Hydrogen Rules 2025

version 1.1 January 22th, 2025

Preface & Foreword

This version of the Hydrogen Rules 2025 was published after Formula Student Austria & Alpe Adria-Academy (FS4A) with feedback from teams, hydrogen experts and sponsors. This document replaces the Hydrogen Rules 2025 Version 1.0.

In case of rules question or any other hydrogen-related topics please send a mail to: hydrogen@fs-world.org

In order to give an indication of where changes are most likely to be made for 25/26, these rules are labeled: TBD= to be discussed.

Changelog

Rule	Version	Change
	1.1	Update Preface and Foreword, add Changelog and Abbreviations
G1.1.1	1.1	Clarify rule
G1.1.3	1.1	Rule simplified
G2.1.2	1.1.	Changed shortcuts
G2.1.3	1.1	Add Scoring
G3.1.4	1.1	Changed Deadline for concept paper submission
G4.1.4	1.1	Change wording
G5	1.1	Add chapter
F1.1.1	1.1	Changed shortcuts
F1.1.2	1.1	Limit maximum pressure to 350 bar, forbid cryo compressed hydrogen
F2.1.1	1.1	Cancell 25 mm between primary structure and hydrogen containing parts
F2.1.2	1.1	Change wording
F2.1.5	1.1	Add conditions for parts designed for below 85°C
F2.1.6	1.1	Add examples
F2.1.7	1.1	Add OTD

F3.1.1	1.1	Allow hydrogen tanks with more than 350 bar
F3.1.2	1.1	Add checks before and after each use.
F3.1.4	1.1	Add specification of OTD and add fire port
F3.1.5	1.1	Change limit from 30 bar to 40 bar, add protection against overpressure
F3.1.7	1.1	Add protection against low temperature
F4.1.1	1.1	Add should be comparable with hydrogen
F4.1.2	1.1	Add new norms, add how to deal with third-party lines
F4.1.3	1.1	Add short as possible unregulated tank pressure lines
F4.1.4	1.1	Add tank nipple specification
C1.1.4	1.1	Change limit from 30 bar to 40 bar
C1.1.6	1.1	Change wording
C2.1.3	1.1	Change wording
C4.1.4	1.1	Change wording
E	1.1.	Complete chapter revised
S1.1.1	1.1	ESO and HSO could be the same person
S2	1.1	Add chapter HSMS, naming incremented by 1 for all subsequent
S3	1.1.	Split chapter S2 in S3 and S4, naming incremented by 1 for all subsequent
S5.1.2	1.1	Changed wording
S5.1.3	1.1	Active ventilation must be powered by LV, no software involved
S6.1.1	1.1	Hydrogen tank in formula student vehicle allowed during transport
S8.1.5	1.1.	Labeling adapted to hydrogen tanks and HV- batteries
S8.1.6	1.1.	Hand cart for more than one hydrogen tank
S8.1.7	1.1	Add refueling protocol
H	1.1	New chapter
D1.1.2	1.1	Only one vehicle on track
D1.1.3	1.1	No driverless vehicles powered with hydrogen
D2.1.1	1.1	No Efficiency scoring
D2.1.2	1.1	No tank change or refueling at driverchange
D2.1.3	1.1	Endurance driving distance can be changed
J	1.1	New chapter

Abbreviations

Shortcut	Full name
BOM	Bill of Material
BOTS	Brake Over Travel Switch
BSPD	Brake System Plausibility Device
CV	Internal Combustion Engine Vehicle
CVMD	Cell Voltage Monitoring device
DI	Direct Injection
EDR	Engineering Design Report
EV	Electric Vehicle
FC	Fuel Cell
FCCU	Fuel Cell Control Unit
FCEV	Hydrogen Fuel-Cell Electric Vehicle
FCSC	Fuel Cell System Container
FCIR	Fuel Cell Isolation Relay
FS	Formula Student
HS	Hydrogen System
HSMP	Hydrogen System Measuring Point
HSMS	Hydrogen System Master Switch
HSO	Hydrogen Safety Officer
HV	High Voltage
HVD	High Voltage Disconnect
H2CV	Hydrogen Combustion Vehicle
H2HY	Hydrogen Combustion Hybrid Vehicle
H2SF	Hydrogen System Form
LVMS	Low Voltage Master Switch
LVS	Low Voltage System
OTD	On Tank Device
OTV	On Tank Valve

PFI	Port Fuel Injection
SDC	Shutdown Circuit
SHYTTA	Safe Hydrogen Tank Transfer Area
TPRD	Thermal Activated Pressure Relief Device
TS	Tractive System
TSAL	Tractive System Active Light

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 Each event decides independently each year whether it will allow hydrogen-powered vehicles.

G1.1.3 At least 2025 and 2026 it is allowed to convert existing CV or EV Formula Student vehicles to run on hydrogen. Eligibility will be determined on a case by case basis. Contact the following e-mail: 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.

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 event organizers discretion.

G3: Hydrogen Concept Challenge 2025

G3.1.1 The Hydrogen Concept Challenges, which have been taking place since 2023, are used to introduce the teams to the topic of hydrogen.

G3.1.2 The Hydrogen Concept Challenge is a static event in which a hydrogen-powered powertrain is to be presented to the judges. The judging will be separate for each team.

G3.1.3 The judging lasts 30 minutes, with the team presenting their concept for the hydrogen-based powertrain in the first 15 minutes, followed by a 15-minute question and answer session similar to the Design Event. A video may also be used for the presentation, whereby the teams themselves are responsible for the equipment required to play the video.

G3.1.4 Prior to the events, a concept paper in text form with images and/or diagrams must be submitted as a PDF (export Word file as PDF) (up to 10 pages) by Thursday 2025-06-19 13:00 CEST at the latest. It is a separate document and not part of the Engineering Design Report (EDR).

G3.1.5 Submission for all events takes place via the following e-mail: hydrogen@fs-world.org

G4: Hydrogen System Form

G4.1.1 All teams must submit a Hydrogen System Form (H2SF) using the H2SF template provided on the competition websites.

G4.1.2 Deadline for the submission of the H2SF is 2025-03-28 13:00 CEST.

G4.1.3 Submission for all events takes place via the following e-mail: hydrogen@fs-world.org

G4.1.4 If no H2SF is submitted, the team can be deregistered and/or penalty points can be awarded.

G5: Vehicle Status Video

G5.1.1 The team must submit the Vehicle Status Video (VSV) that meets all points from the rule A5.6 of the Formula Student Rules.

G5.1.2 In the VSV it must be visible that the car is running on hydrogen and FCEV must verify the function of the fuel cell.

G5.1.3 Submission for all events takes place via the following e-mail: hydrogen@fs-world.org

G5.1.4 Deadline for the submission of the VSV is 2025-06-23 13:00 CEST.

F: Fuel and Fuel System

F1: Fuel

F1.1.1 The permitted 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 gaseous form compressed gas will be provided at the event with a maximum pressure of 350 bar. For EV-H2 it will be hydrogen according to ISO 14687: 2019 - at least grade D. Cryogen, liquid or cryo compressed hydrogen is not allowed.

F1.1.3 Fuel supply of gaseous hydrogen at the event will be arranged in cooperation with participating teams.

F2: Fuel System

F2.1.1 All parts of the fuel system and the hydrogen tanks are considered critical components as defined in T9 in the Formula Student Rules.

F2.1.2 All parts of the fuel system including the hydrogen tank must be located behind a firewall as defined in T4.8 in the Formula Student Rules.

F2.1.3 The hydrogen tank or other hydrogen-containing components may be accommodated in the side pod if it is built as a structural side pod. The structure of the structural side pod must comply with T3.2 of the Formula Student Rules and must protect against front, side and rear impacts.

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. Material and thickness must be equivalent to T7.3.2 in the Formula Student Rules.

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 chassis member behind 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.

F3: Hydrogen Tank

F3.1.1 The hydrogen tank must be designed and manufactured for at least 350 bar nominal operating pressure of hydrogen. It must be certified by an accredited body (typically in the country of origin) and marked or stamped accordingly. e.g. according to ECE R134, HGV-2 or comparable.

F3.1.2 Hydrogen tanks with visible defects, e.g. abrasion, cuts or chemical damage may not be used. In case any kind of damage is detected, the tank must be flushed with inert gas and emptied to low pressure. The tank should be visually checked for damage before and after each use.

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 T9.3 of the Formula Student Rules.

F3.1.4 On tank devices (OTD) must be mounted directly to the hydrogen tank - it must include 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). All OTD must be certified according to ISO 19881, UN GTR No.13 or UN regulation No. 134. Safety against overpressure during the fueling procedure is being reached through safety measures of the fueling system. The risk of overpressure in the vehicle due to excessive temperature is being managed through the mandatory TPRD.

F3.1.5 A pressure regulator that limits 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 closed as possible to the OTD. Every pressure section of the system must be protected against overpressure by mechanical means (eg. burst plate venting to a safe location) and trigger the Shutdown Circuit using a N/C switch.

F3.1.6 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 and F3.1.5).

F3.1.7 The hydrogen tank must be protected against subcooling, i.e. 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.

F4: Lines and Fittings

F4.1.1 All lines, fittings, tanks, regulators, solenoid valves and other equipment exposed to pressurized hydrogen must be certified accordingly. Exceptions for fuel injectors can be granted on request by event organizers.

F4.1.2 Compression fittings certified to ANSI CSA HGV 3.1, HGV 3.1, ISO 19887 or ISO 12619 are recommended. The certification generally relates to the entire fitting + line system. If fittings are used with third-party lines, the certification may expire.

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, F3.1.5 and F3.1.6.

F4.1.4 The fuelling nipple 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.

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

C1: Engine

C1.1.1 Any alternatively fuelled combustion engine, whether the sole prime mover or part of a hybrid powertrain, must use a reciprocating 4 stroke cycle internal combustion engine. The engine can be modified within the restrictions of the rules whereby the displacement is limited to 1600 cc. The number of cylinders is unlimited.

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 is allowed for H2CV/H2HY only.

C1.1.3 Direct injection (DI) and port fuel injection (PFI/MPI) is allowed.

C1.1.4 The injection pressure is limited to 40 bar.

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 could also be useful for the injector.

C1.1.6 The air intake system has to be equipped with a pressure relief valve and a flame arrestor downstream of it, to prevent excess pressure build up in the event of backfire. The open area of this valve must be at least 1900 mm². This valve has to vent towards a safe location and away from the driver. Installation of additional flame arrestors in each intake runner directly upstream of the injectors is highly encouraged.

C2: Boosting

C2.1.1 Boosting is permitted.

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 combination of CV hybrid with hydrogen combustion is allowed, this is called 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 **TBD:** The maximum fuel tank capacity for H2CV/H2HY is 2 kg.

E: Hydrogen Fuel Cell Electric Vehicles [FCEV]

E1: Hydrogen System definition

E1.1.1 Hydrogen System (HS) – every part that is related to the fuel cell. This includes the hydrogen tank, the Fuel Cell (FC), the fuel cell cooling system and the fuel cell HV electrical components.

E2: General Requirements

E2.1.1 The maximum allowed voltage that may occur between any two electric connections is 600 V DC and for internal low power control signals 630 V DC. See EV4.1.1 in the Formula Student Rules.

E2.1.2 All components in the HS must be rated for the maximum voltage in both HS and Tractive System (TS).

E2.1.3 All HS related PCB's shall be compliant with the rules applied to TS PCB's. See EV4.3.6 in the Formula Student Rules.

E2.1.4 All components must be rated for the maximum possible temperature that may occur during usage.

E2.1.5 Same rules for grounding as for TS, see EV3.1 in the Formula Student Rules.

E2.1.6 Same rules for grounding and for overcurrent protection as for TS, see EV3.1 in the Formula Student Rules.

E3: Positioning of Hydrogen System Parts

E3.1.1 All parts belonging to the HS including cables and wiring must be located within the rollover protection envelope, see T1.1.16 in the Formula Student Rules. "Part" is the whole device such as the complete High Voltage Disconnect (HVD).

E3.1.2 Any part of the HS that is less than 350 mm above the ground must be protected from impacts, see T3.14 in the Formula Student Rules. Impact protection must follow T3.15 when having bolted attachments. HS wiring in front of the front hoop may alternatively be shielded by the front bulkhead support structure according to T3.13 in the Formula Student Rules.

E4: Insulation and cabling of the hydrogen system

E4.1.1 Same rules as for TS, see EV4.5 in the Formula Student Rules.

E5: Power Limitation

E5.1.1 The hydrogen mass flow and the air mass flow are unlimited.

E5.1.2 **TBD:** The maximum fuel tank capacity for FCEV is 2 kg.

E5.1.3 The capacity of the HV accumulator is not limited, supercapacitors are allowed.

E5.1.4 Maximum power of the accumulator must not exceed 80 kW and measured with a datalogger.

E5.1.5 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 will be supervised by a second data logger placed at the TS motor-controller(s) input.

E5.1.6 Both data loggers will be identical to the current EV infrastructure.

E5.1.7 For the Endurance, a minimum of 40% of the tractive energy must come from the fuel cell.

E6: Hydrogen System Measuring Point

These measuring points must be connected to the HS circuit (between the FC and the DC/DC).

E6.1.1 Two Hydrogen System Measuring Points (HSMPs) must be installed directly next to the master switches, see T11.2 in the Formula Student Rules. The HSMPs must be directly connected, see T1.3.1 in the Formula Student Rules, to the intermediate circuit capacitors even if the fuel cell is disconnected.

E6.1.2 4 mm shrouded banana jacks rated for 600 V CAT III or better must be used for the HSMPs. The HSMPs must be marked “HS+” and “HS-” and mounted on an orange background.

E6.1.3 The HSMPs must be protected by a non-conductive cover that can be opened without tools. The cover must always be mechanically linked to the vehicle.

E6.1.4 Each HSMP must be secured with a current limiting resistor according to the following table. Fusing the TSMPs is prohibited. The resistor’s power rating must be chosen such that they can continuously carry the current if both HSMPs are short-circuited.

Maximum HS Voltage	Resistor Value
Umax < 200 V DC	5 kΩ
200 V DC < Umax ≤ 400 V DC	10 kΩ
400 V DC < Umax ≤ 600 V DC	15 kΩ

E6.1.5 All electric connections needed to connect the HSMP to the intermediate circuit capacitors, including bolts, nuts, and other fasteners, must be secured from unintentional loosening by the use of positive locking mechanisms. Bolted connections must follow T10.2, soldered connections EV4.5.15 in the Formula Student Rules.

E6.1.6 Next to the HSMPs an Low Voltage System (LVS) ground measuring point must be installed. A 4 mm black shrouded banana jack must be connected to LVS ground and must be marked “GND”. It could be the same as the one used for TS, see EV4.7.8 in the Formula Student Rules.

E7: Discharge Circuit

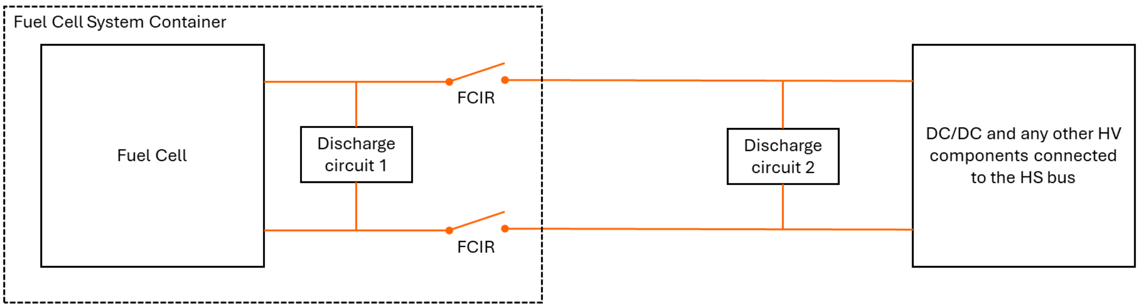

Figure 2: Schematic representation of discharge circuit

E7.1.1 If needed, discharge circuit 2 must be designed to match requirements from EV6.1.5 in the Formula Student Rules.

E7.1.2 Discharge circuits must be activated by the shutdown circuit. See EV6 in the Formula Student Rules and chapter S4.

E7.1.3 Fusing of the discharge main current path is prohibited.

E7.1.4 The discharge circuit 1 shall be designed to discharge (depolarize) the fuel cell stack. Stack voltage must drop below 60 VDC in less than 30 sec.

E7.1.5 It shall not be possible to activate (polarize) the fuel cell if the discharge circuit 1 is not ready (temperature conditions, …).

E7.1.6 Fuel Cell Control Unit (FCCU) shall open the shutdown circuit if nominal working conditions are not satisfied.

E8: Tractive System Active Light

E8.1.1 Tractive system active light (TSAL, see EV4.10) shall be active if there is HV live on the vehicle (either on the TS side, or on the FC side of the HS DCDC).

E9: Activating the Hydrogen System

E9.1.1 It shall not be possible to activate the HS if TS is not active.

E9.1.2 The HS may only be activated if all of the following conditions are met:

- Any of the Fuel Cell Isolation Relays (FCIRs) are closed
- Fuel Cell Stack is polarized
- Hydrogen supply is enabled and active
- Air supply is enabled and active

E9.1.3 Closing the Shutdown Circuit (SDC) by any part defined in EV6.1.2 must not (re-) activate the TS.

E10: Fuel Cell System – General Requirements

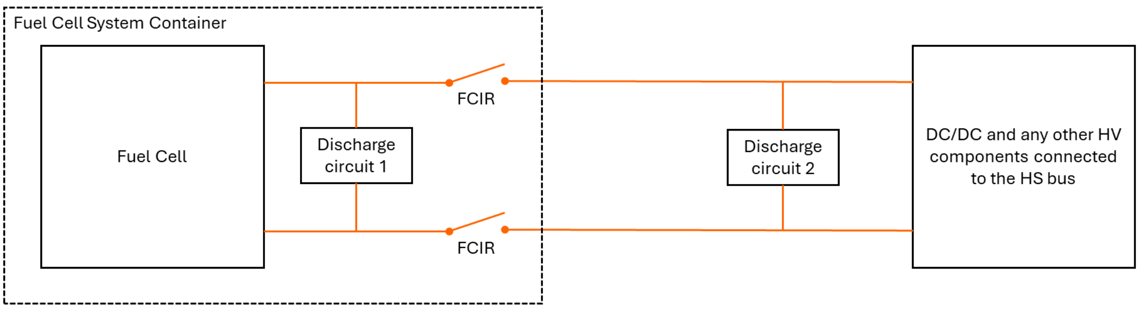

Figure 3: Schematic representation of fuel cell system

E10.1.1 The fuel cell stack must be enclosed in the Fuel Cell System Container (FCSC).

E10.1.2 The FCSC shall be actively ventilated to avoid any accumulation of hydrogen. Minimum air mass flow shall be guaranteed. Ventilation mass flow shall be measured.

E10.1.3 There must be ventilation holes in the FCSC. These holes must follow the EV rules to avoid any access to the HV components and also S5.1.2.

E10.1.4 It must be possible to open the FCSC for technical inspection.

E10.1.5 FSCS 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”.

E11: Fuel Cell System Container – Electrical Configuration

E11.1.1 Every FCSC must contain at least one fuse and at least two FCIRs, see E13 and EV3.2.7 in the Formula Student Rules.

E11.1.2 LVS must not be included in the FCSC except where inherently required. Exceptions include the FCIRs, the FCCU (if located within the FCSC), the TSAL's green light circuitry, and cooling fans.

E11.1.3 Every wire used in a FCSC, regardless of whether it is part of the LVS or HS, must follow EV4.5.2, EV4.5.3, and EV4.5.5 in the Formula Student Rules.

E11.1.4 Each FCSC must have two prominent indicators, voltmeter, or red LED visible even in bright sunlight that will continuously illuminate whenever a voltage greater than 60 V DC or half the maximum HS voltage, whichever is lower, is present at the both sides of the FCIRs. These indicators must be clearly visible while disconnecting the FCSC from the vehicles. These indicators must be clearly marked with "Voltage Indicator" (for the indicator connected to the vehicle side of the FCIR's) and "Stack Voltage Indicator" (for the indicator connected to the stack side of the FCIR's).

E11.1.5 The indicator must be hard-wired electronics without software control, directly and only supplied by the HS from each side of the FCIRs (depending on the indicator), and always working, even if the HS accumulator is disconnected from the LVS or removed from the vehicle.

E12: Fuel Cell System Container – Mechanical Configuration

E12.1.1 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 fulfil all other requirements of a firewall.

E12.1.2 The fuel cell needs to have flexible mounts to prevent stresses introduced by e.g. chassis deformation or vibration. The fuel cell itself and its mounting to the FCSC must adhere to T9.3 of the Formula Student Rules.

E12.1.3 The FCSC itself and its mounting to the chassis must adhere to T9.3 of the Formula Student Rules. The FCSC must be protected from impacts, see T3.14. Impact protection must follow T3.15 when having bolted attachments. The FCSC must not be part of this structure.

E12.1.4 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.

E12.1.5 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.

E12.1.6 The FCSC must be constructed of steel or aluminium. With the following requirements:

- The bottom of the FCSC must be at least 1.25mm thick if made from steel or 3.2mm if made from aluminium
- The internal and external vertical walls, covers, and lids must be at least 0.9mm thick if made from steel or 2.3mm if made from aluminium.

E12.1.7 Alternative materials are allowed with proof of equivalency per T3.3 or for composite materials per EV5.5.6 of the Formula Student Rules. When alternative materials are used, test samples must be presented at technical inspection.

E12.1.8 Composite FCSC must satisfy the following requirements:

- Data obtained from the laminate perimeter shear strength test and three-point bending test, see T3.5, should be used to prove adequate strength is provided.
- Each attachment point requires steel backing plates with a minimum thickness of 2mm. Alternate materials may be used for backing plates if equivalency is approved.
- The calculations and physical test results must be included in the H2SF.

E12.1.9 All fasteners used within or to mount the FSCS 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 FSCS used for non-structural parts do not have to follow T10 of the Formula Student Rules.

E12.1.10 The mounting of the FCSC requires a minimum of 4 attachment points. Any brackets used to mount the FCSC must be made of steel 1.6mm thick or aluminium 4mm thick and must have gussets to carry bending loads.

E12.1.11 The FCSC needs venting holes as described in S5.1.2.

E13: Alternative configuration of E11/E12

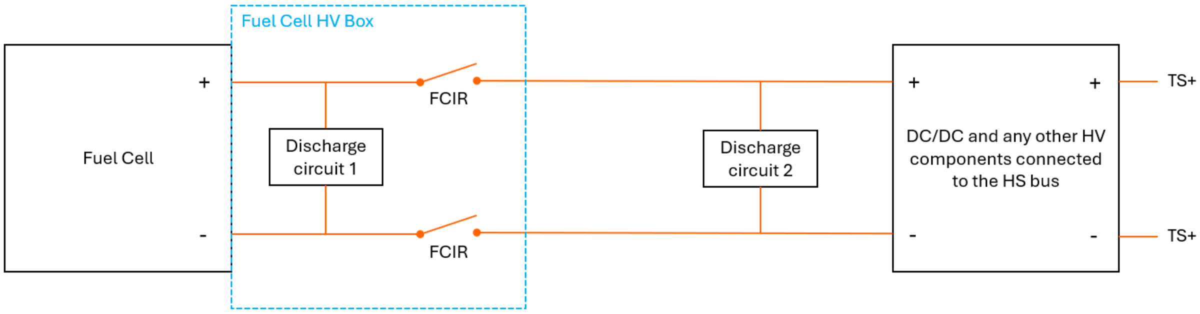

Figure 4: Alternative schematic representation of fuel cell system

E13.1.1 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 E12.

E13.1.2 A FC HV Box is required to contain the discharge circuit 1 and the FCIR's. The stack and HS voltage indicators must be on this box.

E13.1.3 The FC HV Box must be secured against the FCSC using positive locking. The FC HV Box must satisfy the same rules as any other powerbox.

E13.1.4 No HV wires and no HV connectors shall be apparent between the FCSC and the FC HV Box.

Note : Interface between the FCSC and the FC HV Box must be sealed during scrutineering.

E14: Fuel Cell Isolation Relays

E14.1.1 The FCIRs must open both poles of the FCSC. If the FCIRs are open, no HS voltage may be present outside of the FCSC and the vehicle side of the FCIRs must be galvanically isolated from the fuel cell stack side, see EV1.2.1 in the Formula Student Rules.

E14.1.2 The FCIRs must be mechanical relays of a “normally open” type.

E15: Cooling

E15.1.1 Dedicated fuel cell coolant may be used (must refer to stack supplier requirements).

E15.1.2 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.

E16: Fuel Cell System Management

E16.1.1 The FCCU must continuously measure the following parameter of the hydrogen tank:

- Hydrogen detection sensor at the top of the FCSC

E16.1.2 The FCCU must continuously measure the following HS 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 shall be identified
- Stack current shall be measured (if information not given by the DCDC)
- Stack voltage shall be measured (if information not given by the DCDC)

E16.1.3 The FCCU must continuously measure the following anode parameters:

- Stack inlet pressure
- Stack outlet pressure (optional)

E16.1.4 The FCCU must continuously measure the following cathode parameters:

- Stack inlet pressure
- Stack outlet pressure (optional)

E16.1.5 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

E16.1.6 The FCCU must open the HS related SDC, if any measurement reaches critical values according to the stack manufacturer's datasheet.

E16.1.7 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 "FCCU" must light up if and only if the FCCU 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.

E16.1.8 FCCU signals are System Critical Signals, see T11.9. The loss of any safety or control related signal must result in an HS SDC opening.

E16.1.9 It must be possible to individually disconnect the current sensor during technical inspection if any wire is used.

E16.1.10 The FCCU must be able to read and display all measured values according to EV5.8.3 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.

E16.1.11 If CAN communication is used to communicate with the FCCU or the CVM, a dbc file must be available.

E17: Insulation Monitoring Device

E17.1.1 The vehicle shall be equipped with a tunable isometer. When performing the EV testing, the isometer shall be set to a 500 Ohm per Volt (to be calculated with the highest embedded voltage) measured between the powertrain and driver compartment.

E17.1.2 The IMD response may be tunable.

- If a non-tunable IMD is used, the IMD response value must be set to ≥500 Ω/V, related to the maximum voltage in the vehicle.
- If a tunable IMD is used, its response must be set to ≥500 Ω/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 shall be set to a lower value (150 kΩ whatever the maximum voltage in the vehicle).

E17.1.3 The response value must not be changed after electrical inspection.

E17.1.4 If a tunable IMD is used, the team shall 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 (inert), in order for work to be performed on any system of the vehicle by the team.

S1.1.4 An 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. For 2025 and 2026 the HSOs may also be somebody working at the university.

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.

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

S2.1.1 An Hydrogen System Master Switch (HSMS) according to T11.2 must be part of the SDC, see EV6.1.2 or CV4.1.2 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 orange circular area of ≥50mm 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

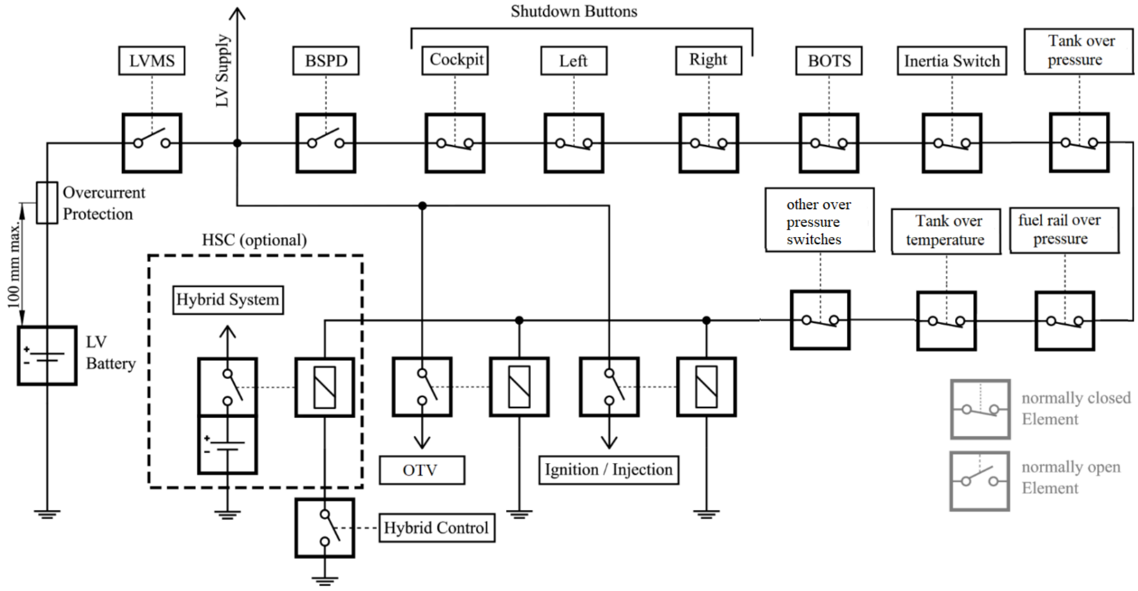

Figure 4: Schematic representation of a Shutdown Circuit for H2CV and HYCV

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
- HSMS, see FS T11.3
- BSPD, see FS T11.6
- three shutdown buttons, see FS T11.4
- BOTS, see FS T6.2
- inertia switch, see FS T11.5
- tank over pressure switch
- tank over temperature switch
- excess pressure in low pressure system switch or switches

Tank over pressure, tank over temperature and excess pressure in low pressure systems must be connected to the SDC through analogue systems, similar to BSPD. No software may be utilized.

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

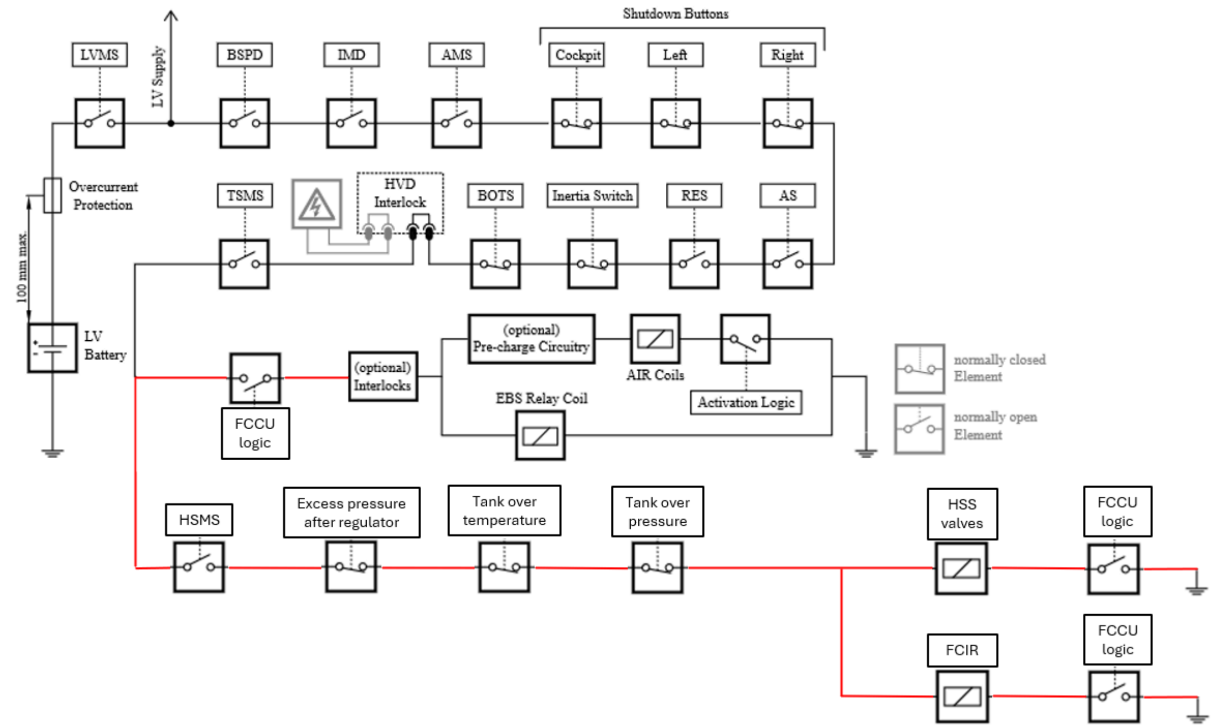

Figure 5.1: Default schematic representation of a Shutdown Circuit for FCEV

Note: The part of the SDC in red is related to the HS and is denoted as the HS related SDC.

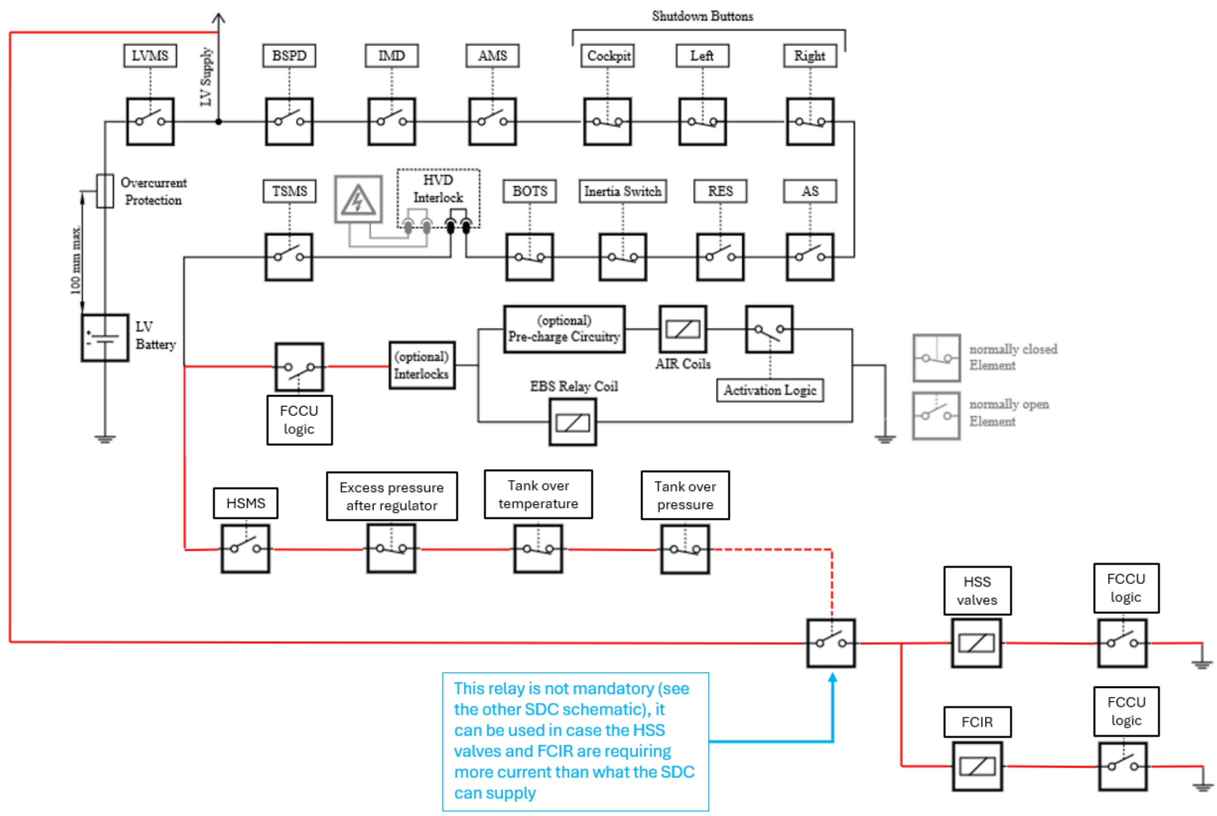

Figure 5.2: Alternative schematic representation of a Shutdown Circuit for FCEV.

Note: The additional relay (see Figure 5.2) can be added to lower the current request through the shutdown circuit.

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 FS T11.3
- tank over pressure switch
- tank over temperature switch
- excess pressure in low pressure system switch
- FCCU activated relays
- HSS valves and FCIR's supply

Tank over pressure, tank over temperature and excess pressure in low pressure system shall be connected to the SDC through analogue systems, similar to BSPD. No software shall be involved.

S4.1.2 All circuits that are part of the HS 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 HS related Shutdown Circuit is triggered the hydrogen system must be switched off, all valves shall return to their default position and the fuel cell HV-bus(es) shall be passively or actively discharged.

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

S4.1.6 It is allowed to supply the FCIR and HSS valves through an external normally open relay (with the command coming from the HS related SDC), no software shall be involved.

S5: Ventilation

S5.1.1 In case of leakage all hydrogen components must be safely vented and hydrogen may not accumulate.

S5.1.2 A safe venting location has to be connected to compartments that do not have an opening of at least 1900mm² (e.g. 50mm circle) in all high points above the hydrogen carrying components. The connection to all these high points must be a sealed path of at least 1900mm² internal cross section. Venting locations have to be unobstructed from above, be outside the cockpit, point away from the driver and be clearly marked with a red circle and "H2 vent". Several high points can share a common venting location.

S5.1.3 Any active ventilation system should push the air and not suck it and must be powered by LV and no software shall be involved.

S6: Arrival and departure to the event

S6.1.1 From departure, during transport and until arrival the hydrogen tank must be at a low positive pressure (lowest pressure permitted by the manufacturer). Keep positive pressure against humidity intrusion or corrosion. The hydrogen tank should not be transported in the passenger compartment of the car, lorry or other vehicle.

S6.1.2 The teams must comply with the laws and regulations for securing loads, in particular for hydrogen tanks, of the respective country. The transport regulations of dangerous goods must also be checked and adhered to by the teams.

S6.1.3 The teams must store the hydrogen tank at Safe Hydrogen Transfer Tank Area (SHYTTA) as soon as they reach the campsite or the event site.

S7: Pits and tools

S7.1.1 No hydrogen tanks or other devices containing hydrogen are allowed inside the pits. Vehicles have to be the “H2 system discharged and inert” state to enter any enclosed structure.

S7.1.2 The hydrogen tank has to be removed and stored at the SHYTTA prior to the vehicle entering the pits.

S7.1.3 Each team has to bring 2 hydrogen detectors to the event. Both have to actively suck in the gas, passive detectors are not sufficient. The correct operation of these detectors has to be demonstrated during H2 scrutineering with calibration gas of a known concentration (provided by the team).

S8: Storage of the hydrogen tank and refueling

S8.1.1 Hydrogen tanks must always be stored according to the manufacturer's requirements.

S8.1.2 The refueling of the hydrogen tanks is carried out by the event organizer outside the vehicle in the SHYTTA. At least one HSO from the team must be present.

S8.1.3 The hydrogen tanks will only be fitted into the vehicle for:

- hydrogen-specific scrutineering
- dynamic disciplines
- dynamic testing in the testing area
- static testing in the engine test area

S8.1.4 After any of the cases from S8.1.3 the tank has to be removed from the vehicle at a designated area and be returned to the SHYTTA as soon as possible. In any case the vehicle has a hydrogen tank on board, the vehicle will be accompanied by an official.

S8.1.5 Each team must provide a handcart with safety devices according to EV8.1 of the Formula Student Rules. The cart may not contain any electronics to safely move the hydrogen tank on the event site. 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.

S8.1.6 If a team uses more than one hydrogen tank, they must all be safely stored on one hand cart or there must be as many hand carts as there are hydrogen tanks.

S8.1.7 The refueling protocol must fulfill the requirements from the following link:

https://cleanenergypartnership.de/wp-content/uploads/2022/03/CEP-Requirements-for-Refuelling-at-Ambient-Temperatures18022020-min.pdf

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
- Electrical- and Accumulator-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 taking place without a mounted hydrogen tank.

H2.1.2 For the Tilt Test a dummy of the hydrogen tank must be provided by the teams and mounted to the vehicle. The dummy must have the same mass and center of gravity as the real hydrogen tank.

H2.1.3 There are two Rain Tests for H2EVs:
- 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 EV cars (500 Ω 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 kΩ).

H2.1.4 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 EV scrutineering, brake and tilt tests are passed.

H2.1.5 The Brake Test can be done with the fuel cell switched off.

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
- Datasheets and documentation for all hydrogen components
- Manufacturer's specifications for installation (installation position, torques, commissioning procedures)
- Copies of communications with officials and manufactures (if applicable)
- Tools needed for the (dis)assembly of parts for Hydrogen Scrutineering
- Tools to install and remove the hydrogen tank to the vehicle
- [EV-H2] EV tools

- IT device for checking every mandatory sensors
- 2 hydrogen leak detectors with a pump
- calibration gas, with less than 2% H2
- New seals for all H2 connectors
- signs “H2 system discharged and inert” and “H2 system HOT”

H4: Hydrogen system leak test

H4.1.1 Procedure of the inert gas leak test:

- Flush the system with inert gas (e.g. nitrogen) from the tank connection until no oxygen is detected at the furthest end of the hydrogen system
- Bring the hydrogen system to nominal pressure
- close off the supply and monitor the system pressure
- the system pressure may not decrease significantly over 15 minutes

H4.1.2 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
- close off the supply and monitor the system pressure
- the system pressure may not decrease significantly over 15 minutes
- Check all hydrogen components and connections with a hydrogen detector
- apply seal stickers to all tested hydrogen components and connections
- Flush the system with an inert gas from the tank connection to the furthest point of the system. Leave approx 0,5 to 1 bar in the system.

H4.1.3 The TS-System must be off during the hydrogen system leak test.

H4.1.4 After passing the hydrogen system leak test a sign “H2 system discharged and inert” 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.

H4.1.5 The hydrogen system leak test is part of the Hydrogen Scutineering and will be executed by Officals.

H4.1.6 The hydrogen system status signs must be visible from the front and the back of the vehicle. TSAL visibility max ne be impeded. See also rule S8.1.3 and S8.1.4.

H5: Installing the hydrogen tank and making vehicle ready to drive

H5.1.1 Procedure of mounting the hydrogen tank and making the “H2 system HOT":

- Team brings the vehicle to the SHYTTA
- Official checks the seals and whether there is still overpressure of inert gas in the system
- Break the tank connection seal
- HSO and max. one helper install the tank under an officials supervision
- Close valve after pressure regulator, open tank valve
- Official checks for leaks in the hydrogen system with hydrogen detector
- The system is slowly flushed with hydrogen from the tank to the farthest most end of the hydrogen system. Test with hydrogen detector
- The vehicle is now confirmed, leak free and 100% filled with hydrogen
- Close tank valve
- Put sign “H2 system HOT” on the main hoop

H5.1.2 Vehicles in the state "H2 system HOT" must be escorted by an official at all times and must not be moved into any buildings or enclosed structures. (this includes for example: pushing the vehicle to dynamic disciplines, dynamic testing in the testing area, static testing in the engine test area)

H6: Removing hydrogen tank and making vehicle inert

H6.1.1 The procedure for removing the hydrogen tank and making the "H2 system discharged and inert" is the reverse of the one in H5.1.1.

H6.1.2 After the steps from H6.1.1 there must be a sign "H2 system discharged and inert" attached to the main hoop.

H7: Modifications and Repairs

H7.1.1 Working on the hydrogen system is only allowed if the vehicle is in a "H2 system discharged and inert" state. All tests done by the team must utilize an inert gas.

H7.1.2 The following steps must be followed (in this order only!)

1. Notify the responsible officials about what kind of work is planed
2. Official will 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 rule H4 will be repeated and H2 inspection sticker reapplied.

H7.1.3 If any seals from the hydrogen system are broken, the team will lose the inspection stickers for Hydrogen Scrutineering.

D: Dynamics

D1: General

D1.1.1 **TBD:** All hydrogen-powered vehicles may run separately from the other vehicles, at the event organizers discretion.

D1.1.2 A maximum of one hydrogen-powered vehicle is allowed on the track at any time.

D1.1.3 Driverless vehicles powered by hydrogen are not allowed.

D2: Endurance

D2.1.1 There will be no Efficiency scoring for hydrogen-powered vehicles, at the event organizers discretion.

D2.1.2 A tank change or refueling during the driver change is not permitted.

D2.1.3 TBD: The driving distance may be adjusted at the event organizers discretion.

J: Judging of the Statics

J1: General

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

J2: Business Plan Presentation Event

J2.1.1 **TBD:** Participation may be omitted or made optional by the event organizer.

J3: Cost and Manufacturing Event

J3.1.1 **TBD:** Participation may be omitted or made optional by the event organizer.

J3.1.2 In the Bill of Material (BOM) there is no special category for hydrogen related parts.

J3.1.3 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.

J3.1.4 If an existing old vehicle is used, it is allowed to use old and new prices in the BOM. For old parts it is allowed to put behind each old price the year, where the vehicle was manufactured. e.g. 56,20€ (2019).

J4: Engineering Design Event

J4.1.1 There will be no special Hydrogen Judge or similar in the Engineering Design Event.

J4.1.2 The events try to use Design Judges with hydrogen knowledge to evaluate the hydrogen-based powertrain.

J4.1.2 Teams have a chance to take part in the Hydrogen Concept Challenge to get additional feedback to their hydrogen-based powertrain.