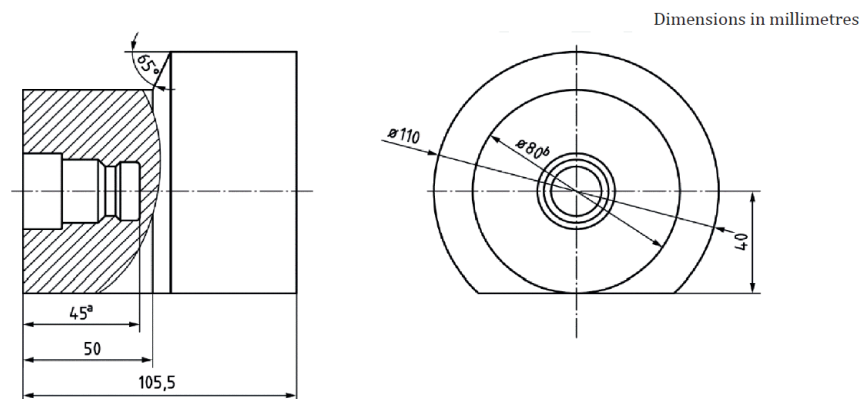
## F4: Lines and Fittings

- F4.1.1** All pipes, fittings, hydrogen tanks, regulators, solenoid valves, seals and other equipment exposed to pressurized hydrogen must be suitable for hydrogen and the pressure in use according to the manufacturer.
- F4.1.2** All combinations of fittings may only be used according to either manufacturer's documentation.
- F4.1.3** Lines carrying the unregulated tank pressure must be as short as possible in order to connect the hydrogen tank with the components of the rules F3.1.4 to F3.1.8.
- F4.1.4** The fuelling valve must be H35 (normal flow or designed for a maximum mass flow of 60 g/s) and specified in accordance with ISO 17268 - Connecting devices for refuelling gaseous hydrogen for land vehicles.
- F4.1.5** The fuelling valve must be positioned in a way that it is protected but easily accessible with a fueling nozzle according to ISO 17268.

ISO/DIS 17268-1:2023(en)

### Annex A (normative)

#### Receptacle/nozzle interface envelope



- <sup>a</sup> Minimum length of the receptacle that shall be clear of provisions for attachment of receptacle or protective cap.
- <sup>b</sup> For minimum coupling clearance only. System designers shall ensure that the dust or protective cap operates freely in the provided space,

NOTE 1 Depending on the vehicle design, the overall depth of the fuelling cavity doesn't need to be as large as indicated here.

NOTE 2 The flat side of the clearance should be downward toward the ground.

**Figure 2:** Screenshot of ISO 17268 with receptacle/nozzle interface envelope

# C: Hydrogen Combustion Vehicles [H2CV] & [H2HY]

## C1: Engine

- C1.1.1 TBD:** The vehicle may be driven by any four stroke internal combustion engine, irrespective of its mechanical layout (eg. reciprocating piston, Wankel, ...). The number of combustion chambers are not limited. The total displaced volume of the engine must not exceed 1600 cc. If an engine concept utilizing over 1000 cc is being considered, the concept must be submitted via email to [hydrogen@fs-world.org](mailto:hydrogen@fs-world.org) by Friday 2026-12-18 13:00 CET at the latest and approval must be obtained.
- C1.1.2** It is allowed to inject water or other non combustible substances into the intake and/or combustion chamber with the goal of reducing the tendency of abnormal combustion phenomena. This applies to H2CV/H2HY only.
- C1.1.3** Direct injection (DI) and port fuel injection (PFI/MPI) are allowed.
- C1.1.4** The injection pressure is limited to 40 bar. Exceptions may be requested with a full system documentation by Friday 2026-12-18 13:00 CET at the latest to [hydrogen@fs-world.org](mailto:hydrogen@fs-world.org).
- C1.1.5** The pressure at direct injection must be below the limit specified by the manufacturer for the injection system used. The rail, the injector and any necessary connector must be properly dimensioned, designed, manufactured and assembled in order to withstand the expected loads, be positively locked and directly attached to the engine block or cylinder head using metal parts. Certification in accordance with ISO 19887, ISO 12619 or HGV 3.1 is recommended. Exceptions may be requested with a full system documentation by Friday 2026-12-18 13:00 CET at the latest to [hydrogen@fs-world.org](mailto:hydrogen@fs-world.org).
- C1.1.6** The crankcase must be equipped with an open crankcase ventilation system and it must vent to a safe location as described in S5.2.1.
- C1.1.7** Devices mitigating pressure pulsations (e.g. buffer volume) may only be installed in pressure lines operating at injection pressure level. These have to comply with rule F4.1.1.

## C2: Boosting

- C2.1.1** Boosting is allowed.
- C2.1.2** Boosting systems may be driven by any means e.g. belts, gears, electrically or any combination of drive systems.
- C2.1.3** In case of an even partially electrically power boosting system, electrical energy may only be supplied from a system that complies with the current Hybrid Rules.
- C2.1.4** Belts, gears, chains etc. need a scatter shield as defined in T7.3 of the Formula Student Rules.

## C3: Hybrid

- C3.1.1** Building a CV hybrid with hydrogen combustion is allowed, this is referred to as H2HY.

## C4: Power Limitation

- C4.1.1 TBD:** Currently there is no power limitation for H2CV/H2HY powertrains.
- C4.1.2 TBD:** The hydrogen mass flow is unlimited.
- C4.1.3** The air mass flow is unlimited.
- C4.1.4** The maximum overall fuel tank capacity for H2CV/H2HY is 2 kg.

# E: Hydrogen Fuel Cell Electric Vehicles [FCEV]

## E1: Hydrogen System definition

**E1.1.1** All Parts of the hydrogen system that are electrically connected to the Tractive System (TS), are considered as TS and must comply with the respective Formula Student Rules. Diodes are not considered as separation.

## E2: Power Limitation

**E2.1.1** The hydrogen mass flow and the air mass flow are unlimited.

**E2.1.2** The maximum overall fuel tank capacity is 2 kg.

**E2.1.3** The capacity of the HV accumulator is not limited, supercapacitors are allowed.

**E2.1.4** Maximum power output of the TSAC must not exceed 80 kW, see EV2.2 in the Formula Student Rules, and is recorded with a data logger.

**E2.1.5** Tractive energy is defined as the time integral over the Endurance run of the electrical power measured at the input of the inverter(s). This is supervised by a second data logger placed at the TS motor-controller(s) input. The total power of all inverter inputs combined must not exceed 100 kW.

**E2.1.6** Both data loggers are identical to the current EV infrastructure.

**E2.1.7** For the Endurance, a minimum of 40% of the tractive energy must come from the fuel cell.

## E3: Discharge Circuit

**E3.1.1** EV 6.1.5 of the Formula Student Rules must be met by all components that are not covered by the Formula Student Rules.

**E3.1.2** The voltage inside the FCSC may stay above 60 V DC if all of the following conditions are met

- FCIRs are used to galvanically separate the fuel cell from the TS
- The FCSC complies with EV 5.5 of the Formula Student Rules

**E3.1.3** The FCIRs must be located in the FCSC and can be placed before or after an optional DC/DC converter.

**E3.1.4** If parts of the hydrogen system are galvanically separated from the TS (e.g. by relays or galvanically isolated DC/DC converters), Hydrogen System Measurement Points (HSMPs) must be installed.

**E3.1.5** The HSMPs must comply with EV 4.7 of the Formula Student rules but must be labeled with "HS+" and "HS-" instead and be connected to the fuel cell side of the galvanic isolation. The respective rules for TS components also apply unchanged to the TSMS.

**E4.1.3** Closing the Shutdown Circuit (SDC) by any part defined in the Formula Student Rule EV6.1.2 must not (re-) activate the TS.

## E4: Fuel Cell System – General Requirements

**E4.1.1** The fuel cell stack must be enclosed in the Fuel Cell System Container (FCSC).

**E4.1.2** The FCSC must be actively ventilated to avoid any accumulation of hydrogen. Minimum air mass flow must be guaranteed. Ventilation mass flow must be measured.

- E4.1.3** There must be ventilation holes in the FCSC. These holes must follow S5.1.2.
- E4.1.4** It must be possible to open the FCSC for technical inspection. Unmodified OEM fuel cell system containers may not be opened if manufacturer documentation is provided. A Scrutineer can always command the team to open their container.
- E4.1.5** FCSC must be labeled with reasonably sized stickers according to “ISO 7010-W012” (triangle with a black lightning bolt on a yellow background). Fuel cell container stickers must contain text “Fuel Cell Inside”. If the voltage is more than 60 V DC, the sticker must also contain the text “High Voltage”.

## **E5: Fuel Cell System Container – Electrical Configuration**

- E5.1.1** It must not be possible to have current flowing into the fuel cell.
- E5.1.2** EV 4.1.2 of the Formula Student Rules does not apply to the fuel cell stack.
- E5.1.3** Every wire used in a FCSC, regardless of whether it is part of the LVS or hydrogen system, must follow EV4.5.2, EV4.5.3, and EV4.5.5 in the Formula Student Rules.
- E5.1.4** Each FCSC must have one prominent voltage indicator, voltmeter, or red LED visible even in bright sunlight that will continuously illuminate whenever a voltage greater than 60 V DC is present at the stack poles (before the fuse and the stack protection diode and FCIRs). This indicator must be clearly marked with "Stack Voltage Indicator".
- E5.1.5** The indicator must be hard-wired electronics without software control, directly and only supplied by the fuel cell, and always working, even if disconnected from the LVS.

## **E6: Fuel Cell System Container – Mechanical Configuration**

- E6.1.1** The FCSC must be located behind a firewall as defined in T4.8 of the Formula Student Rules or must be made of these materials and must fulfill all other requirements of a firewall.
- E6.1.2** The fuel cell itself and its mounting to the FCSC must adhere to T3.3.1 of the Formula Student Rules. The fuel cell must be mounted according to manufacturer's specifications.
- E6.1.3** The FCSC itself and its mounting to the chassis must adhere to T3.3.1 of the Formula Student Rules. The FCSC must be protected from impacts, see T3.15 of the Formula Student Rules. Impact protection must follow T3.16 of the Formula Student Rules when having bolted attachments. The FCSC must not be part of this structure.
- E6.1.4** All FCSC materials as well all structural parts used must be fire retardant, see T1.2.1 of the Formula Student Rules. All calculations must be conducted for an ambient temperature of 60° except for metallic materials and continuous fiber-reinforced laminates.
- E6.1.5** The design of the FCSC and its contents, calculations and/or tests must be documented in the H2SF. This includes materials used, drawings, images, fastener locations, segment weight, cell, and segment position.
- E6.1.6** The FCSC must be constructed of steel or aluminium. With the following requirements:
- The bottom of the FCSC must be at least 1.25 mm thick if made from steel or 3.2 mm if made from aluminium.
  - The internal and external vertical walls, covers, and lids must be at least 0.9 mm thick if made from steel or 2.3 mm if made from aluminium.

**E6.1.7** Alternative materials are allowed with proof of equivalency per T3.4 and T3.5 for composite structures of the Formula Student Rules. When alternative materials are used, test samples must be presented at technical inspection.

**E6.1.8** Composite FCSC must satisfy the following requirements:

- Data obtained from the laminate perimeter shear strength test and three-point bending test, see T3.6, should be used to prove adequate strength is provided.
- Each attachment point requires steel backing plates with a minimum thickness of 2 mm. Alternate materials may be used for backing plates if equivalency is approved.
- The calculations and physical test results must be included in the H2SF.

**E6.1.9** All fasteners used within or to mount the FCSC must comply with T10. Fasteners within the FCSC used for non-structural parts, e.g. PCBs, do not have to follow T10.1.2. Fasteners made of electrically non-conductive material within the FCSC used for non-structural parts do not have to follow T10 of the Formula Student Rules.

**E6.1.10** The mounting of the FCSC requires a minimum of 4 attachment points. Any brackets used to mount the FCSC must be made of steel 1.6 mm thick or aluminium 4 mm thick and must have gussets to carry bending loads.

**E6.1.11** The FCSC needs venting holes as described in S5.1.2.

## **E7: OEM Fuel Cell System Container**

**E7.1.1** If the fuel cell is supplied with a casing (and in this case only), this casing (without any modification) can be considered to be the FCSC. This casing must fulfill all FCSC mechanical rules from E6.

**E7.1.2** If the OEM container does not comply with the E6 section of these rules, the additionally required components must be placed in a housing that complies with the Formula Student Rules related to TS enclosures.

**E7.1.3** Any HV connector between the OEM FCSC and additional enclosures, needed to comply with these rules, must be mechanically held in place. It must not be possible to disconnect them without tools. It must be possible to seal the locking mechanism during scrutineering.

**E7.1.4** If the rules of chapter E7 are not fulfilled, the additional components must be placed in a FCSC, that contains the OEM FCSC.

## **E8: Cooling**

**E8.1.1** Dedicated fuel cell coolant may be used (must refer to stack supplier requirements), whereby its use is limited to only cooling the fuel cell. Other cooling systems must only use plain water, air or oil as coolant, see T1.2.2 of the Formula Student Rules. Ions or non H<sub>2</sub>O components may be removed (e.g. minerals and deionization).

**E8.1.2** Fuel cell coolant electrical conductivity must be measured at any time by the fuel cell control unit. The officials can ask for the value at any time. Teams have to show the value with a laptop.

## **E9: Fuel Cell System Management**

**E9.1.1** The FCCU must continuously measure the following parameter of the hydrogen tank:

- Hydrogen detection sensor at the top of the FCSC

**E9.1.2** The FCCU must continuously measure the following fuel cell electrical parameters (this is often done by a CVMD supplied with the stack from the stack supplier):

- All cell voltages
- Cells with minimum and maximum voltages position must be identified
- Stack current must be measured (if information not given by the DCDC)
- Stack voltage must be measured (if information not given by the DCDC)

**E9.1.3** The FCCU must continuously measure the following anode parameters:

- Stack inlet pressure
- Stack outlet pressure (optional)

**E9.1.4** The FCCU must continuously measure the following cathode parameters:

- Stack inlet pressure
- Stack outlet pressure (optional)

**E9.1.5** The FCCU must continuously measure the following cooling and ventilation parameters:

- Coolant electrical conductivity
- Temperature at stack inlet
- Temperature at stack outlet
- Air mass flow dedicated to ventilation of containers

**E9.1.6** The FCCU must open the hydrogen related SDC, if any measurement reaches critical values according to the stack manufacturer's datasheet.

**E9.1.7** FCCU signals are System Critical Signals, see T11.9 in the Formula Student . The loss of any safety or control related signal must result in an HS SDC opening.

**E9.1.8** It must be possible to individually disconnect the current sensor during technical inspection if any wire is used.

**E9.1.9** The FCCU must be able to read and display all measured values according to EV5.8.3 of the Formula Student Rules in a single overview e.g. by connecting a laptop to the FCCU at any place and any time e.g. inside the dynamic area.

**E9.1.10** If CAN communication is used to communicate with the FCCU or the CVM, a dbc file must be available.

## **E10: Insulation Monitoring Device**

**E10.1.1** The vehicle must be equipped with a tunable isometer. When performing the EV testing, the isometer must be set to a 500 Ohm per Volt (to be calculated with the highest embedded voltage) measured between the powertrain and driver compartment.

**E10.1.2** The IMD response may be tunable.

- If a non-tunable IMD is used, the IMD response value must be set to  $\geq 500 \Omega/V$ , related to the maximum voltage in the vehicle.
- If a tunable IMD is used, its response must be set to  $\geq 500 \Omega/V$ , related to the maximum voltage in the vehicle until the electrical inspection is finished. (Bender ISO 175C for example.) Once the team has been allowed to start their fuel cell, the response value must be set to a lower value (150 k $\Omega$  whatever the maximum voltage in the vehicle).

**E10.1.4** If a tunable IMD is used, the team must be able to show the response threshold to any judge at any time (connected to a laptop is possible).

# S: Safety

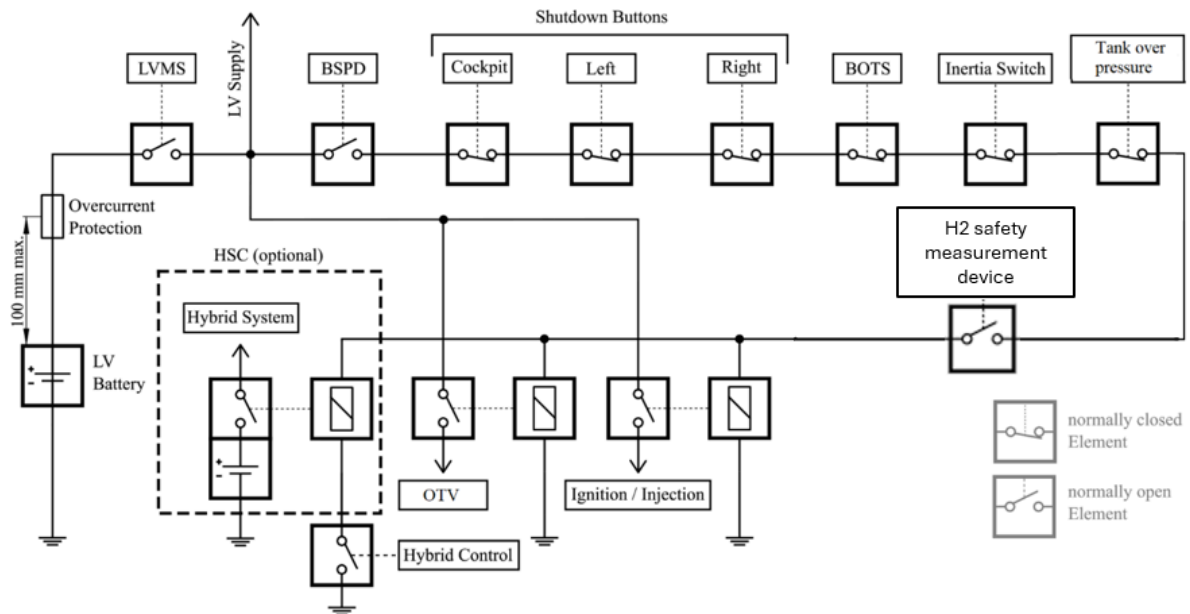
## S1: Hydrogen Safety Officer

- S1.1.1** Every participating team has to appoint two to four Hydrogen Safety Officers (HSO) for the competition. ESO and HSO may be the same person.
- S1.1.2** The HSOs are responsible for all work on the hydrogen system carried out on the vehicle during the competition. The HSOs are responsible for all work on the vehicle that is carried out with the hydrogen tank installed.
- S1.1.3** The HSOs are the only persons in the team who may declare the vehicle hydrogen safe and discharged, in order for work to be performed on any system of the vehicle by the team.
- S1.1.4** A HSO must always be with the vehicle when the hydrogen tank is installed and must carry out the installation and removal themselves and then declare the vehicle safe for further work. At least one HSO per team must be included in the four members per team, if the vehicle is on track or in the dynamic area.
- S1.1.5** At least one HSO must be reachable by phone at all times during the competition.
- S1.1.6** The HSOs must be valid team members and must have a student status, see rule A4.2.6 of the Formula Student Rules.
- S1.1.7** The HSOs must attend practical and theoretical training for working on hydrogen like DGUV FBHM-99 level E2 or comparable which must be held by an external expert. A certificate of the training must be shown at scrutineering. The certificate is valid for 2 years, after which a refresher course is required.
- S1.1.8** The vehicle number, the university name and the HSOs phone numbers must be displayed and written in Roman Sans-Serif characters of at least 20 mm height on the hydrogen tank or its cover. The characters must be clearly visible and placed on a high-contrast background.

## S2: Hydrogen System Master Switch (HSMS)

- S2.1.1** An Hydrogen System Master Switch (HSMS) according to T11.2 must be part of the SDC of FCEV, see EV6.1.2 of the Formula Student Rules.
- S2.1.2** The HSMS must be fitted with a “lockout/tagout” capability to prevent accidental activation of the Hydrogen System.
- S2.1.3** The HSMS must be mounted in the middle of a completely neon pink circular area of  $\geq 50$  mm diameter placed on a high contrast background.
- S2.1.4** The HSMS must be marked with “HS” and a symbol according to “ISO 7010-W012” (triangle with a black lightning bolt on a yellow background).

### S3: Shutdown Circuit for H2CV and H2HY



**Figure 3:** Schematic representation of a Shutdown Circuit for H2CV and H2HY

**S3.1.1** The Shutdown Circuit (SDC) directly controls all electric power to the ignition, fuel injectors and OTV. It must act through a minimum of two mechanical relays. One relay for the OTV and at least one relay for injection and ignition.

**S3.1.2** The SDC is defined as a series connection of at least the following:

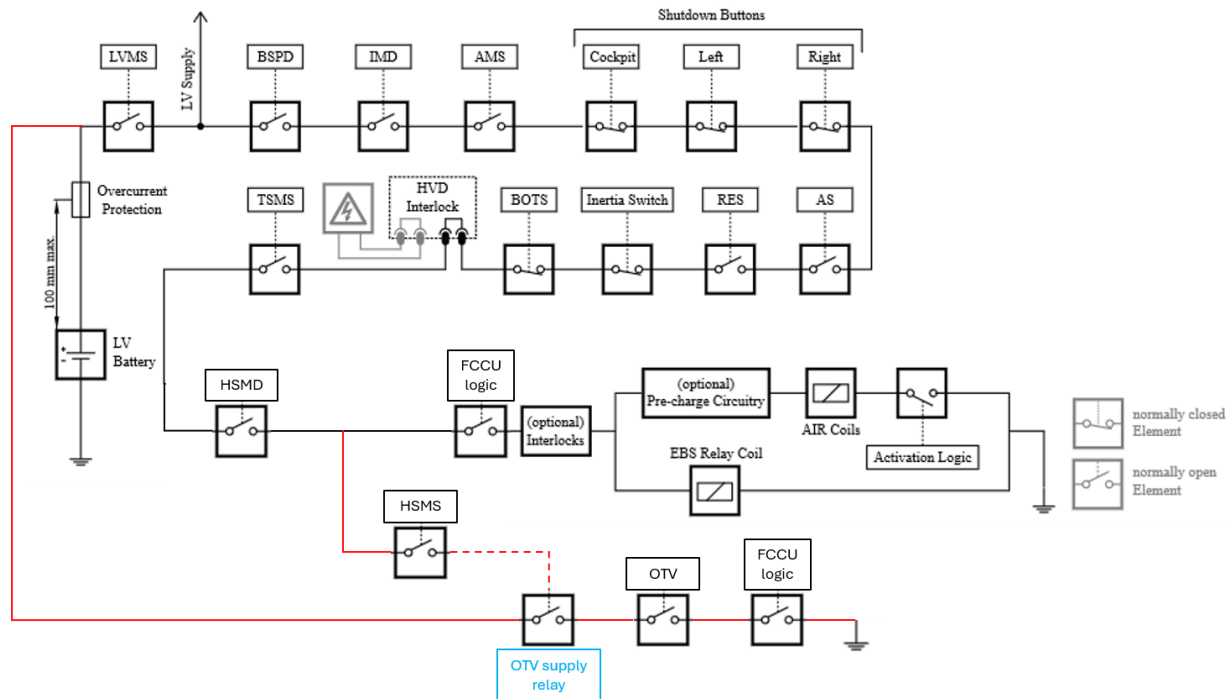
- LVMS
- BSPD, see T11.6 of the Formula Student Rules
- three shutdown buttons, see T11.4 of the Formula Student Rules
- BOTS, see T6.2 of the Formula Student Rules
- inertia switch, see T11.5 of the Formula Student Rules
- H2 Safety Measurement Device, see S10

**S3.1.3** All circuits that are part of the SDC must be designed in a way that in the de-energized/disconnected state they open the SDC.

**S3.1.4** When the Shutdown Circuit is triggered, no more gas may flow from the hydrogen tank into the low pressure part of the fuel system immediately. This must be ensured with the OTV being normally closed.

**S3.1.5** When the Shutdown Circuit is triggered, the ignition of the engine must be switched off.

## S4: Shutdown Circuit for FCEV



**Figure 4:** Alternative schematic representation of a Shutdown Circuit for FCEV.

Comment: The part of the SDC in red is related to hydrogen and is denoted as the hydrogen related SDC.

**S4.1.1** There must be a Shutdown Circuit which must include the same equipment and parts as the Shutdown Circuit in EV6 of the Formula Student Rules. Additionally, it must contain the following hydrogen related components:

- HSMS, see S2
- H2 Safety Measurement Device (HSMD), see S10
- FCCU activated relays
- OTV

**S4.1.2** All circuits that are part of the hydrogen related SDC must be designed in a way that in the de-energized/disconnected state they open the HS related SDC.

**S4.1.3** When the Shutdown Circuit is triggered, no more gas may flow from the hydrogen tank into the low pressure part of the fuel system. This must be ensured with the OTV being normally closed.

**S4.1.4** When the hydrogen related Shutdown Circuit is triggered the hydrogen system must be switched off, all valves must return to their default position and the fuel cell HV-bus(es) must be passively or actively discharged.

**S4.1.5** When any other part of the shutdown circuit (that is not hydrogen related) is triggered, the hydrogen system and the HV-accumulator must be switched off.

**S4.1.6** It is allowed to supply the OTV valves through an external normally open relay (with the command coming from the hydrogen related SDC), no software must be involved.

**S4.1.7** An OTV supply relay can be added. This must be a normally open mechanical relay. This must be a commercially available timed relay (staying closed for a maximum of 2 s after the SDC is opened).

## S5: Ventilation

**S5.1.1** All compartments containing hydrogen components must be safely vented and in case of a leakage, no hydrogen may accumulate.

**S5.1.2** All compartments containing hydrogen components that do not have an opening of at least 1900 mm<sup>2</sup> (e.g. 50 mm circle) in all high points have to be connected to one singular safe venting location. The connection from all these high points must be a sealed path of at least 1900 mm<sup>2</sup> internal cross section. The venting location has to be:

- unobstructed from above
- be outside the cockpit
- behind the main hoop
- point away from the driver and the hydrogen tank
- be clearly marked with a neon pink circle with a 20 mm line with and “H2 vent”
- must not terminate any lower than 75 mm from the highest point of the vehicle

Several connections may terminate in a common venting location.

**S5.1.3** Dedicated venting ports of individual hydrogen components (e.g. OTD or Fuel Cell emergency vents and over pressure protection devices) may be routed to a safe venting location with metallic piping of at least the dimensions specified in the manufacturers documentation.

**S5.1.4** Any active ventilation system must push the air and not suck it and must be powered by LV as soon as HSMS is on. The use of software is strictly prohibited.

## S6: Grounding

**S6.1.1** All metal parts of the hydrogen components must be grounded to the low voltage system ground according to EV3.1 of the Formula Student Rules.

**S6.1.2** A metal tab of at least 30x30x2 mm has to be connected to the grounding path of the tank system. Access must be not obstructed in ready to race state and the tab must be functional with the hydrogen tank in as well as out of the vehicle. This grounding connection point has to be clearly marked with the earthing symbol according to IEC 60417.



**Figure 5:** Earthing symbol according to IEC 60417

## S7: Arrival and departure to the competition

**S7.1.1** The team must be able to show the full functionality of the hydrogen system. E.g TS accumulator must have left over capacitors to run the FC system.

## S8: Pits and tools

**S8.1.1** No hydrogen tanks or other devices containing hydrogen are allowed inside the pits. Vehicles have to be in the “H2 system discharged” state to enter any enclosed structure.

**S8.1.2** The hydrogen tank has to be removed and stored at the SHYTTA prior to the vehicle entering the pits.

- S8.1.3** Each team has to bring 2 hydrogen detectors to the competition. At least one has to be of an actively pumping type. The correct operation of these detectors has to be demonstrated during Hydrogen Scrutineering with calibration gas of a known H<sub>2</sub> concentration (provided by the team).
- S8.1.4** Teams must provide a complete set of tools needed to remove the hydrogen tank during Hydrogen Scrutineering. This set has to remain at the SHYTTA at all times during the competition. It will only be returned after the venting of the tank following endurance.

## **S9: Storage of the hydrogen tank and refueling**

**S9.1.1** Hydrogen tanks must always be stored according to the manufacturer's requirements.

**S9.1.2** The hydrogen tanks are only be fitted into the vehicle for:

- hydrogen-specific scrutineering
- refueling with hydrogen (optional)
- dynamic disciplines
- dynamic testing in the testing area
- static testing in the engine test area

Please check the competition handbooks for details.

**S9.1.3** After any of the cases from S9.1.2 the hydrogen tank has to be removed from the vehicle at a designated area and be returned to the SHYTTA as soon as possible.

**S9.1.4** Each team must provide a handcart according to EV8.1.2 to EV8.1.5 of the Formula Student Rules. The hand cart must comply with the following Formula Student Rules for transporting the hydrogen tank: EV8.1.6, EV8.1.8 to EV8.1.10.

**S9.1.5** The loaded handcart must not be prone to tip over with any steering position.

**S9.1.6** The handcart must not contain any electronics. This handcart may be fitted with a single-pitched solid roof for outdoor storage. This roof must not have any enclosed highpoints and must adhere to S5. The tanks grounding tab must be usable while mounted on the cart and all metal parts of the cart must also be connected to this, see S6. A container to store all tools needed to install and remove the hydrogen tank to the vehicle may be fitted, see H3.1.1.

**S9.1.7** The vehicle number, the university name and the HSOs phone number(s) must be displayed and written in Roman Sans-Serif characters of at least 20 mm high on the cart. The characters must be clearly visible and placed on a high-contrast background.

**S9.1.8** If a team uses more than one hydrogen tank, they must all be safely stored on one handcart or there must be as many handcarts as there are hydrogen tanks.

## **S10: H<sub>2</sub> Safety Measurement Device (H2SMD)**

**S10.1.1** The H<sub>2</sub> Safety Measurement Device (H2SMD) must be a standalone non-programmable circuit that opens the SDC under the following conditions:

- Tank temperature is too high (+85 °C or lower depending on tank specifications) or too low (-40 °C or higher depending on tank specifications)
- Tank pressure is too high or too low (depending on tank specifications)
- Excess pressure in low pressure system (40 bars or lower depending of the low pressure system expected pressure)
- [FCEV Only] Excess pressure in the fuel cell hydrogen supply line (depending on the manufacturer's instructions)

Standalone is defined as there is no additional functionality implemented on all required PCBs.

**S10.1.2** If one or more sensors are disconnected from the H2 Safety Measurement Device the SDC must be and remain open.

**S10.1.3** If the SDC is opened by the H2 Safety Measurement Device, it has to be latched open by a non-programmable logic that can only be manually reset by a person at the vehicle who is not the driver (same as for the AMS and the IMD, see EV6.1.6 of the Formula Student Rules).

**S10.1.4** The H2 Safety Measurement Device must be directly supplied, see T1.3.1, from the LVMS, see T11.3.

**S10.1.5** It must be possible to separately disconnect each sensor signal wire from the H2 safety measurement device for technical inspection.

**S10.1.6** All necessary signals for the H2 Safety Measurement Device are System Critical Signal (SCS), see T11.9 of the Formula Student Rules.

**S10.1.7** A red indicator light in the cockpit that is easily visible from inside and outside the cockpit even in bright sunlight and clearly marked with the lettering "H2SMD" must light up if and only if the H2SMD opens the SDC. It must stay illuminated until the error state has been manually reset, see EV6.1.6. Signals controlling this indicator are SCS, see T11.9 in the Formula Student Rules.

**S10.1.8** It must be possible to connect the tank pressure and temperature sensors to a dedicated device during scrutineering and refueling (instead of connecting them to the H2 safety measurement device).

# H: Hydrogen Scrutineering

## H1: Scrutineering Procedure for hydrogen-powered vehicles

**H1.1.1** The technical inspection for a hydrogen combustion vehicle is divided into the following parts:

- Pre-Scrutineering
- Mechanical-Scrutineering
- Tilt Test
- Hydrogen Scrutineering
- Noise Test
- Brake Test

**H1.1.2** The technical inspection for a hydrogen fuel cell vehicle is divided into the following parts:

- Pre-Scrutineering
- Accumulator-Scrutineering
- Electrical- Scrutineering
- Mechanical-Scrutineering
- Tilt Test
- Hydrogen Scrutineering
- Rain Test
- Brake Test

## H2: Differences to Scrutineering as from FS Rules

**H2.1.1** Mechanical-, Electrical- and Accumulator Scrutineering is done without a mounted hydrogen tank.

**H2.1.2** For the Tilt Test a dummy of the hydrogen tank must be supplied by the teams and mounted to the vehicle. The dummy must have the same mass and center of gravity as the real hydrogen tank system (+/-1%). The dummy must have handles so that at least two people can handle it safely.

**H2.1.3** Tilt Test may be performed on either or both sides of the vehicle.

**H2.1.4** There are two Rain Tests for H2EV:

- The 1st rain test is done as EV only (hydrogen system OFF). If the team is using a tunable isometer, the threshold value must be set to the same limit as an EV vehicle (500  $\Omega$  per volt).
- The 2nd rain test is done with the hydrogen system ON. If the team is using a tunable isometer, the threshold may be lowered (minimum limit is 150 k $\Omega$ ).

Teams have the option to take only ONE rain test, but they must satisfy the EV threshold (500  $\Omega$  per volt) at any time even with the fuel cell running. In this case, they are not allowed to decrease the IMD threshold below this EV limit.

**H2.1.5** In case the team needs to empty their accumulator before this 2nd rain test, they may be allowed to drive in the practice area as EV if all Electrical Scrutineering, Brake and Tilt Tests are passed.

**H2.1.6** The Brake Test may be done with the fuel cell switched off.

**H2.1.7** Teams must provide a H2SMD bypass to perform Electrical Scrutineering without the hydrogen tank being connected.

### H3: Hydrogen Scrutineering

**H3.1.1** The following items must be presented at Hydrogen Scrutineering:

- Training certificates from all HSOs
- Copies of the H2SF and SES
- Copy of the WARF, if needed
- Copy of the IAD (only vehicles according to G1.1.3 und G1.1.4)
- Datasheets and documentation for all hydrogen components including certification and CoC of hydrogen tank and (if applicable) FC
- Manufacturer's specifications for installation (installation position, torques, commissioning procedures) of hydrogen tank and (if applicable) FC
- Copies of communications with officials and manufactures (if applicable)
- Tools needed for the (dis)assembly of parts for Hydrogen Scrutineering
- ALL Tools needed to install and remove the hydrogen tank to the vehicle (to remain at the SHYTТА)
- [EV-H2] EV tools
- IT device for checking every mandatory sensors
- 2 hydrogen leak detectors according to S8.1.3
- Leak detection spray according to DIN DVGW standard
- A gas, with less than 4% H2 for testing the leak detectors
- New seals for all H2 connectors
- Signs "H2 system discharged" and "H2 system HOT"
- Tank bleeding equipment as described in F3.1.11 to F3.1.13

### H4: Hydrogen system leak test

**H4.1.1** Procedure of the hydrogen leak test:

- Flush the system with hydrogen from the tank connection until only hydrogen is detected at the furthest end of the hydrogen system
- Check all hydrogen components and connections with a hydrogen detector
- Apply seal stickers to all tested hydrogen components and connections

**H4.1.2** The TS-System must be off during the hydrogen system leak test.

**H4.1.3** After passing the hydrogen system leak test a sign "H2 system HOT" has to be installed on the main hoop. The sign must be readable from the the front and the back of the vehicle and the TSAL must be still visible.

**H4.1.4** The hydrogen system leak test is part of the Hydrogen Scutineering and is executed by Officials.

**H4.1.5** The hydrogen system status signs must be visible from the front and the back of the vehicle. TSAL visibility can not not be impeded. See also S9.1.2 and S9.1.3.

### H5: Modifications and Repairs

**H5.1.1** Working on the hydrogen system is only allowed if the vehicle is in a "H2 system discharged and inert" state outside the SHYTТА. All tests done by the team must utilize an inert gas.

**H5.1.2** The following steps must be followed for work on the hydrogen system (in this order only!)

1. Notify the responsible officials about what kind of work is planed
2. Official remove the H2 inspection sticker (only after this point is the team allowed to start any work on the H2 system)
3. Perform the repairs

4. Hydrogen system leak test according to the rule H4 will be repeated and H2 inspection sticker reapplied

**H5.1.3** If any non-reusable seals from the hydrogen system are broken, the team is losing the inspection sticker for Hydrogen Scrutineering.

# D: Dynamics

## D1: General

**D1.1.1** Driverless vehicles powered by hydrogen are not allowed.

## D2: Endurance

**D2.1.1** A tank change or refueling during the driver change is not allowed.

## D3: Efficiency Procedure

**D3.1.1** Efficiency points based on the formula given in D9.4.1 in the Formula Student Rules.

**D3.1.2** The efficiency factor is calculated similarly to D9.4.2 in the Formula Student Rules with differences defined in the following rules.

**D3.1.3 TBD:** The efficiency for Hydrogen Combustion Vehicles [H2CV] & [H2HY] is measured and calculated as following:

- Record the size of the hydrogen tank
- The pressure and internal temperature of the hydrogen tank is measured before the Endurance at the SHYTTA
- The pressure and internal temperature of the hydrogen tank is measured after the Endurance at the SHYTTA
- Calculate the different between the two measurements to get the consumption of hydrogen
- The calculated consumed fuel mass of vehicles using hydrogen is multiplied by 2,765 to be comparable to the vehicles using 98 RON.

**D3.1.4 TBD:** The efficiency factor for Hydrogen Fuel Cell Electric Vehicles [FCEV] is measured and calculated as following:

- The tractive energy which is defined in E2.1.5 gives the database for the factor E
- This tractive energy is measured by the second data logger
- Each % that is more than 50% of the total tractive system energy which was converted from hydrogen, gives 1% reduction in the overall energy consumption
- Example: 53% of the tractive energy comes from the fuel cell ->  $E \cdot 0,97$

**D3.1.5 TBD:** In case the lowest Efficiency Factor (EFmin) for all teams is from a H2FC car, the lowest EF over all EV will be used for all scoring calculations, see D9.4 in the Formula Student Rules.

# **J: Judging of the Statics**

## **J1: General**

**J1.1.1** Vehicles may only be presented in the “H2 system discharged” state.

## **J2: Cost and Manufacturing**

**J2.1.1** In the Bill of Material (BOM) there is no special category for hydrogen related parts.

**J2.1.2** All hydrogen related parts should be put in the category Engine and Tractive System of the BOM. For sensors and other electric parts the category Grounded Low Voltage System is also possible.

**J2.1.3 TBD:** A changelog of the vehicle since the submission deadline of the Cost Report Documents (CRD) can be presented to the Judges at the beginning of the BOM discussion. Missing hydrogen related parts are allowed to be part of the changelog. The changelog must be a printed table.

## **J3: Engineering Design**

**J3.1.1** Hydrogen specific knowledge is covered by the existing categories of the Engineering Design.