Technical Regulations 2019

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2 About

Machines competing in the 2019 Word Electric Racing Cup (World ERC) must comply with the World ERC Technical Regulations. These are as stated in this document, which will be referred to as the *Technical Regulations* (abbreviated as TR) in all official World ERC communications. The TR are correct at time of official release, but are subject to amendments made by the World ERC Technical Committee. Newer versions including amendments will be issued by means of a bulletin on the World ERC website (www.worlderc.com) and by communication to registered racing teams. Subsequent editions of the TR within the 2019 World ERC season will be labeled numerical, e.g. World ERC *Technical Regulation 2019: version 1.1* for the first revised version of the 2019 TR. The most recent version of the TR will be leading in the decision of the Race Safety Officer to permit a machine to compete in the events of that race weekend. In case of a dispute regarding implementations of the Technical Regulations, the Race Safety Officer holds the right to withdraw a machine's permission to compete in the event at any time, according to his or her judgement.

All machines must comply fully to the TR, except for machines that are in its entirety commercially available. The Race Safety Officer must be informed before application if you wish to join the competition using a commercially available machine. If any questions persist after reading the TR, please contact the Technical Committee.

3 Changes and releases

Version 0.1 (Concept): 20-10-2018
Version 0.2 (Concept): 21-10-2018

Section	Change
4.3.3.1 Resistance	Faulty 110V changed to 1000 V for 1 MOhm resistance
Other	Small textual changes throughout the document

Version 0.3 (Concept): 05-12-2018

Section	Change
Multiple	Change of section title references to section numbers references
2	Specification added: '…except for machines that are *in its entirety* commercially available. …'
4.1	Reformulation section 4.1 Energy source
4.2	
4.3.2	Redefinition of Low Voltage (LV) to <50V Specification added: '… must be separated from *chassis ground and earth* ground. The HV systems must be insulated from the LV system, frame, *earth* and chassis ground …' Redefinition of Vdc to peak voltage (covering AC and DC)
4.3.3	Specification added: '… All electricity conducting parts that are not directly connected to the electric circuitry must be connected to chassis ground. …'
4.4.1 & 4.4.2	Switch of sections 4.4.1 discharge and 4.4.2 indication
4.1.1	Redefinition of HV light as '*flashing* red light'
4.3.3	Addition: '…is seen as a Class I vehicle *corresponding to IEC61440* '
4.3.3.1	Redefinition of 'classes' as 'categories'
4.4.2	Reformulation discharge limit and indication
4.4.3	Deleted word: '… must be able to disconnect the battery *mechanically* from the tractive system… ' Added sentence: 'In order to … chemistry/composition of the main accumulator' (from note under section 4.4.5)
4.3.6.1	Addition of: 'On top of that, the cable must be rated at a higher current than the maximum operating current of the connected equipment.'
5.2	Addition of: 'The machine must contain no more or less than two wheels.'
5.2	Addition: 'The tires mounted on a machine must be properly rated. I.e. the load index must be higher or equal to the weight of the machine and the speed index must be higher or equal to the top speed of the machine.'

	Deletion: 'Any suitable tire may be used, modifications to tires are allowed only when distinguishably made by a person authorized by the tire manufacturer.'
5.3	Redefinition minimum lean angle to 50 degrees (deleted sentence regarding 40 degrees MLA. Specification: '…counterclockwise *in the horizontal plane.* …'
5.4	Reformulation: '…This means that, in event of a crash, the …' replaced by '…ensuring that…
5.5	Addition: '…, *pure* water must be used.'
6.1	Reformulation: '… rider kill switch must electrically unlatch the main accumulator …' Addition: '… The switch itself must be operable by simple pushing *or a pull-cord. In case of an accident, the rider kill switch must not keep the rider attached to the machine.* …'
6.1.1	Addition: 'In case of an accident, the rider kill switch must not keep the rider attached to the machine. '
6.1.2	Reformulation: '… emergency stop button must *electrically* unlatch the main accumulator …'
6.4	Deletion of 'When yellow flags are displayed on track, the horn must be activated'. Addition: '… *In rain or* low visibility…' Addition: '…operating *under driving conditions*…' Addition: '…, *ranging at least 15 degrees to both left and right sides of the machine center line.*' Addition: 'This red tail light is referred to as the rain light, and must be a different light than the HV light.'
6.6	Addition: '…, must *remain* higher than the maximum voltage…' Reformulation: '… Consequently, the required values for dielectric strength will increase. Safety values as stated in these regulations, such as max DC bus voltage, cable insulation and fuse must not be exceeded using field weakening. …'
7.2	Reformulation of section
8	Addition: 'Depending on the events World ERC races are collaborating with, a separate technical inspection could be performed by the appropriate authorities. In such a case teams will be notified beforehand. '

4 Electrical

4.1 Energy source

The World ERC is a fully electric competition. Accordingly, all machines must use electricity as the only energy source for propulsion purposes. The storage medium for the energy, referred to as the main accumulator, must directly store electrical energy in an electrochemical battery. The use of fossil fuels is not allowed for any kind of function of the machine. Liquids or gasses may be used for cooling purposes of components inside the machine.

4.2 General Electric Safety

Under all conditions it must be ensured that all components used are safe and cannot cause harm or injury, either during normal operation or foreseeable cases of malfunction. It must be ensured that components used for protecting persons or objects can reliably fulfill their function. Teams must be able to prove that their designs minimize the risk on electric shock, burning or explosion.

4.3 Basic Electric Safety

4.3.1 Low Voltage

All voltage differences smaller than or equal to 50 Volts are considered to be part of the Low Voltage (LV) system. The LV system may be floating compared to earth ground. Note that the LV area can only be considered safe when appropriately insulated from the HV system. See also section 4.3.3.

4.3.2 High Voltage

Following the international standard IEC 60038, all voltage differences lower than 50 Volts are defined as Low Voltage (LV). All systems operating with voltage differences above this value are High Voltage (HV) and must be separated from chassis ground and earth ground. The HV systems must be insulated from the LV system, frame, earth and chassis ground with an adequate insulator as specified under section 4.3.3. The peak voltage difference between any two points must be smaller than 1000 V_p.

4.3.3 Insulation

A machine in the World ERC is seen as a Class I vehicle corresponding to IEC61140. This means that a connection to earth (PE connection or earth ground) must be made at all times whenever maintenance is performed.

All electrical live parts must be protected against (accidental) contact. Insulation materials used must have sufficient mechanical resistance against wear and tear. Materials such as (paint) coating, enamel, oxides, fiber coatings and insulating tapes are therefore not accepted. All electricity conducting parts that are not directly connected to the electric circuitry must be connected to chassis ground.

4.3.3.1 Resistance

The minimal required resistance divided into three categories. Machines with an HV system working below 110 V, below 500 V or below 1000 V.

Machines with a working voltage below 110 V must have a resistance between the HV system and the LV system or ground of at least 250 kOhm. Machines with a working voltage below 500 V must have a resistance between the HV system and the LV system or ground of at least 500 kOhm. Finally, machines with a working voltage below 1000 V must have a resistance between the HV system and the LV system or ground of at least 1 MOhm.

4.3.3.2 Dielectric strength

All components that form a barrier between HV and LV or earth in a Class I machine must meet a dielectric strength test value of at least 1200 Vrms above the working voltage. For example, a 1000 V machine must have a dielectric strength of 2200 Vrms test voltage.

4.3.4 HV Relay

The tractive system must be separated from the main accumulator by at least two relays. One (un)latching the HV + (positive lead), one (un)latching the HV – (negative lead). The relays must be properly rated for current, voltage and temperature. This means the relays must be able to brake under all conditions whenever the emergency button (see section 6) is pressed. It is advised to make use of relays with feedback contacts, which allows for a safe measurement of the actual relay status.

4.3.5 Water resistance

All electrical systems must be water proof according to the standard IP55. This means the motorcycle can safely ride on a wet track. The IP55 standard also specifies dust/particle protection, to which all designs must comply.

4.3.6 Fusing

A fuse is a device or component that acts as circuit breaker above a predefined current value for a predefined amount of time. Fuses can be resettable or non-resettable.

4.3.6.1 Low Voltage fusing

All cables directly connected to a LV accumulator must be fused accordingly. The fuse must be rated at 80% of the current rating of the cable. On top of that, the cable must be rated at a higher current than the maximum operating current of the connected equipment. A charging cable to LV accumulator must be fused similarly.

4.3.6.2 High Voltage fusing

The main accumulator must be fused with at least one fuse. The trip current of the fuse must be smaller than or equal to the peak current the main accumulator may deliver or the current the cables connected are rated for (whichever one has the lowest value). On top of that, the fuse must be rated properly for current, voltage and temperature.

4.4 Functional Electric Safety

4.4.1 Indication

All equipment where voltages can exceed 48 Volts, indicators must be placed. These indicators must comprise a black lightning flash inside a yellow triangle. See figure 1 for an example.

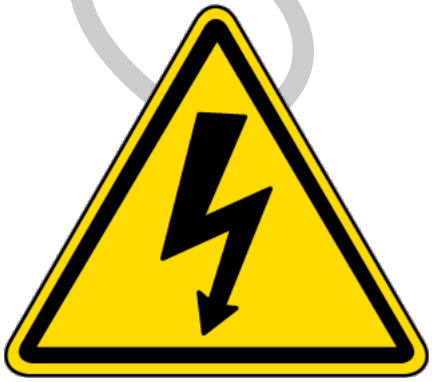

Figure 1: example of an HV indicator

During times the main accumulator is physically connected to the tractive system, a flashing red light must be switched on. This is light is referred to as the HV light. The light must be clearly visible from both sides and rear of the machine, even when the machine is not on its wheels.

4.4.2 Discharge

Whenever the main accumulator is disconnected from the tractive system, the voltage in de tractive system must drop under the LV upper limit in less than 5 seconds. The HV light must turn off when the voltage has reached this limit.

4.4.3 Battery Management System

The main accumulator must be accompanied by a battery management system (BMS). This means safety critical values of the battery chemistry must be monitored continuously and acted upon accordingly. The BMS must at least monitor accumulator temperature(s) and cell voltages. Also, the BMS must be capable of disconnecting the battery from the tractive system whenever needed. In order to ensure adequate provision for on-track incident handling, you are required to declare the chemistry/composition of the main accumulator

4.4.4 DC bus protection

The DC bus (i.e. input capacitor of the inverter of the tractive system) must be protected against over-voltage. For example, this can be done by turning off the output stage of the inverter. The maximum allowed voltage is defined as 90% of the rated maximum voltage of the bulk capacitors in the inverter input stage.

4.4.5 Charging

The main accumulator may be charged with custom equipment. The charging system must have the following parameters set within safe boundaries for the main accumulator: a standard power supply must be set to a maximum current and maximum voltage below or equal to the main accumulator specifications. In case of overvoltage or overcurrent, the charger must limit itself to safe values, or shut itself down. As described in section 4.4.3, the BMS must react in case of overcharge as well, which follows directly from the definitions described. During charging, a technically educated team member – who is familiar with the emergency protocol, the electric system, and the use of fire safety equipment – must be present at all times.

5 Mechanical

5.1 Dimensions and weight

The allowed maximum length of the machine is 3.0 meters and the maximum width must not exceed 1.0 meters. Minimum weight is 100 kg and maximum weight is 300 kg, when in race-ready modus.

5.2 Wheels and tires

The machine must contain no more or less than two wheels. Wheel rim diameters and width are free. The tires mounted on a machine must be properly rated. I.e. the load index must be higher or equal to the weight of the machine and the speed index must be higher or equal to the top speed of the machine.

5.3 Clearances, lean/steering angles and streamlining

The ground clearance of the unloaded motorcycle must be at least 100 mm. The minimum free lean angle, or angle from vertical without any other part of the machine than the tire touching the ground, for the unloaded motorcycle is 50 degrees.

The front wheel and steering mechanism of the motorcycle must be able to turn at least 15 degrees both clockwise and counterclockwise in the horizontal plane. No objects are allowed to obstruct the rotating movement, nor may there be any risk on locking into a certain steering angle.

Spoilers or air foils may only be fitted as integral part of the fairing. They may not extend beyond the width of the fairing, nor above the height of the handlebars. Sharp edges must be rounded off with a minimum radius of 8 mm. Rearward facing streamlining must be rounded off with a minimum radius of 3.5 mm.

5.4 Main accumulator

The main accumulator must be fitted inside the frame. The accumulator may not extend outside the frame, ensuring that impact forces are directed around or away from the main accumulator cells. The main accumulator must be fastened in such a way that in event of a crash, it remains secured inside the frame. The main accumulator and rider must be separated by a safe fire barrier.

5.5 Liquids

Water and brake fluid are the only two types of liquid allowed. When using a liquid coolant system, pure water must be used.

6 Safety

6.1 Emergency systems

The emergency system should be designed to allow both a rider and marshal to disable the tractive system easy and at no risk. Therefore, at least two buttons must be placed on the machine, defined as the rider kill switch and the emergency stop button. Engaging either button/switch or both must result in electrical disconnection of the main accumulator from the tractive system. The mechanism of the emergency system must be either physically or directly electrically, i.e. no software/chip may be used for unlatching the relays of the main accumulator.

6.1.1 Rider kill switch

The rider kill switch must be operable by the rider, without replacement of the hand under normal driving conditions. The rider kill switch must electrically unlatch the main accumulator from the tractive system. The switch itself must be operable by simple pushing or a pull-cord. In case of an accident, the rider kill switch must not keep the rider attached to the machine.

6.1.2 Emergency stop button

The emergency stop button must be operable by anyone within reach of the machine. The emergency stop button must be operable while the machine is standing on both wheels, as well as while the machine is lying on either side. The emergency stop button must electrically unlatch the main accumulator form the tractive system.

The button itself must comply the following physical specifications: by pressing the button down, it must unlatch the tractive system. Once pressed, it must stay in latched condition. To reset the button, the button must be rotated. The button must be red, surrounded by a red or yellow circle with the text ‘emergency stop’, ‘emergency button’ or ‘emergency’. The text must be clearly readable and in black or a strongly contrasting color.

6.2 Main accumulator

As mentioned in section 5.4, the rider must be separated from the main accumulator by means of a fire safe barrier. In case of a crash, the accumulator must remain inside the frame and may not come loose. Also, the casing must protect the accumulator such that, in case of a crash, the accumulator remains intact.

6.3 Rider

When on a circuit, a rider must be on the machine. The use of autonomous vehicles is not allowed. The rider must be on, but not connected to the machine. In case of a crash, the rider must always be able to immediately leave the machine. The use of a rider attached pull cord as a rider kill switch is allowed.

6.4 Horn and Lights

Machines must be fitted with an acoustic horn, minimum 90 dB(A). In rain or low visibility conditions, a red tail light must be operating under driving conditions. The red tail light must be clearly visible from at least 30 meters distance, ranging at least 15 degrees to both left and right sides of the machine center line. This red tail light is referred to as the rain light and must be a different light than the HV light.

6.5 Brakes and Chain

Machines must be equipped with brake lever protection. Machines must be equipped with a shark-fin toe chain guard.

6.6 Regenerative braking and field weakening

The use of field weakening in electric motor inverter combinations is allowed, but the considered 'working voltage' as specified under section 4.3.3, must remain higher than the maximum voltage of the main accumulator. Consequently, the required values for dielectric strength will increase. Safety values as stated in these regulations, such as max DC bus voltage, cable insulation and fuse must not be exceeded using field weakening.

The use of regenerative braking is allowed. In case of an emergency shutdown of one of the systems, the regenerative braking may result in an excessive amount of energy being released to other components. Therefore, teams must be able to show and explain a safe and reliable emergency system.

7 Other

7.1 Transponder

An AMB/MYLAPS transponder must be used, fitted securely and in a sensible, safe position. Mount it such, that it is no more than 60 cm from the ground. It must be mounted vertically, with a clear view of the ground; the transponder signal does not travel through metal or carbon fiber based plastics. The transponder must be fitted and operating when the machine is taken to the assembly area and whenever on track.

Note that no time will be recorded when the transponder is not fitted or operating. During events of the World ERC, the registered teams will receive a transponder during the Technical Inspection.

7.2 Other regulations

Depending on the events World ERC races are collaborating with, additional rules, regulations and technical requirements may be added. If this is the case, the teams will be notified beforehand.

8 Technical inspection

After applying as a World ERC racing team, the team will be asked to show safety critical designs and calculations well before the start of the first event. These design checks are necessary for the Technical Committee to check whether the team's machine is compliant with the TR.

Technical inspections will be carried out before admission on the track at the first participating event. During the technical inspection, teams need to:

- show and explain the working of the rider kill switch and emergency stop button;
- show and explain a working discharge system;
- show and explain the protection around the main accumulator;
- show working front and rear brakes;
- show maximum steering angles;
- show working HV and rain light(s);
- show brake lever protector and toe chain protector.

In case of a dispute, the decision of the Race safety officer will be final.

Depending on the events World ERC races are collaborating with, a separate technical inspection could be performed by the appropriate authorities. In such a case teams will be notified beforehand.

NOTE: the full technical inspection is not yet designed. Therefore, the full testing procedure above is subject to change. Teams will be notified of all changes.