

Technical Regulations for Solar Boats

Version: 9 February 2026



These regulations are being maintained by Solar Sport One and Young Solar Challenge.

Preamble

The organization has frozen the main parameters of exiting boat categories for a period of 5 years. Thus, no changes in these parameters will be made until 1 October 2030.

If the Technical Committee intends to change the rules mentioned above after 1 October 2030, this will be officially announced before 1 October 2029 on the Solar Sport One website.

Recommendations for proposed rule changes from teams are welcomed.

Note: In case safety is at stake, the necessary adjustments to the rules will be made. This will be only done after submitting/informing the changes to the Skippers' council and race organizations.

1. General

- 1.1. The rules stipulated herein apply to the events organized in 2026, hereinafter referred to as the 'Races'.
- 1.2. All participants in the race must have read, understood and agreed to the Technical Regulations. The race organization may penalize all participants and teams that ignore or violate the Technical Regulations. Penalties could be given in the form of warnings up to and including disqualification and elimination from further participation.
- 1.3. The rules will be published on the website of the organization and are binding for all participants. If deemed necessary by the organization, she has the right to amend these regulations.
- 1.4. All questions concerning the interpretation of the Technical Regulations must be submitted to the organization in writing.
- 1.5. Deviation from the rules may be granted based on a written application to the organization with due motivation including a design description and a valid reason why a deviation is necessary.
- 1.6. In case these regulations allow for exceptions with special permission from the organization, advance application for such exceptions is advised. If an application is submitted shortly before or during an event, the organization has the right to reject the application and postpone the assessment until a later date.
- 1.7. All participants are at all times responsible for the technical condition and safety of their boats during the race.
- 1.8. The design must be made such that the boat can safely participate in the race considering all aspects of the race (racing, storage in the paddock, etc.).
- 1.9. Approval of the design and approval during the inspection will under no circumstances exempt the participants of their responsibility.

2. Definitions

- Rules: The provisions of the Notice of Race, the Technical Regulations, the Solar Racing - Race Elements Catalogue, the Race Instructions (all latest versions) and the local rules as issued by the national and/or local authorities on the use of inland and offshore waters together constitute the Rules. This also includes any subsequent additions and/or amendments implemented by the race organization.
- Team: The group of persons registered with the race organization who as competitors enter the race with a boat.
- The organization: The combined group of race organizations.
- Race organization: The local organization that organizes a specific race or specific races.
- Solar boat: A boat that is exclusively powered by solar energy derived from solar panels mounted on board the vessel.
- Solar panel: Energy source for the propulsion of the solar boat.
- Hydrogen powered boat: A boat that is exclusively powered by electricity generated using hydrogen as the sole on-board energy carrier.
- Fuel cell: The device that converts hydrogen into electrical energy.
- Fully loaded: The condition of the vessel in which all systems and equipment have been installed, all the necessary ballast has been installed and the crew member on board is equipped with the prescribed safety devices. **[V10-H2]**: additionally, a full fuel load is onboard.
- Dead man's switch: A device that is designed to cut the power supply to the engine when the pilot leaves the boat, whether voluntarily or involuntarily.
- Mains switch: A switch that when switched to the 'on' position connects the electrical power of the boat. This switch is not the same as the emergency mains switch.
- Emergency mains switch: A switch that, in case of emergency, can be used to disconnect the electrical power between the solar panel(s) and the battery and between the battery and the electric motor.
- Freeboard: Distance between the waterline in fully loaded condition and the lowest edge of the deck or the lowest opening in the side of the vessel, whichever is closer to the waterline.
- Openings: Feedthroughs in the main deck or side of the vessel such as bilge pump outlets, feedthroughs of overboard tubing, feedthroughs of cables, etc.
- Added buoyancy: Closed volume which can take up loads on top of the static loading of the vessel.
- Pilot: A team member who has qualified in accordance with the rules to pilot the boat during the race.
- Paddock: An area allocated by the race organization where the vessels shall be kept during the race at the times when they are not actually competing in the qualifications and the race itself, or in transit between the racing area and the paddock.

3. Classes

These Technical Regulations apply to different classes of solar boats and one class of hydrogen powered boat. The organization of a race can decide which classes are allowed participate in that race. For some classes restrictions may apply to their participation, as determined by the license holder for the design of the boat used in that class.

The following classes exist:

- V10 solar boat [V10]
- V10 hydrogen powered boat [V10-H2]
- V20 solar boat [V20]
- Open class/apprentice class solar boat [Open]
- Master class solar boat [Master]
- Young Solar boat (2022 version) [YS]

Rules in these Technical Regulations that do not apply to all classes are marked with the class(es) they do apply to using bold font. A class marking is also valid for all subsections of the marked rule. For example, a rule that only applies to the V20 class is marked **[V20]**.

Rules marked **[V10]** also apply to the V10-H2 class. Rules marked **[V10-H2]** only apply to the hydrogen powered boat, not to the solar boat.

4. The boat

4.1. Hull & construction

4.1.1. Main dimensions

- a) **[Open, Master]** The dimensions of the boat are limited to:
 - i. Length: 8.00 m
 - ii. Width: 2.40 m
 - iii. No maximum draught or height is prescribed for the boats. Participants must however consider the fact that the depth of the water is limited in certain sections of the routes raced. The actual water depth and height clearance may vary from time to time. It is the responsibility of the participant to check this.
- b) **[V10, V20, YS]** The dimensions of the boat are standard to their particular class.
- c) The length is the overall length from the front end of the boat, including the registration panel, up to and including the rear end of the boat, including the propulsion system.

4.1.2. Cockpit

- a) All boats must be single pilot boats.
- b) The pilot must have clear field of view and have unobstructed hearing at all times.
- c) The boat may not have a closed cockpit.
- d) The edge of the cockpit must be designed such that it prohibits significant amounts of water entering the cabin in all racing conditions expected. Alternatively, the use of a spray skirt for this purpose is allowed.
 - a. **[YS, V20]** The standard design of the edge of the cockpit of these classes is compliant with this rule.
- e) The use of a spray skirt during racing is allowed under all circumstances.
- f) The boat must be designed to ensure that the pilot will be able to evacuate the boat within 5 seconds without any form of outside assistance. Hatches that need to be opened before the pilot can evacuate the boat are not allowed.
- g) The minimum width of the cockpit is 0.50 m.
- h) The cabin must have a suitable seat for the pilot. This seat must be fixed to the boat such that it cannot come loose under all racing circumstances.
- i) The use of safety belts is allowed.
- j) The cockpit may not have any potential hazards for the pilot.
- k) If the boat is loaded with ballast to compensate for a deficiency in the pilot's mass, it must be properly fixed to the boat in or near the pilot's seat and easily accessible for inspection.

4.1.3. Construction details

- a) **[YS]** The boat design as issued by the foundation Young Solar Friesland has to be built according to the description and may not be modified. Installing systems for optimizing the design and other means to increase the speed of the boat are not allowed. A system to change the location of the centre of mass and a system to change the vertical position of the electric motor are exempted from this.
- b) No prescriptions apply to the use of materials with exception of the following limitations:
 - i. The use of (flexible) materials and constructions that might serve as sails is not allowed.
 - ii. The use of materials that may directly or indirectly pollute the environment is not allowed.
- c) All fastening systems used on board the boat must be mechanically secured.

- i. All connections that are meant to be able to rotate during operation must be secured using a cotter pin, lynch pin or similar securing means.
 - ii. The use of chemical means of securing fasteners such as Loctite is not allowed except with explicit approval from the organization.
 - iii. In a bolted connection the thread must stick out of the nut with a minimum of two full turns. For a self-locking nut with nylon ring, the thread must stick out of the nylon ring with a minimum of two full turns.
 - iv. The use of Tuflok is allowed under the condition that the connection is not adjusted or retightened more than 5 times.
 - v. The use of Velcro is allowed under the condition that this has been clearly indicated in the design and approved by the organization prior to the technical inspection.
 - vi. The organization may ask additional connections to be installed at all times, especially when it concerns the solar panels or items that influence the safety of the pilot or the operation of the boat.
- d) All sharp edges of the boat must be adequately protected.
- e) **[V10, V20, Open, Master]** Adding removable parts to the boat is allowed. These additional parts have to meet all applicable requirements of these Technical Regulations.
- i. The removable parts must be either installed or carried in the boat during the complete race. A designated area in the hull for storage of removable parts must be marked.
 - ii. The use of removable parts is only allowed with approval from the organization prior to the race.
 - iii. Removable parts may be installed or removed during a race. In case of removal this means taking them off and storing them in their designated area in the hull before travelling further.
 - iv. Propellers, hydrofoils and their support structure on the outside of the hull are considered removable parts but do not need to be specifically mentioned as such. They may always be changed and do not need to be carried in the boat during the race.
 - v. Solar panels and parts necessary for achieving the required stability, such as floats, cannot be classified as removable parts and must be installed in their intended position during the race.

4.1.4. Stability and control

- a) The stability of the boat must be such that when a rolling moment of 150 Nm is applied to the boat, with the boat loaded with a load equal to the minimum required mass of the pilot at the location of the seat of the pilot, the boat will not lean over more than 12.5° averaged over a measurement period of 5 seconds.
 - i. Additionally, under application of this rolling moment, no openings in the hull, such as the outlet opening of the bilge pump(s) or the edge of the deck, nor any of the solar panels may be submerged.
 - ii. **[V10, V20, YS]** The standard design of these classes is compliant with this rule.
- b) **[Open, master]** In case one or more (additional) floats are being used, the floats on either side must have a total volume of at least 0.050 m³ (= 50 l).
- c) **[Open, master]** A boat having floats or multiple hulls must be designed such that the highest float touches the water surface before reaching a roll angle of 5°.
- d) Regardless of meeting the requirements in rule 4.1.3, the race organization may require extra stability measures if it deems that the risk of capsizing is too large.
- e) The use of flywheels for stability reasons is allowed.
 - i. The flywheels must be adequately protected against failure by a housing that will contain the flywheels in case of such failure.
 - ii. The flywheels may only be spun up with the help of solar energy or energy from the onboard energy storage system.

- iii. The flywheel and its control system must be designed such that it cannot deliver energy to the boat and its systems.
- f) The steering gear of the boat must provide adequate controllability, must operate smoothly and must be free of play both in loaded and unloaded condition.
- g) Trimming of components (e.g. small adjustments of the pitch angle of the blades of a hydrofoil) may be done mechanically, electrically or manually.
 - i. Manual operation may be direct or indirect via a manually powered hydraulic or pneumatic system.
 - ii. Manual operation may not result in significant propulsive force being generated by the trimming.
- h) A system that takes components (e.g. hydrofoils) in and out of the water without removing them from the boat is allowed.
 - i. Such a system will be operated electrically using the main battery or is operated by the forward speed of the boat.
 - ii. For safety reasons, components taken out of the water may not extend further away from the boat than they did in their original position. In other words, the movement must be either straight upwards or inwards under the boat.
- i) The configuration and layout of the boat is not prescribed and may be adjusted during the race.
 - i. Any means to adjust the configuration must be electrically operated from the main battery only.
 - ii. **[YS]** Only the vertical position of the electric motor and the position of the battery within the hull may be adjusted. Manual adjustment is allowed. The installation of an anti-cavitation plate of reasonable dimensions is allowed.
 - iii. The boat must comply with these regulations in all possible configurations.

4.1.5. Freeboard and buoyancy

- a) All boats must be designed with a minimum freeboard of 0.25 m over the first 2.0 m measured from the front end of the boat and a freeboard of at least 0.20 m over the rest of the boat.
 - i. Both freeboards must be determined in fully loaded condition.
 - ii. The connection between the hull and the deck must be watertight.
- b) All boats must be designed to be capable of generating sufficient buoyancy under full load.
 - i. Sufficient buoyancy is defined as the capacity required to carry the fully loaded boat with a minimum reserve capacity of 100%. In other words, the watertight volume above the waterline has to be equal or larger than the displacement of the hull.
 - ii. The buoyancy capacity must be demonstrated by means of a calculation and/or a weighing. In the demonstration of the minimum reserve capacity any foam used in the structure of the hull is to be excluded.
 - iii. The buoyancy must be distributed over the hull such that the boat is balanced under all circumstances and does not show an excessive tendency to roll or dive in any direction.
 - iv. **[YS]** Young Solar class boats have to install buoyancy aids in the stern as well as in the bow with a combined minimum watertight volume of 50 litres.

4.1.6. Appearance of the boat

- a) All participating boats must show the registration number provided by the organization.
 - i. **[YS]** The registration number must be placed on four prescribed locations on the boat. There must be enough contrast between the colour of the boat and the (black) registration number. E.g. the colour of the hull may not be too dark at the location of the registration number.

- ii. **[Master, Open, V20, V10]** The registration number must be positioned on the registration panel mounted to the boat.
 - i. The team is responsible for acquiring and mounting the registration panel permanently fixed to the boat. It must be constructed such that a radar reflector for speed measurements can be mounted to it.
 - ii. The registration panel must be of a rigid design and material.
 - iii. The registration panel must be no less than 300 mm in height and 300 mm in length.
 - iv. The registration panel must be positioned above the deck no further than 2 m from the bow.
 - v. The bottom of the registration panel may not be placed lower than the top of the solar panels.
 - vi. The registration panel must always be visible, from all angles.
 - vii. The placement of the registration panel may not hinder the accessibility of the towing eye in the prow.
 - viii. Alternatively, the registration number may be placed on both sides of the hull on a surface that does not deviate more than 15 degrees from a surface perpendicular to the waterline and has at least a height of 200 mm and is permanently visible in its entirety during sailing.
- b) Participants are allowed to finish the boat with aesthetic embellishments of their own choice taking into account the rules given in the Notice of Race.
 - i. Participants are allowed to display their sponsors.
 - ii. The appearance of the boat and displays of sponsors may not be in conflict with sound moral standards whatsoever subject to the sole discretion of the organization.
 - iii. The appearance of the boat and displays of sponsors must be in compliance with the local legislation.
 - iv. **[YS]** The instructions of the painting scheme provided by the organization must be complied with. The colour scheme used for the striping described in these instructions may be chosen freely provided the used colours are contrasting enough to make the striping visible.
 - v. **[YS]** The instructions of the sticker plan provided by the organization must be followed. The stickers provided must be put on the boat without modification. Room specifically for 'team sponsors' and 'event sponsors' will be provided in the sticker plan.
- c) A transponder for tracking and tracing during the race may be provided by the organization and must be positioned on the boat according to the instructions from the organization.

4.2. Electrical and propulsion system

4.2.1. General

- a) **[Master, Open, V20, V10]** The maximum allowed system voltage is 60 Vdc.
- b) **[YS]** The maximum allowed system voltage is 30 Vdc.
- c) The open-circuit voltage of the solar panels when the maximum power point trackers (MPPTs) or solar controller(s) are inactive may be higher but is limited to:
 - i. **[Open, Master, V20, V10]** 100 Vdc
 - ii. **[YS]** 50 Vdc
- d) The cabling and connectors used between the solar panels and the MPPTs, not including the MPPTs themselves must be of protection class IP65 or higher.
- e) **[YS]** Components that are off-the-shelf parts or systems may not be taken apart or modified. E.g. the original cables attached to the solar panels and to the motor must be used. They may not be removed, shortened or modified in any other way.

- f) All energy conducting parts must be fully insulated such as to prevent the occurrence of hazardous situations in the case of contact and exposure to water. For instructions on how to do this, please refer to the NEN/DIN standards for example. Special care must be taken in case of boats made of conducting materials (e.g. aluminium, carbon fibre, etc.).
- g) The design of the electrical wiring and circuitry must be based on NEN/DIN standard colour coding.
 - i. A plus-cable must be coloured or marked red
 - ii. A minus-cable must be coloured or marked black or blue.
- h) All electrical cables must be properly sized to expected currents. As a guideline the following table may be used. The table is based on continuous currents in a hot environment. It is the sole discretion of the organization to approve the cables used. For this they may deviate from the values given in the table.

Crossectional area [mm²]	Allowed current [A]
1.5	20
2.5	27
4	36
6	46
10	62
16	80
25	105
35	125
50	155
70	195
95	235
120	270

- i) All cables must be provided with a suitable strain relief.
- j) All electrical systems must be provided with a fuse in serial connection with the main battery ('main fuse').
 - i. The main fuse may under no circumstances carry more than 200% of the expected power.
 - ii. The main fuse must be mounted as close as possible to the main battery.
 - iii. The rating of the fuse may not be higher than the allowed current in the thinnest wire in the relevant part of the electrical system.
- k) In addition to the main fuse, as a minimum the following systems must be fused:
 - i. MPPTs
 - ii. Motor controller
 - iii. Battery Management System

4.2.2. Propulsion system

- a) **[YS]** The propeller must be a propeller that is available as standard for the electric motor used. For the Torqeedo Cruise 3.0 motor, propeller types 198400 and 199600 are the only types allowed.
- b) **[Open, Master, V20, V10]** More than one electric motor intended for propelling the boat may be installed.
- c) **[Open, Master, V20, V10]** It is allowed to change the motor configuration (type of motor, number of motors, type of propeller) between race elements.

4.3. Solar panel

4.3.1. General

- a) All solar boats must be fitted with solar panels, which will serve as the sole source of energy.
- b) The solar panels must consist of photovoltaic solar cells.
- c) **[YS]** The solar panels are limited to two or three commercially available solar panels.
 - iv. The race organization of a race will determine whether two or three solar panels may be used.
 - v. The maximum power output of each individual solar panel is not limited.
 - vi. The solar panels must have a metal rim and a glass cover plate.
 - vii. The maximum outer dimensions of each of the solar panels including metal rim are limited to 1800 mm by 1140 mm.
 - viii. When the solar panels are integrated in the deck of the boat, the seams between the deck and the solar panels need to be adequately sealed.
 - ix. When the solar panels are placed on top of the deck, the holes in the deck must be adequately closed and the edges of the solar panels must be adequately protected.
 - x. The solar panels must be connected to a commercially available MPPT that is rated for the solar panel it is connected to.
- d) **[Open, Master, V10, V20]** The boat may have a total combined exposed solar cell area as given in the table below.

PV cell chemistry	Allowable total exposed cell area [m ²]		
	Open	Master, V20	V10
Si	6.000	9.20	5.000
Thin film GaAs	5.328	8.170	4.440
Thin film CIGS	6.783	10.400	5.653
Multijunction	4.000	6.133	3.333

- i. The exposed solar cell area is defined as the area of the solar cell that is in direct or indirect contact with the solar light.
- ii. The solar panel area will be determined by summing the total area of each solar cell from manufacturer's data sheets. For the purposes of these regulations, the area of an uncut Sunpower cell having a width and length of 125 mm and diameter of 160 mm is 0.015333 m². The area of an uncut Sunpower cell having a width and length of 125 mm and a diameter of 166 mm is 0.015506 m².
- iii. Areas of exposed bus bars, junctions and internal structures on top of the solar cell may not be deducted from the solar cell area.
- iv. The use of bifacial solar cells is not allowed.
- v. The use of concentrators such as reflectors or lenses is not allowed.

4.3.2. Construction

- a) Placing solar panels in a tilted position is allowed under the condition that the angle of tilt is no more than 10° with respect to the waterline.
 - i. The maximum tilt angle of any of the solar cells in a curved solar panel is also subject to this limit.
 - ii. The use of adjustable solar panels is allowed provided they are adjusted by using (electrical) energy derived from the solar panels or the main battery.
 - iii. **[YS]** In case the race organization has determined that three solar panels may be used, boats are exempted from this rule only for the most aft solar panel. The most aft solar panel may only be tilted such that the rear edge of the panel is lifted upwards with a maximum tilt angle of 20°.
- b) Each solar panel must be mechanically secured to the boat, either in a frame or otherwise, and suitably protected against the influence of water.
 - i. The design of the fastening system must be such that it will be wind- and water-resistant in all directions, including turbulence, waves and gusts.
 - ii. Attaching flexible solar panels to the boat may be done using Velcro and/or water-proof double-sided tape.
- c) All parts of the solar panel as well as the frames used to attach the solar panels extending outside the hull must be provided with protection of sharp edges.
- d) Cooling and/or cleaning of the solar panels during race elements is allowed.
 - i. Cooling and/or cleaning during the race elements may only be done with the help of energy from the solar panels or the main battery.
 - ii. Cooling and/or cleaning fluids must be carried on board during the race element and/or may be pumped up from the water in which the race element is being raced.

4.4. Energy storage

4.4.1. General

- a) **[Open, Master, V20, V10]** The use of energy storage systems other than batteries (e.g. super capacitors) for storing electrical energy is allowed.
 - i. Flywheels are not allowed as a form of energy storage intended for propulsion.
 - ii. The use of an energy storage system other than batteries is only allowed after approval by the organization during the design process.
- b) The total capacity of the energy storage system may not exceed:
 - i. **[Open, Master]** 1500 Wh (= 5400 kJ)
 - ii. **[V20]** 1750 Wh (= 6300 kJ)
 - iii. **[V10-H2]** The storage capacity for hydrogen is not limited. Instead, the actual amount of hydrogen onboard at the start of each race element is limited by the race organization.
- c) The energy storage may be brought to the race fully charged.
- d) During the race, the energy storage with exception of the hydrogen fuel may only be charged from the solar panel or hydrogen system, depending on the class.

4.4.2. Battery

- a) **[YS, V10]** The type of battery prescribed by the race organization must be used.
- b) All battery cells used in the race must be commercially available or supplied by the organization. In the latter case, all teams in the same class must be supplied with batteries of the same type and capacity.
- c) The participants must disclose all data related to the batteries to the organization. The battery data provided must at least include a detailed description of the type of battery to be used and the so-called "material safety data sheet" as supplied by the manufacturer thereby providing the organization with adequate information in case of an emergency.

- d) Off-the-shelf batteries may under no circumstances be modified in any way whatsoever.
- e) A dedicated, properly function Battery Management System is mandatory for all batteries other than lead-acid and lead-gel batteries.
 - i. A solar controller is not allowed as a Battery Management System.
 - ii. The Battery Management System must monitor both the battery's voltage and temperature, and must also be capable of disconnecting the battery electrically when necessary.
 - iii. For lithium-based batteries, the monitoring of both charge and discharge currents is required. A means of controlling too high currents must be installed.
 - iv. The Battery Management System must be designed to monitor all individual battery cells. A means to monitor the individual battery cell voltages must be provided and demonstrated during the battery test.
- f) The maximum allowed system voltage of the (composed) main battery is limited to what has been in 4.2.1.
 - i. **[Open, Master, V20, V10]** In order to comply with this rule also during charging, the amount of battery cells placed in series is limited. The following limitations must be taken into account:

Type of battery	Nom. cell voltage	Max. charge voltage	Max. allowed cells in series
Lead-acid and lead-gel	12 V	14.4 V	4
Nickel-cadmium	1.2 V	1.5 V	40
Nickel-metal-hybrid	1.2 V	1.6 V	37
Lithium-ion and lithium-polymer	3.7 V	4.2 V	14
Lithium-iron-phosphate	3.4 V	3.6 V	16

- ii. **[Open, Master, V20, V10]** For the use of other types of batteries not mentioned in the table above, it is required to contact the organization to determine the maximum allowed number of cells in series.
- iii. **[YS]** The standard battery/batteries must be placed in series or parallel as per the instructions from the organization.
- iv. It is not allowed to install additional batteries at any given time, in any location in the boat and for any purpose with the following exceptions:
 - i. Hand-held navigation and communication equipment powered by batteries is allowed as long as they are not electrically connected to the electrical system of the boat.
 - ii. (Laptop) computers powered by batteries are allowed as long as they are not electrically connected to the electrical system of the boat. The battery must be an integral part of the computer.
 - iii. Telemetry equipment not connected to other system(s) of the boat or only connected to other system(s) of the boat via cables carrying data.

4.4.3. [Open, Master, V20, V10] Capacity test

- a) All batteries and other energy storage systems will have to undergo a capacity test, unless a battery standard for its class has been installed. All batteries tested and sealed in previous races are exempted from the capacity test under the condition that the seal is still intact.
 - i. In case an energy storage system different than a battery is used, the method of the capacity test will be determined by the organization when the team is seeking approval for the system during the design process.
- b) For lithium based batteries the capacity test will be a constant resistance, full discharge test or a constant current, full discharge test.

- i. In a constant resistance test the resistance applied during the test is determined by the nominal voltage of the battery and given by the following expression:

$$R_{\text{test}} = V_{\text{nom}} / C_{\text{nom}} (\pm 15\%)$$
 Where:
 - R_{test} = resistor value used during the test in Ohm
 - V_{nom} = nominal voltage of the battery in V
 - C_{nom} = nominal capacity of the battery in Wh
 - ii. In a constant current test the current applied during the test is determined by the nominal voltage of the battery and given by the following expression:

$$I_{\text{test}} = C_{\text{nom}} / V_{\text{nom}}$$
 Where:
 - I_{test} = test current in A
 - C_{nom} = nominal capacity of the battery in Wh
 - V_{nom} = nominal voltage of the battery in V
- c) Teams using non-lithium-based batteries must indicate this during the design procedure. An appropriate means of testing these batteries will be provided.
 - d) The starting point of the capacity test is a fully charged battery.
 - i. Fully charged is defined as the point where the individual cells have reached their maximum voltage and the battery pack as a whole is balanced.
 - ii. Maximum cell voltages are:
 - i. Lithium-ion: 4.2 V \pm 0.05 V
 - ii. Lithium-polymer: 4.2 V \pm 0.05 V
 - iii. Lithium-ion-phosphate: 3.6 V \pm 0.05 V
 - iii. A lead-based battery is considered fully charged when the voltage is 14.4 V for a 12 V nominal battery voltage and current through the battery has declined to less than 2% of the nominal capacity of the battery in Ah (e.g. 2 A of a 100 Ah battery).
 - e) The end of the capacity test is when the battery is fully discharged.
 - i. Fully discharged is defined as the point where the discharge is stopped by the Battery Management System. This must be the point where all individual cells have reached a voltage below the value given:
 - i. Lithium-ion: 2.7 V \pm 0.3 V
 - ii. Lithium-polymer: 2.7 V \pm 0.3 V
 - iii. Lithium-ion-phosphate: 2.5 V \pm 0.3 V
 - ii. A lead-based battery with a nominal voltage of 12 V is considered fully discharged when the voltage is 10.5 V. In order not to damage the battery during discharge, the discharge will continue until the voltage reaches 11.7 V. At that time a depth of discharge of 70% is considered to have been reached. The full capacity will be calculated based on that.
 - f) Only one battery pack per team can be offered for testing.
 - g) The battery pack offered for testing must be balanced and have been fully cycled for at least 5 times.
 - h) The organization does not take responsibility for incorrect functioning of the Battery Management System, unbalanced battery cells, and other kinds of failures of the battery pack that may appear during testing. These will also form no grounds for seeking redress.
 - i) **[Open, Master, V20, V10]** It must be possible to easily seal the energy storage system.
 - i. The team must make sure that the necessary means are made available such that the organization can apply the seal in a simple and fast way.
 - ii. The organization will apply the seal on the energy storage system after it has been tested and technically approved.
 - iii. It must be impossible to replace the battery cells inside the battery or otherwise change the capacity of the energy storage system without breaking the seal.

- iv. If a team needs to break the seal, the organization must be notified as soon as possible.
- v. A boat is prohibited from racing from the moment the seal has been broken. The boat may then only return to the race once it has been subjected to a technical re-inspection which may include a capacity test, and a new seal has been installed.

4.4.4. Construction

Note: in this section, the regulations mention batteries but these regulations are valid for alternative energy storage systems as well.

- b) **[Open, Master, V20, V10]** The minimum distance between the batteries and the pilot is 1 m.
- c) The batterie(s) must be mounted in separate housing(s).
 - i. The battery housing(s) may be fully integrated in the hull or be separate housings secured to the hull.
 - ii. The battery and housing must be fixed securely to the boat.
 - i. The battery housing and its attachments must be designed to withstand a 10g acceleration or deceleration in any direction.
 - ii. When the boat is capsizing, the battery must remain in position.
 - iii. The use of Velcro for mounting the battery and/or its housing is not permitted.
 - iii. The housing(s) must prohibit that, in case of damage to the battery, electrolyte flows into the hull and/or into the environment.
 - iv. The battery housing must be made of materials that are:
 - i. Resistant to the electrolyte of the batteries.
 - ii. Material that is not electrically conductive, including but not limited to metals and carbon fibre-based composites, not even when protected by an insulating layer on the inside of the housing.
 - iii. Fire-retardant.
- v. **[Open, Master, V20, V10]** The battery housing must be fitted with a forced ventilation system with a minimum capacity of 0.3 m³/min unless it can be demonstrated that the batteries do not require air cooling.
 - i. In case of battery failure, gasses may never reach the compartment of the pilot.
 - ii. Both the inlet and the outlet of the ventilation system must be located behind the pilot. Alternative positions must be suitably distant from the pilot, with a minimum of 1 m, and must be approved by the organization during the design phase.
 - iii. **[V20]** The inlet and the outlet of the ventilation system may be less than 1m from the pilot but must at least be positioned on the aft side of the class standard cockpit and the outlet must face in rearward direction.
 - iv. The ventilation system must always be operational when the battery is electrically connected to the motor and solar panels.
 - v. The ventilation system must be designed such that upward spray and rainwater are not able to make direct electrical contact with the battery.
 - vi. The battery ventilation system must be powered by the main battery and/or the solar panels.

4.5. **[V10-H2] Hydrogen system**

4.5.1. Safety devices

- a) The boat must have an on-board leak detector (Lowest Explosive Limit or LEL-detector) suited for measuring hydrogen and that can close the hydrogen supply to the boat. This leak detector must be a commercially available and CE certified

or equivalent. It must be set to trigger at 25% of the Lowest Explosive Limit (=1% hydrogen in air).

- i. The hydrogen system should entail a solenoid valve in the low-pressure part of the system that is operated based on the input of leak detector.
 - ii. After the leak detector has been triggered, the electrical and hydrogen systems of the boat must require an extra intentional action to be restarted.
 - iii. A test of the hydrogen system with the use of a calibration bottle is compulsory. This test must show that when hydrogen is detected the safety valve(s) in the hydrogen system shut down the supply of hydrogen.
- b) The hydrogen system must include a Thermal and Pressure Relief Device (TPRD) that assures the timely relief of hydrogen in case of overpressure or overtemperature. The setting of the TPRD must be such that it starts venting when the temperature reaches 110°C. The TPRD must be installed in the high-pressure part of the hydrogen system.
 - c) The hydrogen system must include a pressure reduction valve on or nearby the hydrogen tank.
 - d) The hydrogen system after the pressure reduction valve must include a pressure relief valve set to no more than 0.8 bar overpressure over the atmospheric pressure.
 - e) The hydrogen system must be grounded to the water. All electrical components must be connected to the same grounding.

4.5.2. Compartments and construction

- a) The hydrogen system must contain an approved hydrogen tank which must be placed and secured on the deck of the boat.
 - i. The hydrogen tank must be securely mounted such that it can withstand accelerations/decelerations of no less than 20 m/s².
 - ii. The distance between the hydrogen tank and the edge of the cockpit as well as the major electric components of the boat may not be less than 1.0 m.
- b) The hydrogen tank, fuel cell(s) and battery may not be housed in the same compartment.
- c) There may be no bilge pump placed in the same compartment the fuel cell(s) have been placed. Elsewhere in the boat an equivalent amount of buoyancy must be created to compensate for the potential filling up of the fuel cell compartment with water. The distribution of this additional buoyancy must be such that the boat remains balanced in case this fuel cell compartment fills up with water.
- d) All elements of the hydrogen system that can carry an overpressure of more than 1 bar may not be placed in a (partially) closed compartment.
- e) Any compartment that houses components that use or carry hydrogen must be constructed such that, regardless of the presence of forced ventilation, hydrogen that has leaked will be vented to the outside air automatically.
 - i. Pipes and hoses are exempted from this rule when they are not interrupted by a coupling or connection of any sort.
- f) On top of every compartment that houses components that use or carry hydrogen a goose neck vent system must be installed. The gooseneck structure must be placed such that any hydrogen leaked, is vented to the environment without significant amounts of water coming into the compartment. The goose neck structure must be fitted with a drain allowing incoming water to be drained.
- g) All teams operating a hydrogen powered boat must supply the organisation with a Piping and Instrumentation Diagram (P&ID) including an overview of all components used and their data sheets well in advance of the race. The P&ID should show at least the elements mentioned under rules 4.5.1 a) thru d) of these Technical Regulations as well as the hydrogen tank and fuel cell.

4.6.Safety

4.6.1.Dead man's switch and main emergency mains switch

- a) All boats must be fitted with a commercially available, approved and functional dead man's switch.
 - i. The functionality of the dead man's switch must be such that when removed, the motor stops running and that when replaced it requires at least one more action before the motor starts running again.
- b) All boats must be fitted with an emergency mains switch that can simultaneously interrupt the power supply to the engine and the power between the solar panels and the MPPTs / Solar Controllers or alternatively, between the MPPTs / Solar Controllers and the battery and engine. Thereby it isolates the power sources from the rest of the electrical system.
 - i. **[V10-H2]** Additionally, the emergency mains switch should shut down the hydrogen supply to the fuel cell.
 - ii. The emergency mains switch is not the same as the dead man's switch or the mains switch.
 - iii. The switch must be capable of breaking the electrical power supply under full load.
 - iv. The switch must be accessible for emergency personnel from the outside of the cabin. Its position must be marked clearly with at least 20 mm high letters on the outside of the boat such that the switch can be easily located.
 - v. The switch must be operated via a red-coloured "mushroom" type push button.
 - vi. It is allowed to use one or more relays in the switching system.
 - vii. In the case of the use of a relay or contactor, this relay or contactor must be rated for the application.
 - viii. A system that short-circuits the solar panels is allowed for interrupting the current to the MPPTs / Solar Controller.

4.6.2.Bilge pump

- a) All boats must be fitted with one or more electrical and automatic bilge pumps.
- b) The pump(s) must be designed to empty all compartments that house the pilot or electrical components.
 - i. The pump(s) must be placed such that they can empty the hull both in static and in racing conditions. This includes conditions arising from accelerating or decelerating manoeuvres.
 - ii. The system must be designed to ensure that separate, not connected compartments can be pumped empty automatically and independently.
 - iii. If floats are fully watertight it is not compulsory to install a bilge pump in the floats. If there is a feedthrough of any kind in a float, the float will not be considered watertight.
- c) The pump(s) must have a minimum combined flow rate of 1500 litre per hour.
 - i. **[Open, master]** If the boat is of a multi-hull design, the pump capacity may be distributed; in other words, a twin-hull boat may be fitted with two pumps, one in each hull, and each with a capacity of 750 litre per hour.
- d) The pipes and/or hoses that are connected to the pump(s) must have a minimum internal diameter that is not smaller than the pump's outlet.
- e) The pipes and/or hoses must be installed such that all bilge water is pumped overboard. The pipes and/or hoses must be free of kinks and sharp bends, and their lengths must be minimized.
- f) **[V10, V20, Open, Master]** In addition to the electric bilge pump(s) the race organization may prescribe that one manually driven bilge pump must be carried in the boat.

- i. The manually driven bilge pump must be function such that it is possible for the pilot to remove water from the main compartment(s) of the boat while in the normal seating position in the cockpit.
- ii. The capacity of the manually driven bulge pump must be at least 0.4 litre per stroke.
- iii. The manually driven bilge pump must be permanently fastened to the structure of the boat, such that one hand operation is possible.

4.6.3. General

- a) All rotating components in or on the boat must be adequately shielded to prevent unintentional contact both on the water and on land. Propellers are exempted from this rule.
- b) All boats must be fitted with a floating towline attached to a fastening point in front of the hull.
 - i. The fastening point(s) and its supporting structure must be capable of holding a minimum load of at least the boat's own weight.
 - ii. The minimum internal diameter of the fastening point(s) must be 20 mm.
 - iii. The towline(s) must have a minimum diameter of 8 mm and a minimum length of 5 m, or less if there is a chance the towline will hit the propeller. The towline(s) must be easy to cut in case of emergency.
 - iv. The towline(s) must be carried on the bow of the boat and easily accessible from a rescue boat for emergency towing.
 - v. **[Open, Master]** Catamarans must have a fastening point on each hull with a floating towline attached to each fastening point.
- c) All boats must carry the following safety items. These items are all separate items and may not be combined.
 - i. A uniformly coloured orange or red warning flag with a minimum size of 300 x 300 mm attached to a stick or similar structure with a minimum length of 1 m.
 - ii. An audible warning system audible at reasonable distance, e.g. an orally, compressed air or electrically operated horn.
 - iii. A clearly visible yellow or orange marker buoy with a diameter of at least 120 mm permanently connected to the boat by a buoyant rope with a minimum length of 5.0 m. The buoy must be positioned such that when the boat disappears under the water surface the buoy starts floating on the water surface indicating the position of the boat.
 - iv. A paddle with a minimum overall length of 0.60 m, minimum blade length of 0.30 m and minimum blade width of 0.13 m. The paddle must be easily accessible from the pilot's seat.
 - v. A boat hook with a minimum length of 1.0 m. The hook must be non-metallic.
 - vi. An approved fire extinguisher with a capacity suitable for extinguishing fires on board the boat, easily accessible from the pilot's seat.
 - i. A capacity of 1 kg (powder) or 1 l (liquid) will be considered suitable. The organization may accept a smaller capacity for certain extinguishing materials or extinguisher types.
 - ii. The extinguishing material must be suitable to extinguish onboard fires, it is preferably foam based.
 - iii. The fire extinguisher must show the date when it was last inspected and the date the next inspection is due. In case no inspection sticker is present, a production date must be visible and the fire extinguisher is considered to be usable for a period of two years after production.
- d) **[Master, Open, V20, V10]** It is mandatory to always use eye protection when assembling, mounting and / or relocating the batteries and / or when performing any other type of activity related to the batteries.

4.7. Miscellaneous

4.7.1. General

- a) **[V20, V10]** The average speed of the boats over long distance must be at least 8 km/h.
- b) **[Master, Open]** The average speed of the boats over long distance must be at least 12 km/h.
- c) The required average speed may be tested during a Prologue to a race or at any other time the race organization deems appropriate. During this test a distance of 10 km will have to be covered with an average speed equal or higher than stated above.
- d) The race organization may require a higher average speed for specific races. This will be published in advance of the race.
- e) The race organization may require a higher average speed for specific race elements. This will be published in advance of the race or during the pilots briefing before the race or race element.

4.7.2. Repairs and modifications

- a) In the case of the occurrence of a (technical) failure on board, the participants are entitled to repair and/or replace the failed or flawed components with identical ones.
 - i. Wherever possible, repairs/replacements must be done under the supervision of a Technical Inspector from the organization.
 - ii. In the case of major repairs/replacements, e.g. replacing of a battery, refuelling with hydrogen, replacing a solar panel and likewise, without prior permission of the organization, the participant will be disqualified for the first upcoming race element.
 - iii. All repairs to the boats' electrical systems must be reported to the organization in advance.
 - iv. Repairs to other parts of the boats may be reported after the repair has been completed.
 - v. Replacement or recharging of batteries must be reported to the organization and will lead to disqualification for the first upcoming race element. An equivalent rule applies for non-battery energy storage devices and power generating/conversion devices.
- b) Modifications to the boat during the racing season are allowed under the following conditions:
 - i. Modifying the boat during a race, after the boat has been technically approved by the organization, is not allowed.
 - ii. Modifying the boat in between races is allowed.
 - iii. All modifications have to be reported to the race organization before the start of the first race element after completion of the modification.
 - iv. Failing to report a modification will lead to issuing a penalty.
 - v. A participant will only be allowed to participate in the race after the modification has been inspected and approved by the race organization.
 - vi. Modifications to the hull, the solar panel, the battery and the motor are not allowed, unless such modifications are demanded by the organization.
 - vii. Modifications demanded by the organization must be incorporated before the given deadline.
 - viii. Changes and/or updates of the software in any component of the boat is allowed at any time.
 - ix. **[YS]** The software of the propulsion system may not be changed and/or updated.

5. Inspections and tests

5.1. Technical inspection

5.1.1. General

- a) The organization is entitled to conduct inspections of the boats at any time of its own choosing. The participants are bound to cooperate with such inspections.
- b) The organization will inspect all boats for full compliance with the regulations prior to the start of the race.
 - i. All participants will be notified in advance of the time and location of the inspections.
 - ii. The organization will invite the participants for an inspection.
 - iii. During the inspection the participants are required to present their boat in a race-ready condition.
 - iv. Boats that fail to comply with the applicable regulations will not be allowed to enter the race until the time they do come into full compliance and this has been confirmed by means of a re-inspection.
 - v. All modifications or repairs to the boat, made after the inspection, will be subject to re-inspection. In order to judge whether a modification or repair is allowed, refer to section 4.7.2.
- c) The inspection set-up will be announced to all participants in advance by means of an inspection form that will be used during the inspection. Participants are asked to prepare themselves for the inspection by means of the inspection form, such that this will facilitate a smooth inspection.
 - i. The organization may decide on the scope of the inspection, but it shall at least include an inspection of the safety equipment and systems.
- d) Participants are at all times responsible for the technical condition and safety of the boat during the course of the race. Approval during the inspections will under no circumstances exempt participants of their due responsibilities.
- e) From the technical inspections onwards, boats shall be kept in the paddock at all times during a race when they are not actually competing in the qualifications and the race itself, or in transit between the race area and the paddock.
 - i. Leaving the paddock without prior permission from the race organization will lead to disqualification.
 - ii. No permission will have to be asked when a boat is to be driven to the racing test, the prologue or the starting point of an element of a race.

5.2. Tests on the water

5.2.1. Evacuation test

- a) The pilot will have to demonstrate that it is possible to evacuate the boat within 5 seconds.
 - i. The evacuation will be performed with the boat in racing configuration and the pilot wearing all required equipment. This includes, among other things:
 - i. Life jacket
 - ii. Helmet
 - iii. Wired communication equipment (if applicable)
 - iv. Installed dead man's switch
 - v. Safety belts (if applicable)
 - vi. Quick release steering wheel (if applicable)
 - vii. Spray skirt (if applicable)
 - ii. The evacuation may be performed towards dry land or into the water, at the discretion of the pilot.

5.2.2. Sailing test

- a) All pilots are required to demonstrate the racing performance of their boats as well as the pilots' own ability to control the boat. During the demonstration the participants have to sail a prescribed circuit or perform a prescribed set of manoeuvres. The boat and the pilot will be judged on the following aspects:
 - i. Sailing skills of the pilot
 - ii. Controllability of the boat
 - iii. Stability of the boat
 - iv. Freeboard of the boat in racing conditions
 - v. Spray characteristics of the boat
- b) Every pilot that will take part in the race have to pass the sailing test.
- c) In case parts have been classified as removable parts under section 4.1.3 e), the sailing test must be passed with and without the removable parts installed.
- d) Based on the results of the sailing test, the organization may decide to exclude a participant from one or more elements of the race even if the boat has been found technically in order. This may be a conditional exclusion based on for instance the expected weather conditions.

6. Pilot and equipment

6.1. The pilot

6.1.1. General

- a) **[Master, Open, V20, V10]** The minimum age of the pilot at the time of the race is 18 years.
- b) **[YS]** The minimum age of the pilot at the time of the race is 16 years.
- c) All pilots are expected to have a minimum mass during the race.
 - i. **[Master, Open, V20, V10]** The minimum mass of the pilot is 70 kg.
 - ii. **[YS]** The minimum mass of the pilot is 60 kg.
 - iii. All pilots will be weighed before the race, at a time and location announced by the race organization.
 - iv. During the weighing, pilots may not wear more clothing than what is reasonable for the race conditions expected. A helmet and approved life vest may be worn.
 - v. In case a pilot weighs less than the required minimum mass, ballast must be carried in the boat when the pilot is sailing in a race element. The mass of the ballast will be determined by subtracting the mass of the pilot from the minimum required mass in the applicable class.
 - vi. The required ballast will be marked with a unique mark for the applicable pilot.
- d) If the boat can sail faster than 20 km/h, the pilot must be in possession of a Small Boat License. The license number must be presented to the race organization.

6.1.2. Pilot equipment

- a) All pilots on board the boat must wear an approved life jacket.
 - i. The capacity of the life jacket must be 150 Newton classed or equivalent.
 - ii. The life jacket may be automatically inflatable when coming into contact with water.
 - iii. The life jacket must be designed such that it keeps the head of the wearer above the water, e.g. it must be supplied with a collar.
- b) All pilots on board the boat must wear a helmet.
 - i. The helmet must be of a bright colour contrasting with the water and with reflections on the water (e.g. blue sky).
 - ii. An open face helmet is preferred.
- c) All pilots should wear bright coloured clothes or a bright coloured wetsuit.
- d) If a pilot wears shoes, they may not be buoyant.
- e) The pilot shall be capable of communicating with one member of the onshore team by any appropriate means.
 - i. The communication equipment must have a broadcast range of at least 3.7 km (2 nautical miles).
 - ii. **[Master, Open, V20, V10]** The means of communication must be integrated in the helmet of the pilot or must be such that it can be worn in combination with the helmet used.
 - iii. **[YS]** Handheld communication may be used.
 - iv. The communication equipment must be waterproof.
 - v. The means of communication must be supplied with a battery of sufficient capacity to last at least one race element without being recharged.
- f) A mobile phone with a tracking app prescribed by the race organization (e.g. eStela) must always be on board the boat during the race.
 - i. This mobile phone must be solely used for the tracking app during the race to ensure battery capacity, app stability and data transfer.

- ii. The race organization may decide to add additional or different tracking equipment to the boat, this will be announced well in advance of the race.