



Technical Regulations 2020

Version 7-Feb-2020

The Technical Regulations presented in this document serve as directives for the races. Situations that are not covered by the Rules will be decisively resolved at the sole discretion of the jury.

The most important changes with respect to the 2019 Technical Regulations have been highlighted in yellow

The maximum system voltage of the Newborn class boats is under discussion. The organization received a suggestion to raise this to 60 VDC. This will allow the use of more commercially available components in the design. These rules show the consequences of that. The final decision will be taken in consultation with the skippers council.

Change in the version 7-Feb-2020: New logo for NK Groenleven Zonnebootrace

Preamble

The organization will freeze the main parameters of the boats for a period of 5 years. Thus no changes in these parameters will be made until 1 October 2025. These means that no categories will be removed (Chapter 4). Furthermore, the onboard energy storage (Rules 5.3.1/5.3.2), the solar panel area (Rules 6.4.2/6.4.3) and maximum system voltage (rule 7.10) will not change.

An exception may be made for rule 7.10 for the Newborn class. During the 2019 award ceremony we received the suggestion to raise the maximum system voltage for this class to 60 VDC such that more commercially available electrical components could be used. This could lead to lowering the costs of the electrical system. With the help if the Skippers' council we will try to reach a conclusion here soon.

If the Technical Committee intends to change the rules mentioned above after 1 October 2025, this will be officially announced before 1 October 2024 on the Solar Sport One website.

Competitors are in any case free, to ask Solar Sport One for a status update.

Recommendations from teams are in any case welcome.

Note: In case safety is at stake, Solar Sport One will make the necessary adjustments to the rules mentioned above. This will be only done after submitting/informing the changes to the Skippers' council and race organizers.

1. General

- 1.1 The rules stipulated herein apply to the events organized in 2020, hereinafter referred to as the 'Races'.
- 1.2 All participants in the race are expected to have read, understood and agreed to the Technical Regulations. The organization will 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 All questions concerning the interpretation of the Technical Regulations must be submitted to the organization in writing.
- 1.4 The rules will be published on the website and are binding for all participants. If deemed necessary by the organization, she has the right to amend these regulations.

2. Technical condition and safety

- 2.1 All participants are at all times responsible for the technical condition and safety of their boats during the course of the race,

- 2.2 The design must be made such that the boat can safely participate in the race taking into account all aspects of the race (racing, storage in the paddock, etc.),
- 2.3 Approval of the design and approval during the inspection will under no circumstances exempt the participants of their responsibility.

3. Definitions

- 3.1 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, as well as any subsequent additions and/or amendments implemented by the race organizers.
- 3.2 Officials: Members of the race committee, the technical committee, the race jury and the organizers, all personnel that can be recognized as such and whose instructions competitors shall promptly follow during the course of the race.
- 3.3 Guests: Persons who have been invited by the organizers to the locations specified as guest areas at specific times and locations, as indicated by the organizers.
- 3.4 Team: The group of persons registered with the organizers who as competitors enter the race with a boat.
- 3.5 Solar boat: A boat that is exclusively powered by solar energy derived from solar panels mounted on board the vessel.
- 3.6 Solar panel: Energy source for the propulsion of the solar boat.
- 3.7 Fully loaded: The condition of the vessel in which all systems have been mounted, all systems have been installed and all systems are operational, all the necessary ballast has been installed and the crew member(s) on board is/are equipped with the prescribed safety devices.
- 3.8 Pilot: The team member who has qualified in accordance with the rules to pilot the vessel during the race.
- 3.9 Steward's vessel: A vessel that is marked as such by means of a flag and that is used for the race-technical and safety supervision of the race.
- 3.10 Paddock: An area allocated by the organizers 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.

- 3.11 Safety gate: Deviation from the shortest possible route that may be introduced by the race organizers for safety reasons. The safety gate consists of 2 buoys that the vessels shall pass in between from the direction of the last start or last control point.
- 3.12 Outside help: All assistance possible provided to any crew member or the boat. Support by team members will not be considered outside help.
- 3.13 Maximum voltage: The maximum voltage, measured in Volts, which is measured with a voltmeter set between any two different points in the electrical system.
- 3.14 Nominal battery voltage: The nominal value of the voltage of the battery.
- 3.15 Dead man's switch: A device that is designed to cut the power supply to the engine as soon as the pilot loses control of the boat or when the pilot leaves the vessel, whether voluntarily or involuntarily.
- 3.16 Battery: The device that is used to store the electrical energy. The following types of batteries for the storage of electrical energy are distinguished in the framework of the race: Lead-acid, Lead-gel, Nickel-Cadmium, Nickel-metal hydride, Nickel-Zinc, Silver-zinc, Nickel-Iron Lithium-ion, Lithium-Iron-Phosphate and Lithium-polymer.
- 3.17 Freeboard: distance between the waterline in fully loaded condition and an imaginary parallel line tangent to the lowest edge of the deck or a line that connects openings in the side of the vessel, if applicable. The smallest distance is governing.
- 3.18 Openings: feedthroughs in the main deck or the side of the vessel such as, bilge pump outlets, feedthroughs of overboard tubing, feedthroughs of cables, etc.
- 3.19 Means of energy storage: Any means, other than batteries, to store energy (e.g. super capacitors, flywheels, heated water, etc.)
- 3.20 Added Buoyancy: closed volume above the loaded waterline, which can take up loads on top of the static loading of the vessel.
- 3.21 Mains switch: a switch that when switched to the 'on' position, electrically powers the boat. This switch is not the same as the emergency mains switch.
- 3.22 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. Its functionality and requirements are given in rule 7.16.

4. Categories

4.1 The race is open to the following boat categories:

4.1.1. Newborn class boats,

4.1.2. Open class boats,

4.1.3. V20-class boats,

4.1.4. Young Solar Class boats.

4.2 All boats must be single pilot boats.

4.3 The dimensions of boats in the Open class are limited to

4.3.1 length: 8.00 m

4.3.2 width: 2.40 m

4.4 The dimensions of the Newborn class boats are standard to their particular class.

4.5 The dimensions of the V20-class boats are standard to their particular class.

4.6 The dimensions of the Young Solar class boats are standard to their particular class.

4.5.1. 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.

4.5.2. The rear part of the boat (transom) must to be strengthened sufficiently to carry the load of the engine. The design makes this possible.

4.5.3. Components supplied are standard and may not be taken apart or modified. E.g. the original cables attached to the solar panels and the original cables attached to the motor must be used. They may not be removed, shortened or modified in any other way.

4.5.3.1. The propeller may only be replaced by an identical one.

4.5.3.2. The batteries may only be replaced by identical ones.

4.5.3.3. Maximum Powerpoint Trackers may only be replaced by identical ones.

- 4.7 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, and including the propulsion system. Exceeding the maximum length by more than 0.5% of the allowed length will lead to disqualification.
- 4.8 No maximum draught or height is prescribed for the boats. Participants must however take into account 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.

5. The Boat

- 5.1 All boats must be fitted with solar panels, which will serve as the sole source of energy.
- 5.2 No prescriptions apply to the use of materials with the exception of the following limitations:
 - 5.2.1. The use of (flexible) materials and constructions that might serve as sails is not allowed.
 - 5.2.2. The use of materials that may directly, or indirectly, pollute the environment when in contact with water is not allowed.
- 5.3 The use of energy storage systems, other than batteries for storing electrical energy, is allowed (e.g. flywheels, super capacitors, etc.).
 - 5.3.1. **The total onboard energy storage capacity for Newborn class boats and Open class boats** is limited to 1.500 kWh (=5.400 MJ). This capacity includes the storage capacity of batteries for storing electrical energy.
 - 5.3.2. The total onboard energy storage capacity for V20-class boats is limited to 1.750 kWh (=6.300 MJ). This capacity includes the storage capacity of batteries for storing electrical energy.
 - 5.3.3. The total onboard energy storage capacity for Young Solar class boats is limited to the storage capacity of the batteries that are standard to this class.
- 5.4 The pilot must have a clear field of view and have unobstructed hearing at all times.
- 5.5 The boat may not have a closed cabin.
 - 5.5.1 The edge of the cabin 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 to prohibit water entering the cabin is allowed.

- 5.5.2 Under all circumstances the use of a spray skirt during racing is allowed.
- 5.5.3 The standard design of the edge of the cabin of Young Solar class boats and V20-class boats can be considered such that compliance with rule 5.5.1 has been shown.
- 5.6 All boats must be designed to ensure that the pilot will be able to evacuate the boat within 5 seconds without any form of outside assistance.
 - 5.6.1. This must be demonstrated by means of an evacuation test.
 - 5.6.2. The dead man's switch must also be activated simultaneously during the evacuation without having a delaying effect of any nature whatsoever on the evacuation.
 - 5.6.3. Hatches that need to be opened before the pilot can evacuate the boat are not allowed
 - 5.6.4. The minimum width of the cabin is 50 cm.
 - 5.6.5. The cabin must have a suitable seat for the pilot.
- 5.7 The use of safety belts is not allowed on board the boats.
- 5.8 The cabin may not have any potential hazards for the pilot.
- 5.9 The stability of the boats must be such that a prescribed rolling moment of 150 Nm 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, will not result in lean over exceeding 12.5 degrees averaged over a measurement period of 5 seconds.
 - 5.9.1. In that case none of the openings in the hull, such as the outlet opening of the bilge-pump(s) or the edge of the deck or any of the solar panels may be submerged below the waterline.
 - 5.9.2. In case (additional) floats are being used, the floats on either side must have an additional volume of at least 50 dm³.
 - 5.9.3. It is allowed to use more than one (additional) float on either side of the boat.
 - 5.9.4. In that case the total displacement of the combined floats on either side must be 50 dm³ or more.
 - 5.9.5. A boat having floats or multiple hulls must be designed such that the highest floater touches the water surface before reaching a roll-angle of 5 degrees.

- 5.10 All boats must be fitted with a commercially available and approved dead man's switch that will remain fully functional at all times while the pilot is on board.
 - 5.10.1. This will be tested during the evacuation test,
 - 5.10.2. The functionality must be such that when removed the motor stops running and that when replaced it requires at least one more additional action to have the motor start running again.
- 5.11 If the boat is loaded with ballast, it must be properly fixed to the boat.
 - 5.11.1. The ballast required to make up for a deficiency in the pilot's mass must be placed in or near their seat.
 - 5.11.2. It must be easily accessible for inspection.
- 5.12 It is mandatory for all boats to be fitted with one or more electrical and automatic bilge-pumps.
 - 5.12.1. The pump(s) must be designed to empty all compartments that house passengers or electrical components.
 - 5.12.2. The pump(s) must be placed such that they can empty the hull both in static and in racing condition. This includes accelerating and decelerating manoeuvres.
 - 5.12.3. The system must be designed to ensure that each of the above-mentioned compartments can be pumped empty automatically and independently.
 - 5.12.4. The pump(s) must have a minimum combined flow rate of 1500 litres per hour.
 - 5.12.5. The pipe(s) 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.
 - 5.12.6. The pipes and/or hoses must be installed such that all bilge water is pumped overboard.
 - 5.12.7. If the boat is a multi-hull design, the pump capacity may be distributed; in other words, a catamaran may be fitted with two pumps, one in each hull, and each with a capacity of 750 litres per hour.
 - 5.12.8. If floats are fully watertight it is not compulsory to install an electrically driven bilge pump in the floats.
 - 5.12.9. If there is a feed-through of any kind in a float, the float will be considered to be not watertight.

- 5.12.10. In addition to the electric bilge pump(s) one manually driven bilge pump must be carried in the boat.
 - 5.12.11. The manually driven bilge pump must be functional such that it is possible for the pilot to remove water from the boat, preferably from the normal seating position in the cockpit
 - 5.12.12. The capacity of the manually driven bilge pump must be at least 0.4 litre per stroke.
 - 5.12.13. The manually driven bilge pump must be permanently fastened to the structure of the boat such that operation from within the cockpit is possible.
 - 5.12.14. Young Solar class boats are exempted from the obligation to install an additional, manually driven bilge pump.
- 5.13 All rotating components in or on the boat must be adequately shielded to prevent unintentional contact.
- 5.13.1. This applies both on the water and on land.
 - 5.13.2. Propeller(s) used for propulsion are exempted from this rule.
 - 5.13.3. In the case of the use of a flywheel for power storage purposes, it must be fitted into a protective housing that is capable of containing all released components in the case of disintegration of the system.
 - 5.13.4. The latter characteristic must be demonstrated by means of a suitable test or calculation.
- 5.14 All fastening systems used on board the boat must be mechanically secured.
- 5.14.1. All connections that may rotate during operation must be secured with the use of a cotter pin.
 - 5.14.2. The use of securing means, such as "loctite" is not allowed, except with the special permission of the organization.
 - 5.14.3. Permission will only be granted based on a prior written application to the organization with due motivation.
 - 5.14.4. The application must also include a design description and a description of the need for the use of this type of securing means.
 - 5.14.5. In a bolted connection the thread must stick out of the nut with a minimum of two full turns.
 - 5.14.6. When using self-locking nuts the thread must stick out of the plastic locking ring with a minimum of two full turns.

- 5.14.7. The use of Velcro is allowed under the condition that this has been clearly indicated in the design and approved by the Organiser prior to the technical inspection.
- 5.14.8. The use of Tuflok is allowed under the condition that the connection is not adjusted or retightened more than 5 times
- 5.14.9. The Organiser 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.
- 5.15 All boats must be designed with a minimum freeboard of 25 cm over the first 2 m measured from the front end of the boat and a freeboard of at least 20 cm over the rest of the boat.
- 5.15.1. Both freeboards must be determined in fully loaded condition.
- 5.15.2. The connection between the hull and the deck must be watertight.
- 5.16 All boats must be designed to be capable of generating sufficient buoyancy under full load.
- 5.16.1. In this context 'sufficient' is defined as the capacity required to carry the complete construction, including the pilot, 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.
- 5.16.2. The latter capacity must be demonstrated by means of a calculation and/or a weighing. In the demonstration of the minimum reserve capacity foam used in the structure of the hull is to be excluded.
- 5.16.3. Young Solar class boats have to install buoyancy aids in the stern as well in the bow, with a combined minimum upward force of 500 N.
- 5.16.4. In addition, the boat must also be designed and built such as to ensure that it remains floating the moment it fills up with water and that there is no contact possible of the water with critical parts of the electrical system like the battery. In this case it may be assumed that the pilot is no longer on board.
- 5.17 All boats must be fitted with a fastening point for a towline in front of the hull (catamarans must have a fastening point on each hull).
- 5.17.1. The fastening point(s) and its supporting structure must be capable of holding a minimum load of at least the boat's own weight.

- 5.17.2. The minimum internal diameter of the fastening point(s) must be 20 mm.
 - 5.17.3. All boats must be provided with a floating towline with a length of 5 m or less if there is a chance the towline will hit the propeller. The minimum diameter of the towline must be 8 mm. The towline must be easy to cut in case of emergency.
 - 5.17.4. Catamarans must be fitted with two floating towlines, with a length of 5 m and a minimum diameter of 8 mm, one attached to each of the two hulls. These lines must be easy to cut in case of emergency.
 - 5.17.5. The towline(s) must be carried on the bow of the boat and easily accessible from a rescue boat for emergency towing.
- 5.18 All boats must be fitted with a minimum of two types of signaling systems.
- 5.18.1. An uniformly coloured orange or red warning flag with a minimum size of 30 x 30 cm attached to a stick or similar structure with a minimum length of 100 cm.
 - 5.18.2. The warning flag may not be combined with the required boat hook.
 - 5.18.3. An audible warning system, such as a ship's horn audible at reasonable distance, e.g.
 - 5.18.3.1. An orally operated horn
 - 5.18.3.2. A horn operated by a compressed air bottle
 - 5.18.3.3. An electrically operated horn
- 5.19 All boats racing on inland waterways must be fitted with a clearly visible yellow or orange marker buoy with a diameter of at least 12 cm.
- 5.19.1. The buoy must be permanently connected to the boat by a buoyant rope with a minimum length of 5 m.
 - 5.19.2. The connection and storage of this buoy must be such that when the boat disappears under the water surface the buoy starts floating on the water surface and thereby indicates the position of the boat.
- 5.20 All boats must be fitted with at least one paddle.

- 5.20.1. The paddle must be functional such that it is possible for the pilot to paddle the boat, preferably from the normal seating position in the cockpit.
 - 5.20.2. The paddle(s) must have a minimum overall length of 60 cm, a minimum blade length of 30 cm and a minimum blade width of 13 cm.
 - 5.20.3. The paddle(s) must be fastened in an easily-accessible location on board the boat.
 - 5.20.4. The paddle may not be used as a means of propulsion during the race.
 - 5.20.5. The paddle must have a single function. It may not be combined with any other (emergency) device on board the boat.
- 5.21 All boats must be fitted with an approved fire extinguisher with a minimum capacity of 1 kg of extinguishing material suitable for extinguishing fires on board, preferably with a foam-based means of extinguishing
- 5.21.1. Only fire extinguishers showing a valid approval are allowed. The approval should show the date the fire extinguisher was tested last and the date when the next test is due. **In case no valid approval is visible on the fire extinguisher(s), the fire extinguisher is considered to be usable for a period of two years after production.**
 - 5.21.2. The fire extinguisher must be mounted in a position such that it can be reached easily by all the pilot from the normal seating position in de cockpit and cannot drop into the water after taking it out of its attachment.
 - 5.21.3. In addition to the manually operated fire extinguisher an automated means of fire extinguishing may be installed.
- 5.22 All boats must be equipped with a boat hook.
- 5.22.1. The minimum length of the boat hook is 1 m.
 - 5.22.2. The boat hook must have a non-metallic hook.
 - 5.22.3. The boat hook may not be combined with the paddle.
- 5.23 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.
- 5.23.1. Wherever possible repairs/replacements must be done under the supervision of a Technical Inspector.

- 5.23.2. In the case of major repairs/replacements, e.g. in the case of the replacement of a battery, the participant will be disqualified for the first upcoming race element.
- 5.23.3. All repairs to the boats' electrical systems must be reported to the Organiser in advance.
- 5.23.4. Repairs to other parts of the boats must be reported subsequently.
- 5.23.5. Replacement or recharging of batteries must be reported to the Organiser and will lead to disqualification for the first upcoming race element. An equivalent rule applies for non-battery energy storage devices.
- 5.23.6. Modifications to the boat are allowed under the following conditions:
 - 5.23.6.1 Modifying the boat during a race, after the boat has been technically approved by the Organiser, is not allowed.
 - 5.23.6.2 Modifying the boat in between races is allowed.
 - 5.23.6.3 All modifications have to be reported to the Organiser before the start of the first race element after completion of the modification.
 - 5.23.6.4 Failing to report a modification will lead to issuing a penalty.
 - 5.23.6.5 A participant will only be allowed to participate in the race after the modification has been inspected and approved by the Organiser.
 - 5.23.6.6 Modifications to the hull, the solar panel, the battery and the motor are not allowed.
- 5.23.7. Modifications demanded by the Organiser must be incorporated before the given deadline.
- 5.23.8. A change and/or update of the software in any component of the boat is allowed at any time.
- 5.23.9. While performing a modification, participation in the race is suspended until the modification has been inspected and approved by the Organiser.

- 5.24 The average speed of the boats in the Newborn Class and the V20-class must be at least 8 km/h. The average speed of the boats in the Open class must be at least 12 km/h. This may be tested during a Prologue to the race or at any other time the organization deems appropriate. During this test a distance of 10 km will have to be covered within a time of 1 hour and 15 minutes for Newborn class boats and V20-class boats and within 50 minutes for Open class boats.
- 5.25 All sharp edges of the boat must be adequately protected.
- 5.26 The steering gear of the boat must be sized for adequate controllability, must operate smoothly and must be free of play both in loaded and unloaded condition.
- 5.27 Adding removable parts to the boat is allowed for Newborn class boats, Open class boats and V20-class boats. These additional parts have to meet all necessary requirements of these Technical Regulations
- 5.27.1. The removable parts must either be installed or carried in the boat during the complete race.
- 5.27.2. During the design process it must be clearly indicated that you want to apply this rule and this has to be approved
- 5.27.3. The boat will have to pass the technical inspection both with and without the removable parts installed
- 5.27.4. Marking parts as removable parts after having passed the design process is not allowed
- 5.27.5. Propellers, hydrofoils and their support structure on the outside of the hull are considered removable parts but do not need to be specifically mentioned. They may be changed at all times and do not need to be carried on board the boat during the race.
- 5.27.6. Certain parts may not be allowed to be classified as removable parts. These include at least:
- 5.27.6.1. parts necessary for achieving the required stability, for example floats.
- 5.27.6.2. solar panels
- 5.27.7. Physical removal/installation of removable parts may be done manually. In the case of removal this means taking them off and storing them in the hull of the boat before travelling further. The first bullet of this rule applies. Inside the hull it must be clearly marked where the removed parts will be stored such that they don't go "missing".

- 5.27.8. Using a system that makes it possible to take components (hydrofoils, etc.) in and out of the water without removing them from the boat will have to be a system that is operated electrically from the main battery. This may be done in both a direct (e.g. an electrically operated actuator) and indirect way (e.g. the system requires forward speed of the boat to operate and the required forward speed is achieved via the propulsion system that is powered electrically). Rule 5.28 applies.
 - 5.27.9. Trimming the setting of components (e.g. small adjustments of the pitch angle of the blades of a hydrofoil) whilst being installed and submerged in the water may be done both electrically and manually. Manual operation may be direct (manual operation of a control) or indirect (e.g. using a hydraulic or pneumatic system that is powered manually). The condition for manual operation is that there may be no significant propulsive force being generated from the manual operation of the system.
- 5.28 The configuration of the boat is not prescribed and may be adjusted throughout the race.
- 5.28.1. Any means to adjust the configuration must be electrically operated from the main battery.
 - 5.28.2. It is not allowed to install a secondary power source for that purpose.
 - 5.28.3. The adjustment of the solar panels may only be done electrically.
 - 5.28.4. Furthermore, the boat must meet all requirements of these regulations in all possible configurations.
 - 5.28.5. In Young Solar class boats only the position of the electric motor and the battery may be adjusted. They may be adjusted manually

6. Solar panel

- 6.1 Sunlight is the only power source that shall be used for propulsion. Wind and human power are not allowed.
 - 6.1.1. The sunlight may be used directly (received on board during the race using the solar panel) or may be stored in batteries or in other approved energy storage devices.
 - 6.1.2. Batteries may be charged only from the solar panel during the race.
 - 6.1.3. Batteries may be brought to the race fully charged.

- 6.2 The solar panels of the V20-class boats are standard to their particular class.
- 6.3 The solar panels of the Young Solar class boats are standard to their particular class.
- 6.4 The solar panel of **all boats** must comprise of photovoltaic solar cells.

6.4.1. **Newborn class boats may have a total combined exposed solar cell area as is given in the table below.**

PV cell chemistry	Allowable total cell area (m ²)
Si	5.000
Thin film GaAs	4.440
Thin film CIGS	5.653
Multijunction	3.333

6.4.2. **Open class boats may have a total combined exposed solar cell area as is given in the table below.**

PV cell chemistry	Allowable total cell area (m ²)
Si	6.000
Thin film GaAs	5.328
Thin film CIGS	6.783
Multijunction	4.000

6.4.3. V20-class boats may have a total combined exposed solar cell area as is given in the table below.

PV cell chemistry	Allowable total cell area (m ²)
Si	9.200
Thin film GaAs	8.170

Thin film CIGS	10.400
Multijunction	6.133

6.4.4. 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 153.33 cm². The area of an uncut Sunpower cell having a width and length of 125 mm and a diameter of 166 mm is 155.06 cm².

6.4.5. Areas of exposed bus bars, junctions and internal structures on top of the solar cell may not be deducted from the solar cell area.

6.4.6. 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.

6.5 The use of concentrators such as reflectors and/or lenses is not allowed.

6.6 The solar panels must be placed horizontally on all boats.

6.6.1. The maximum deviation from the horizontal position is 10 degrees.

6.6.2. This also holds for the maximum deviation from the horizontal position of curved solar panels.

6.6.3. 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.

6.7 Each applied solar panel must be mechanically secured to the boat, either in a frame or otherwise, and suitably protected against the influence of water.

6.7.1. 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.

6.7.2. All parts of the solar panel sticking out of the hull as well as the frames used to attach the solar panels must be provided with protection of sharp edges

7. Electronics

7.1. Participants are only allowed to use batteries that can be recharged electrically.

- 7.1.1. The use of other types of batteries, such as mechanically charged batteries is not allowed.
 - 7.1.2. Every team is responsible for its own batteries.
 - 7.1.3. All batteries cells used in the race must be commercially available.
 - 7.1.4. The batteries may under no circumstances be modified in any way whatsoever.
 - 7.1.5. The participants must disclose all data related to the batteries to the Organiser. The battery data provided must at least include a detailed description of the type of battery to be used and the so-called "materials safety data sheet" as supplied by the manufacturer thereby providing the organisation with adequate information in case of an emergency.
- 7.2. The batteries must be mounted in separate housings, such as to eliminate the risk of direct contact between the pilot and the batteries and environmental pollution is prohibited.
- 7.2.1. The purpose of the battery housing is to simplify the mounting of the battery in the boat.
 - 7.2.2. The batteries and the fastening systems must be designed and manufactured such that they will remain fixed in their positions in the case of the boat capsizing and thereby prohibiting environmental pollution.
 - 7.2.3. The battery housing may be a separate housing or may be fully integrated in the hull.
 - 7.2.4. The battery housing must prohibit, in case of damage of the batteries, that electrolyte flows into the hull and/or into the environment.
 - 7.2.5. The battery housing must be manufactured out of materials resistant to the electrolyte of the batteries.
 - 7.2.6. The battery housing may not be made out of a galvanic conductive material. Thus, the battery housing may not be made of carbon fibre-based composite and/or metals, not even when protected by an insulating layer on the inside of the housing. Nor may the battery be mounted to a metal or carbon fibre-based plate.
 - 7.2.7. The battery housing must be made out of a fire-resistant material.
 - 7.2.8. The attachment of the battery housing must be designed to withstand a 10 g acceleration or deceleration in any direction.

- 7.2.9. The use of Velcro for mounting the battery and/or its housing is not permitted.
- 7.2.10. The minimum distance between the batteries and the pilot is one metre. Young Solar class boats are exempted from this rule.
- 7.2.11. All requirements with respect to mounting the batteries and their housing also apply to all other means of energy storage.
- 7.2.12. The housing must be fitted with a forced ventilation system with a minimum capacity of 0.3 m³/minute. Young Solar Class boats are exempted from this rule.
- 7.2.13. Alternatively, the battery housing may be closed and cooled in another way (e.g. liquid cooling). In that case the cooling must be adequate for all expected circumstances of weather and power consumption.
- 7.2.14. In case of a battery failure gasses may never reach the compartment of the pilot.
- 7.2.15. The ventilation system must be operational at all times from the time the battery is electrically connected to the boat (= when the mains switch of the electrical system is on).
- 7.2.16. Both the inlet and the outlet of the ventilation system must be located in a position behind the pilot or in an alternative position that is suitably distant from the pilot; all subject to the sole discretion of the Organiser. The minimum distance required is one metre.
- 7.2.17. The battery ventilation system must be designed such that upward spray and rainwater will not be able to make direct electrical contact with the battery,
- 7.2.18. The battery ventilation system must be powered by the main battery and/or the solar panels.
- 7.3. The boats may be fitted with a battery pack with a maximum capacity given in rule 5.3 of these regulations. All further references to the battery pack will refer to the 'main battery'.
 - 7.3.1. To be able to judge this requirement, all batteries of Newborn class, V20-class and Open class boats will have to undergo a capacity test.
 - 7.3.2. Young Solar class boats are exempted from the capacity test.
 - 7.3.3. All batteries tested and sealed in previous races are exempted from the capacity test.

- 7.4. For lithium-based batteries this capacity test will be a constant resistance, full discharge test or a constant current, full discharge test.

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:

$$R_{\text{test}} = V_{\text{nom}}^2 / C_{\text{nom}} (\pm 15\%)$$

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

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

- 7.5. Teams using non-lithium based batteries must indicate this during the design procedure. An appropriate means of testing these batteries will be provided.

- 7.6. The starting point of the capacity test is a fully charged battery.

7.6.1. 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.

7.6.2. The maximum cell voltages are:

Lithium-ion: 4.2 V \pm 0.05 V

Lithium-Polymer: 4.2 V \pm 0.05 V

Lithium-Iron-Phosphate: 3.6 V \pm 0.05 V

7.6.3. 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 Amp-hours (e.g. 2 Amps for a 100 Ah battery).

- 7.7. The end of the capacity test is when the battery is fully discharged.

7.7.1. 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:

Lithium-ion: $2.7 \text{ V} \pm 0.3 \text{ V}$

Lithium-Polymer: $2.7 \text{ V} \pm 0.3 \text{ V}$

Lithium-Iron-Phosphate: $2.5 \text{ V} \pm 0.3 \text{ V}$

7.7.2. 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 on the basis of that.

7.8. Only one battery pack per team can be offered for testing.

7.8.1. The battery pack offered must be balanced and have been fully cycled for at least 5 times.

7.8.2. The organisation does not take responsibility for incorrect functioning Battery Management Systems, 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.

7.9. A dedicated, properly functioning Battery Management System is mandatory for all batteries other than lead-acid and lead-gel batteries.

7.9.1. A solar controller is not allowed as a Battery Management System

7.9.2. The system must monitor both the battery's voltage and temperature, and must also be capable of shutting the system down when necessary.

7.9.3. For Lithium-based batteries the monitoring of both charge and discharge currents is required. A means of controlling too high currents must be installed.

7.9.4. 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.

- 7.10. The maximum allowed system voltage for Open class boats is 52 VDC. The maximum allowed system voltage for Newborn class boats is 60 VDC. The maximum allowed system voltage for Young Solar class boats is 30 VDC. However, a set-up of the solar panels where the open circuit voltage is higher is acceptable under the following conditions:
- 7.10.1. When the electrical system is switched on (e.g. a maximum power point tracker or solar controller is active) the maximum voltage in the complete electrical system is 52 VDC or below for Open class boats, 60 VDC or below for Newborn class boats or 30 VDC for Young Solar class boats.
- 7.10.2. In case the electrical system is switched off, the maximum voltage measured in the system is also 52 VDC for Open class boats, 60 VDC for Newborn class boats, or 30 VDC for Young Solar class boats, with the exception of the part of the electrical system between the solar panels and the maximum power point tracker or solar controller.
- 7.10.3. In that part of the system and under that specific condition the maximum voltage must be 100 VDC or less or 50 VDC or less for Young Solar class boats.
- 7.10.4. The cabling and connectors used as well as the housing of the MPPTs will have to be of insulation class IP65 or higher. Possible cables can be of the type Ölflex solar XLS with Epic solar 4 connectors.
- 7.11. The maximum nominal allowed voltage of the (composed) main battery is 48 VDC for Open class boats or xxx VDC for Newborn class boats.
- 7.11.1. In order to be able to comply with this rule in combination with rule 7.8 also during charging, the amount of batteries placed in series will be limited. The following limitations must be taken into account:

Type of battery	Nominal voltage used	Maximum charge voltage	Maximum allowed number of batteries in series for Open class boats	Maximum allowed number of batteries in series for Newborn class boats
Lead-acid and lead-gel batteries	12 V	14.4 V	3	4
Nickel-Cadmium	1.2 V	1.5 V	34	40
Nickel-metal hydride	1.2 V	1.6 V	32	37
Standard Lithium-	3.7 V	4.2 V	12	14

Ion				
Lithium-Polymer	3.7 V	4.2 V	12	14
Lithium-Iron-Phosphate	3.4 V	3.6 V	14	16

7.11.2. Young Solar class boats must install 2, 12V, batteries in series.

7.11.3. For the use of other types of batteries not mentioned in the overview the participant is required to contact the organisation to have determined the maximum allowed number of batteries in series.

7.12. It is not allowed for a team to install additional batteries at any given time, in any location in the boat and for any purpose with the following exemptions:

7.12.1. 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.

7.12.2. The use of (laptop) computers powered by batteries is allowed as long as they are not electrically connected to the electrical system of the boat.

7.13. 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 has to be taken in case of boats made out of conducting materials (e.g. aluminium, carbon fibre, etc.).

7.14. The design of the electrical wiring and circuitry must be based on standard colour coding (NEN/DIN standards).

7.14.1. A plus-cable must be coloured or marked red.

7.14.2. A minus-cable must be coloured or marked black or blue.

7.14.3. All cables must be provided with a suitable strain relief.

7.15. All electrical cables must be properly sized to expected system 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 Organiser to approve the cables used. For this they may deviate from the values given in the table.

Crosssectional area (mm ²)	Allowed current (A)
0.75	6
1	8

1.5	12
2.5	17
4	22
6	29
10	40
16	54
25	71
35	87
50	105
70	135
95	165
120	190
150	220

7.16. 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 Maximum Powerpoint Trackers / Solar Controllers in emergency situations. Thereby it isolates the power sources from the rest of the electrical system. This switch is not the same switch as the dead man's switch **or the mains switch**.

7.16.1. The switch must be capable of breaking the electrical power supply under full load.

7.16.2. The switch must be accessible for emergency personnel from the outside of the cabin. It's position must be marked clearly on the outside of the boat such that the switch can be easily located.

7.16.3. The switch must be clearly marked as an emergency switch.

7.16.4. The switch must be operated via a red coloured 'mushroom' type push button

7.16.5. The lettering must be of a minimum height of 20 mm.

7.16.6. It is allowed to use one or more relays in the switching system.

7.16.7. In the case of the use of a relay or contactor, this relay/contactor must be rated for the application.

7.16.8. A system that short circuits the solar panels will be allowed for interrupting the current to the MPPTs /solar controller.

7.17. All electrical systems must be provided with a fuse in serial connection with the main battery ('main fuse').

7.17.1. The main fuse may under no circumstances carry more than 200% of the expected power.

- 7.17.2. The main fuse must be mounted as close as possible to the main battery.
- 7.17.3. The rating of the main fuse may not be higher than the allowed current in the thinnest wire in the relevant part of the electrical system.
- 7.17.4. In addition to the main fuse, as a minimum, the following systems must be fused:

- Solar panel
- Motor controller
- Battery
- Battery Management System

- 7.18. Participants are bound to use eye-protecting eye gear at all times when assembling, mounting and / or relocating the batteries and/ or when performing any other types of activities related to the batteries.
- 7.19. It must be possible to easily seal the energy storage system(s) (battery or any other type of energy storage).
 - 7.19.1. The participating teams must make sure that the necessary means are made available such that the organisation can apply the seal in a simple and fast way.
 - 7.19.2. The Organiser will apply the seal after the boat has been technically approved.
 - 7.19.3. If a participant needs to break the seal, he or she is bound to notify the organization as soon as possible.
 - 7.19.4. The boat is prohibited from racing from the moment the seal has been broken.
 - 7.19.5. The boat may only return to the race once it has been subjected to a technical re-inspection and a new seal has been installed.
 - 7.19.6. It must be possible to easily seal the housing. This must be done in such a way that it is not possible to (re)charge the battery with any other source than solar energy and that it is not possible to replace the battery without breaking the seal.
- 7.20 During the technical inspections and/or at any moment on request, the teams are obliged to show the electrical circuitry schemes.

8. Appearance of the boats

- 8.1 All participating boats must show the registration number provided by the organisation.

- 8.1.1. The registration number must be positioned on the registration panel mounted to the boat
 - 8.1.2. The registration panel must be no less than 300 mm in height by 300 mm in length.
 - 8.1.3. The participating team is responsible for the acquiring and mounting the registration panel that must be rigid and permanently fixed to the boat.
 - 8.1.4. The registration panel must be positioned above deck no further than 2 meters from the bow.
 - 8.1.5. The bottom of the registration panel may not be placed lower than the top of the solar panels.
 - 8.1.6. The registration number must be visible at all times and from all angles.
 - 8.1.7. The placement of the registration panel may not hinder the accessibility of the towing eye in the prow.
- 8.2 Participants are allowed to finish the boat design with aesthetic embellishments of their own choice taking into account the rules given in the Notice of Race.
- 8.2.1. Participants are also allowed to display their sponsors,
 - 8.2.2. These displays may not be in conflict with sound moral standards whatsoever,
 - 8.2.3. All subject to the sole discretion of the organization.
 - 8.2.4. Young Solar class boats must comply with the instructions of the drawing '7148-02 Verfplan rev0 .pdf' where the required striping is displayed. This striping has to be matched exactly. The colour scheme used is free of choice. Make sure there are enough contrasting colours to make the striping stand out.
 - 8.2.5. The Young Solar class boats must comply with the instructions of the sticker plan in drawing '7148-01 Stickerplan rev0.pdf'. The stickers provided have to be put on the boat. In this sticker plan room is provided specifically for 'team sponsors' and 'event sponsors'.
- 8.3 A transponder for tracking and tracing during the race may be provided by the organisation and must be positioned on the boat as instructed by the organisers.

9. Inspections

- 9.1 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.
- 9.2 The Organiser will inspect all boats for full compliance with the requirements prior to the start of the race.
 - 9.2.1. All participants will be notified in advance of the time and location of the inspections,
 - 9.2.2. The organization will invite the participants for an inspection,
 - 9.2.3. During the inspection the participants are required to present their boat in a race-ready condition,
 - 9.2.4. Boats that fail to comply with the applicable requirements 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,
 - 9.2.5. 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 rule 5.23.
- 9.3 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.
- 9.4 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.
- 9.5 During a race the boats are not allowed to leave the paddock without permission.
 - Leaving the paddock without prior permission of the Organiser will lead to disqualification,
 - No permission will have to be asked when a boat is to be driven to the racing test, the prologue, the sprint or the starting point of an element of a race.

10. Racing test

10.1 The participants are required to demonstrate the racing performance of their boats. During this demonstration the participants have to race a prescribed circuit. The boat and the pilot will be judged on the following aspects:

Controllability of the boat,
Racing skills of the pilot,
Stability,
Freeboard in racing condition,
Spray characteristics.

10.2 In case parts have been classified as removable parts under rule 5.27 the racing test must be passed with and without the removable parts installed.

10.3 Based on the results of the racing tests, the Organiser 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.

11. Pilot requirements and communication

11.1 The minimum age of a pilot at the time of the race is 18 years. Pilots of Young Solar class boats must be at least 16 years of age at the time of the race.

11.2 All pilots on board the boat must wear an approved life jacket.

11.2.1. The capacity of the life jacket must be 150 Newton classed or equivalent.

11.2.2. The life jacket may be automatically inflatable when coming into contact with water.

11.2.3. The life jacket must be designed such that it keeps the head of the one wearing it above water (e.g. is supplied with a collar).

11.3 All pilots expected to have a minimum mass during the course of the race.

11.3.1. To determine the mass all pilots will be weighed.

11.3.2. During weighing pilots must at least wear a bathing suit and an approved life jacket.

11.3.3. The minimum mass for pilots of Newborn class, V20-class and Open class boats is 70 kg,

- 11.3.4. The minimum mass for pilots of Young Solar class boats is 60 kg,
 - 11.3.5. In case a pilot weighs less than the required minimum mass, the mass of the ballast that he or she must carry throughout the race will be determined by subtracting the mass of the pilot from the minimum required mass.
 - 11.3.6. The applicable ballast will be marked with a unique mark for the applicable pilot.
- 11.4 All pilots must wear a helmet
- 11.4.1. The helmet must be of a bright orange colour.
 - 11.4.2. An open face helmet is preferred.
 - 11.4.3. Pilots of Young Solar class boats are exempted from wearing a helmet
- 11.5 All pilots shall be capable of communicating to one member of the on-shore team (radio person) by any appropriate means
- 11.5.1. The means of communication must have a broadcast range of at least 2 nautical Miles.
 - 11.5.2. The means of communication must be integrated into the helmet of the pilot. Pilots in Young Solar class boats may use a hand held means of communication.
 - 11.5.3. The means of communication must be waterproof.
 - 11.5.4. The means of communication must be portable and supplied with a battery of sufficient capacity to last at least one race without being recharged.
 - 11.5.5. A full radio check of each boat will be part of technical scrutineering in order to guarantee that all radios are working.
- 11.6 All pilots should wear bright colour clothes or a bright colour wetsuit. If a pilot wears shoes they may not be buoyant.
- 11.7 If the boat is able to move faster than 20 km/h the pilot must be able to show his or her boat driver permit to the organisation.