Rule change proposal for section M by Germany

The following rule change proposal has the aim to increase the usability (number of usable cycles) of the currently used Lipo batteries, without great additional administrative and financial effort. Furthermore, the proposal is also intended to improve the mechanical durability, in order to avoid damage to the skin made of aluminium foil as well as the tearing off of the terminals. The proposed amendment concerns all endurance race classes.

Everyone knows that LiPo batteries are aging with each charging and discharging cycle. They are like the tires on a car a wearing-out item. Depending on the handling, the Lipo battery can be used more or less cycles.
In order to avoid rapid wear of the Lipo batteries in only a few cycles (3-5), and to counteract this effect, one has to understand the reason for this at first. As widely known, the electrolyte used in the Lipo batteries is only stable up to a certain temperature (about 60°) and decomposes when this is exceeded. It evaporates and this ends up in the well-known swelling! To prevent from this, excessive temperatures of the battery have to be avoided. A cooling of the Lipo battery, as practiced partly, improves the situation, but solves the problem only superficially. The problem is that the high temperatures are restricted to small spots at very high load peaks (as they occur during the operation of model boats) and cannot be distributed quickly enough away from these hotspots. However, these load peaks are very problematical only towards the end of the discharge, when the battery already has a higher basic temperature. An additional effect appears due to the characteristic behavior of the battery chemistry which leads to an increase in the internal resistance in the last 20 -10% of the battery capacity so that the temperature of the Lipo battery increases more than proportionally in this range.
In order to increase the lifetime of a Lipo battery, high temperatures in general and strong load peaks in the last 20 -10% of the battery capacity should be avoided. This can be achieved by means of a higher than previously defined discharge voltage recovery limit (3.0V without load). In order to find a good compromise regarding the lifetime and utilization of the maximum amount of energy emitted by the battery, Figure 1 shall be used. The figure shows a typical voltage development of a Lipo battery used in racing boats at a low load of approx. 2C. This typical characteristic is almost independent from the rated capacity.
As can be seen from Table 1, a discharge voltage below 3.6V makes no sense since the Lipo battery is almost empty at this stage. Also, a voltage of 3.8V is not constructive, since to this point only around 50% of the capacity of the battery can be used. A very good compromise between usable energy and acceptable lifetime is a load-free recovery voltage per cell after a run between 3.70V and 3.65V (see Table 1). From experience, a battery treated like this can be used a season (about 20-30 cycles or runs), if not longer at least for training purposes.

To protect even weaker cells in a battery, it is suggested that the new discharge voltage is not applied to the total voltage, but for each individual cell in a battery. To control this, a balancing connector with a connector pitch of 2.54 mm (eg, EHR, JST / XH, etc.) must be provided on each battery pack.

Since it is crucial how long the battery can recover after a run prior to check, the order for the voltage control at international competitions (EC, WC) is suggested to be as follows using the start number:

- First run: 1, 2, 3 …6
- Second run: 6, 5, 4 …1
- Third run: 3, 4, 1, 6, 2, 5 or 4, 3, 6, 1, 5, 2

For the final race, the order of finishing should be used. For national events the sequence of voltage control is left to the respective nation itself.

In order to increase the mechanical durability, but still being able to use the actual batteries, it is necessary to increase the maximum permissible weights. Table 2 provides the information about how much the weight limits should be increased for the respective classes. The weight limits are increased due to the following two measures:

1. Covering the whole battery with heat shrink tube (higher protection against damage to the outer casing)
2. At least 30mm highly flexible connection cable per pole and battery pack with the corresponding cable cross sections given in Table 2 for the respective class to avoid tearing off the terminals

The length of the connection cables is measured from the terminal of the battery to the leading edge of the connection system used. In addition, the terminals should be strain-relieved with adhesive tape (Kapton) as usual now.

The decision over the above-mentioned proposals for rule changes should be done separately for each proposal. These are listed once more in the following:

a) Discharge recovery voltage from 3.0V to 3.7-3.65V
b) The discharge voltage threshold shall be applied to each individual cell in a battery -> balancing connector with a 2.54 mm pitch spacing is mandatory
c) Sequence of the voltage control after a run as described, if agreement to b)
d) Covering of the whole battery (s) with heat shrink tube
e) At least 30mm highly flexible connection cable per pole and battery

It has become obvious in the last time that the currently available power in the mono2/hydro2 classes, and in ECO Expert, can hardly be used effectively on actual race course layouts due to the high speeds. Therefore, it is proposed to reduce the weight limits for the batteries in the future as they are listed at the end of Table 2. The stated weights already include the measures for increasing the mechanical safety (connecting cable and shrink tube). However, the decision on this weight change of the batteries shall take place at the World Cup in 2019, and the introduction then in 2020 after a positive decision.

Figures and Tables

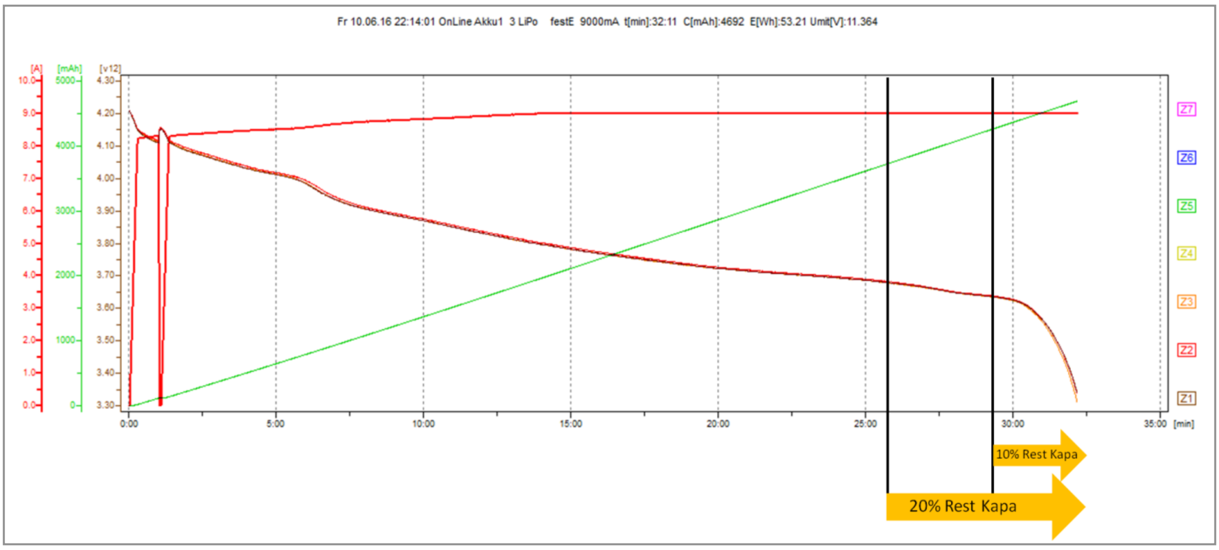

Figure 1: Typical voltage development of a lipo battery used in a racing boat at low load approx. 2C.

Table 1: Percental discharged capacity (example given for typical 3S 4800mAh lipo battery) at different discharge voltages based on Figure 1.

Discharge voltage	Discharged capacity	Percentaldischarged capacity
3,80 V	2370	50,5 %
3,70 V	3930	83,8 %
3,65 V	4415	94,1 %
3,30 V	4690	100 %

Table 2: Overview of the suggested rule changes regarding the batteries used for the various racing classes.

Classes	Mini ECO Mini Mono Mini Hydro	ECO Expert Mono 1 Hydro 1	Mono 2 Hydro 2	FSR-E
Discharge voltage (worst cell)	3.7 - 3,65V	3.7 - 3,65V	3.7 - 3,65V	3.7 - 3,65V
Minimalcable length	30mm each pole	30mm each pole	30mm each pole and battery	30m each pole and battery
Minimal wire cross section	AWG 16 1.3mm²	AWG 12 3.3 mm²	AWG 12 3.3 mm²	AWG 12 3.3 mm²
Envelop with heat shrink tube	yes	yes	yes	yes
Maximal weight (from 2018)	110g + 3g = 113g	280 + 5g = 285g	560g + 2x5g = 570g	840g + 3x5g = 855g
Maximal weight (from 2020)	100g	200g	400g	600g