Hydrogen Rules 2025

version 1.0 October 3rd, 2024

Preface & Foreword

This version of the Hydrogen Rules 2025 is a preliminary version to provide a basis for discussion before Formula Student Austria & Alpe Adria-Academy (FS4A). Teams are welcome to give feedback and submit it until the 16th of November 2024 by email to: hydrogen@fs-world.org

After FS4A, a final version (version 1.1) will be published at the end of November or beginning of December with feedback from teams, hydrogen experts and sponsors.

In order to give an indication of where changes are most likely to be made, these rules are labeled: TBD= to be discussed. In some cases, comments are written for you in red.

G: General

G1: Hydrogen cars

G1.1.1 In addition to the existing CV / CV hybrid class and EV class categories, Formula Student cars powered by hydrogen are also allowed to participate.

G1.1.2 Each event decides independently each year whether it will allow hydrogen-powered cars.

G1.1.3 For 2025 and 2026 it is allowed to use existing CV or EV Formula Student cars which participated and passed scrutineering in 2019 or later at any official formula student event and made them run on hydrogen. The use of other cars is not forbidden, but in this case individual approval by the organizer must be obtained.

G1.1.4 A hydrogen car may be used for two years, counting from the first day onsite of its first competition.

G2: Target group of the rules

G2.1.1 For teams that do not build a hydrogen-powered car, only the FSG Rules apply.

G2.1.2 The Hydrogen Rules are aimed at teams in only one of the following both classes:
- Hydrogen fuel cell technology within the existing EV class - short: [EV-H2]
- Hydrogen combustion within the existing CV / CV hybrid class - short: [CV-H2]

G2.1.3 For teams building a hydrogen-powered car, the Hydrogen Rules and the FSG Rules apply, whereby the Hydrogen Rules take precedence in the event of a conflict.

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 3 weeks of the first event which features Hydrogen Concept Challenge. 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 an Hydrogen System Form (H2SF) using the H2SF template provided at 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 get penalty points.

F: Fuel and Fuel System

F1: Fuel

F1.1.1 The allowable forms of power in addition to those covered by the Formula Student Rules (Gasoline, E85 and Electric) are specified as, Hydrogen combustion and Hydrogen fuel cell.

F1.1.2 Only hydrogen up to grade 5.0 or hydrogen ISO14687 grade D in the form of gaseous form compressed gas will be provided at the event. Cryogen or liquid 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 (see Formula Student Rules T9). There must be a minimum gap of 25 mm from each hydrogen tank, HV-accumulator and fuel cell to the Primary Structure Envelope.

F2.1.2 All parts of the fuel system and 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 can be accommodated in the side pod if they are 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 impact.

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 car. This side pod must be sufficiently ventilated. The formation of hydrogen pockets must be prevented. See S3.1.2.

F2.1.5 The hydrogen tank and other parts containing hydrogen must be shielded from any heat sources that can reach a temperature of 85°C (e.g. brake discs or exhaust system). For fuel rails and injectors are exempt from this.

F2.1.6 Accumulation of the hydrogen in insulation or shielding materials must be prevented.

F2.1.7 The hydrogen tank and other parts with hydrogen must be shielded from debris and other material 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 can 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 with a maximum fuel tank pressure of 350 bar must be designed and made for the pressure and medium used and 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 that any damage is detected, the tank must be flushed with inert gas and emptied to low pressure.

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 needs to have flexible mounts to prevent stresses introduced by e.g. chassis deformation or engine vibration. The hydrogen tank itself and its mounting to the chassis must adhere to T9.3 from the Formula Student Rules.

F3.1.4 A tank pressure relief device (TPRD) must be mounted directly to the hydrogen tank. It must vent upward from a safe location outside the chassis and be unobstructed and be clearly marked.

F3.1.5 **TBD:** A pressure regulator that limits the downstream pressure of the hydrogen to maximum 30 bar or the maximum operating pressure of the lowest rated component must be mounted directly to the tank. Is this pressure limit realistic or does it unnecessarily limit the choice of components ?

F3.1.6 The hydrogen tank must be equipped with a connection that is designed to be repeatedly reconnected directly after all tank mounted components.

The following graphic aims to give an impression of how a hydrogen system of a fuel cell car can look and is not intended to be exhaustive. Additional components can be installed as required.

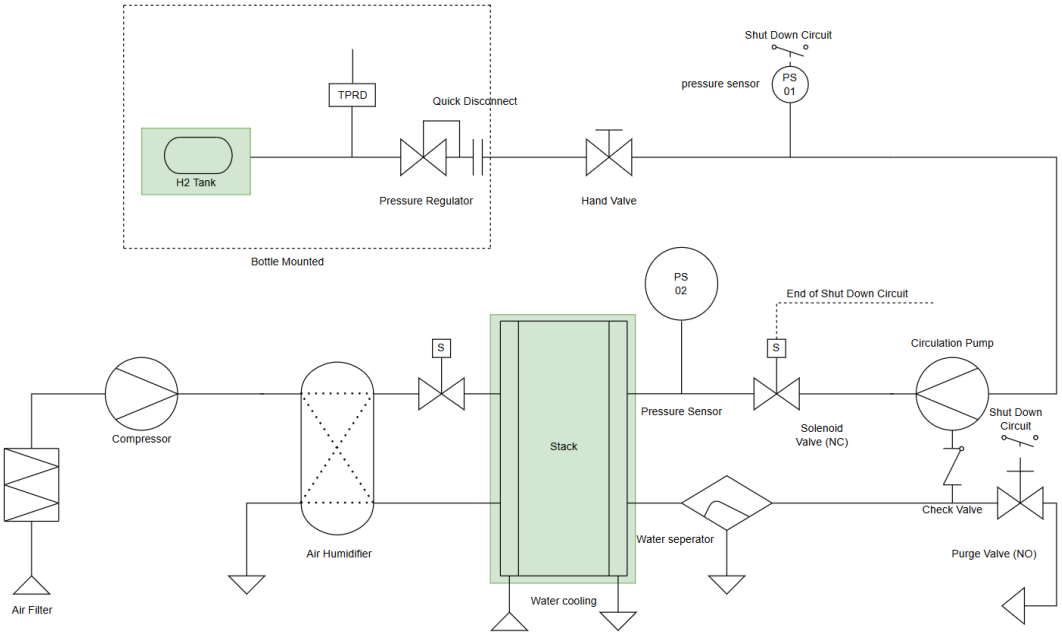

Figure 1: Schematic representation of hydrogen-related parts of a fuel cell car

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 and only be use according to these.

F4.1.2 Seamless steel pipes made from stainless steel are favored for the transport of hydrogen. In places where a flexible line is necessary and sensible, the lines should have a steel braiding, are polymer lined on the inside (for low H2 permeation) and most often also on the outside must be approved for use with hydrogen.

F4.1.3 All hydrogen lines must be steel and be certified for the application they are used in. Compression fittings certified to EC-79 are recommended. Please let us know your opinion and or if you have a better solution.

C: Hydrogen Combustion Cars

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 hydrogen CV cars only.

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

C1.1.4 **TBD:** The injection pressure is limited to 30 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 and 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.

C1.1.6 The air intake system has to be equipped with a pressure relief valve and flame arrestor to prevent excess pressure build up in the event of backfire. The open area of this valve must be at least 1900 mm^2. This valve has to vent towards a safe location and away from the driver.

C2: Boosting

C2.1.1 Boosting is permitted.

C2.1.2 Boosting systems can 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 can only be supplied from a system that complies with the Hybrid Rules.

C2.1.4 Belts, gears, chains etc. need a scatter shield as defined in T7.3 in the Formula Student Rules.

C3: Hybrid

C3.1.1 Making a combination of CV hybrid with hydrogen combustion is allowed.

C4: Power Limitation

C4.1.1 Currently there is no power limitation for H2CV powertrains. This will definitely change in the future. Any suggestions for the next few years?

C4.1.2 **TBD:** The hydrogen mass flow is unlimited. Maybe we will change that for the future. Any suggestions for the next few years?

C4.1.3 The air mass flow is unlimited.

C4.1.4 **TBD:** The maximum permitted quantity of hydrogen on board of CV-H2 cars is 2 kg. What is a realistic quantity of hydrogen to finish one Endurance? What should be our limit in your eyes?

The following graphic aims to give an impression of how a hydrogen system of a hydrogen combustion car can look and is not intended to be exhaustive. Additional components can be installed as required.

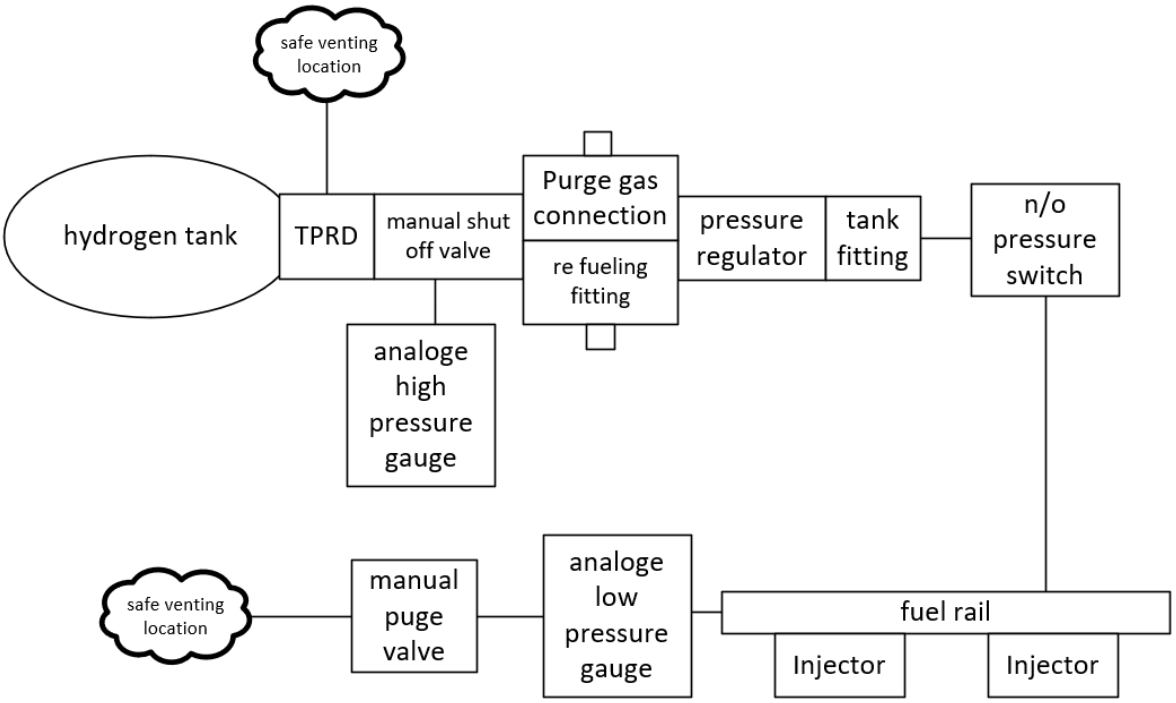

Figure 2: Schematic representation of hydrogen-related parts of a hydrogen combustion car

E: Hydrogen Fuel Cell Cars

E1: Fuel Cell

E1.1.1 There is no limitation of the size or power of the fuel cell.

E2: Location of the Fuel Cell and HV-components

E2.1.1 All parts of the fuel system and hydrogen tank must be located behind a firewall as defined in T4.8 in the Formula Student Rules.

E2.1.2 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 chassis must adhere to T9.3 from the Formula Student Rules.

E3: Power Limitation

E3.1.1 The hydrogen mass flow is unlimited.

E3.1.2 The air mass flow is unlimited.

E3.1.3 **TBD:** The maximum fuel tank capacity for EV-H2 cars is 2 kg. What is a realistic quantity of hydrogen to finish one Endurance? What should be our limit in your eyes?

E3.1.4 The capacity of the HV accumulator is not limited, supercapacitors are allowed.

E3.1.5 **TBD:** Maximum power of the tractive system at the input of the inverter(s) < 100 kW. Is putting the limit from 80 kW to 100 kW fair in comparison to the EV cars, so that you can compensate for your additional weight because of the fuel cell, tank,... so that you can compete at the same lap time as EV cars.

E3.1.6 For the Endurance, a minimum of 50% of the tractive energy must come from the fuel cell.

E3.1.7 For rule E3.1.6 tractive energy is 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 datalogger.

E3.1.8 For rule E3.1.6 fuel cell energy is the time integral over the Endurance run of the electrical power measured, with a second data logger, at the output of the fuel cell system.

E3.1.9 Both data loggers will be identical to the current EV infrastructure.

E4: Electrical safety

E4.1.1 **TBD:** The car 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. Is that necessary? Doubled to current EV rules?

E5: Cooling

E5.1.1 Dedicated fuel cell coolant shall be used (refer to stack supplier requirements).

E5.1.2 Fuel Cell coolant conductivity shall be measured at any time.

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.

S1.1.2 The HSOs are responsible for all work on the hydrogen system carried out on the car during the competition. The HSOs are responsible for all work on the car 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 car hydrogen safe (inert), in order for work to be performed on any system of the car by the team.

S1.1.4 An HSO must always be with the car when the hydrogen tank is installed and must carry out the installation and removal themselves and then declare the car safe for further work. At least one HSO per team must be included in the four members per team, if the car 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 they must have a student status, see rule A4.2.6 from the Formula Student Rules. For 2025 and 2026 the HSOs can also be somebody from 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 and be held by an external expert. A certificate of the training must be shown at Scrutineering.

S1.1.8 The car 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 it's cover. The characters must be clearly visible and placed on a high-contrast background.

S2: Shutdown Circuit

S2.1.1 There must be a Shutdown Circuit, and must include the same equipment and parts of the Shutdown Circuit as in the common Formula Student Rules.

S2.1.2 **TBD:** The following additional sensors must also be implemented in the Shutdown Circuit: Pressure sensors in the low and high pressure part of the fuel system, temperature sensor of the hydrogen tank and other critical parts like fuel cells. Cars with fuel cells also need the sensor from S3.1.3 in the Shutdown Circuit. Limits still need to be defined.

S2.1.3 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 solved with a valve which is normally closed if there is no power.

S2.1.4 **TBD:** When the Shutdown Circuit is triggered the engine and/or fuel cell and HV-accumulator must be switched off. The fuel cell shall the switched off and the fuel cell bus shall the passively or actively discharged. Second sentence open for discussion.

S2.1.5 A system to safely deal with residual hydrogen and electrical energy in the fuel cell in case the Shutdown Circuit being triggered must be implemented.

S3: Ventilation

S3.1.1 Any leaked gas must be able to freely dissipate without pockets of gas accumulating.

S3.1.2 Covers that clad or cover components containing hydrogen must have openings of at least 25 mm at local high points through which hydrogen can escape. No venting holes in direct sight of the driver.

S4: Arrival and departure to the event

S5.1.1 From departure, during transport and until arrival the hydrogen tank must be removed from the car and must be at a low positive pressure (lowest pressure permitted by the manufacturer). Keep positive pressure against humidity intrusion or corrosion.

S5.1.2 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 be also checked by the teams.

S5.1.3 The teams must store the hydrogen tank at the designated hydrogen storage area (DHSA) as soon as they reach the campsite or the event site.

S5: Pits and tools

S5.1.1 No cars, tanks or other devices containing hydrogen are allowed in the pits.

S5.1.2 The hydrogen tank has to be removed and stored at the DHSA prior to the car entering the pits.

S5.1.3 Each team has to own 2 hydrogen leak detectors with a pump (to have at least 1 ready tobe used at any time) and test gas and bring those to the hydrogen-specific Scrutineering.

S6: Storage of the hydrogen tank and refueling

S6.1.1 Hydrogen tanks must always be stored according to the manufacturer's requirements.

S6.1.2 The refueling of the hydrogen tanks is carried out by the event organizer outside the car in the DHSA. At least one HSO from the team must be present.

S6.1.3 The hydrogen tanks will only be fitted into the car for:

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

S6.1.4 After any of these cases the tank has to be removed from the car at a designated area and be returned to the DHSA.

S6.1.5 Each team must provide a hand cart with safety devices similar to EV 8.1 from the Formula Student Rules to handle the hydrogen tank at the eventside. Team name and car number must be written on the cart.

D: Dynamics

D1: Endurance

D1.1.1 Hydrogen-specific changes to the Efficency scoring are **TBD**