GTR-EVS TF6 State-of-Charge

Position of OICA to the Proposal for Adjustment of State of Charge provided by NHTSA, Oct 10th 2015:

Dear Members of TF-SOC,

With high interest OICA has taken note of NHTSA's alternative proposal related to the SOC adjustment and its attached justification.

Reviewing the alternative proposal we are happy that the TF's original proposal seems to be basically agreed, including the principle distinction between initial charging process (under consideration of the operational in-use charging methods) and the post-charging respective pre-test process. While the settings for the initial charging process seem to be agreed, NHTSA's proposal relates to the latter process; however the differences don't seem to be of principle nature.

We understand that there is agreement that depending on the duration of the vehicle preparation, or specific vehicle electrical architectures, or capacity of the REESS the relative discharge can vary. Care should be taken by the tester to minimize such losses.

Following we would like to explain the motivation for our currently supported proposal.

48h-Provision:

The current TF-proposal attempts to address this in the way that the lab has to either start the actual test within 48h after the initial charging process, necessary for conducting the final test preparations e.g. for a vehicle crash test or fire test. Within this period reasonable care has to be taken to preserve the charge level, generally by external power-sourcing the vehicle's 12V-system or the BMS directly (in case of a subsystem test) until short before the test. Given this the assumption should be justifiable that the loss is negligible. After the 48h period automatically another SOC-check shall be performed. We do therefore not see this time limit as restrictive.

Regarding the proposed pre-test procedure we can understand the difficulty its transposition into a self-certification environment poses. It is however felt necessary for the practical implementation of the SOC requirements within a type approval scheme. Specifically in the cases of non-externally chargeable HEVs as well as in the cases of REESS-system tests at external test laboratories, the SOC adjustments require specific tools and knowledge of the control systems, often only available to the manufacturer. It is assumed for such cases that the manufacturer provides the devices to be tested at a sufficient/full SOC level; however the further control over the devices may then be out of his influence. OICA of course agrees with NHTSA that this given time span is no guarantee that the SOC is maintained, but it is a very short period that should allow a test facility to run a test without having the equipment and knowledge to re-charge the specific REESS.

SOC Assessment:

It is further important to keep the relative complexity of assessing the actual SOC – in contrast to the OCV – in mind. Depending on the cell chemistry used there can be very minor influence of SOC on

OCV (see figures 1 and 2), at least within the nominally used SOC ranges (e.g. between 20% and 80% of physical cell capacity range), while there may be influence of the saturation time and the speed of charging, but also of the charging temperature. These factors may prevent using OCV as suitable indicator for absolute SOC levels. When in practical levels OCV is monitored the purpose is to check relative changes from a known SOC level. Ideally then an OCV-check will show minimal ΔV, indicating SOC is preserved.

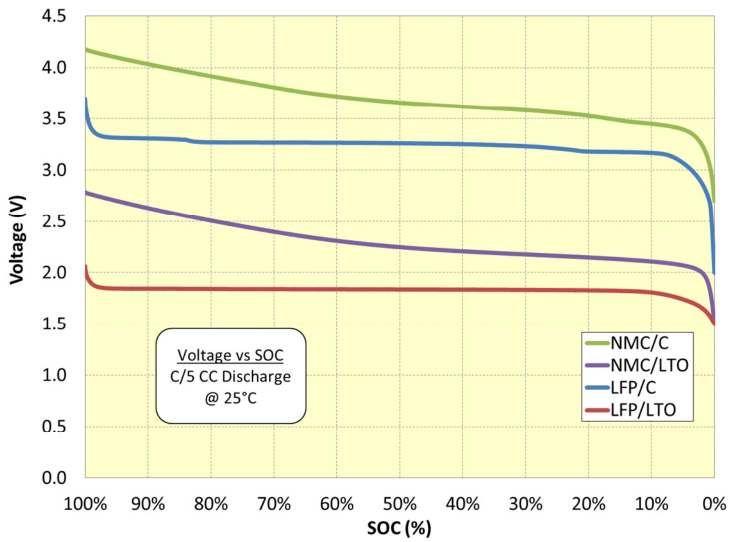

Figure 1: Voltage (V) vs State of Charge (%) for Various Lithium Ion Battery Cathode/Anode Couples (Source: Ford Motor Company, published at 2015 Battery Symposium Japan 56, Nagoya, JP, November 11, 2015)

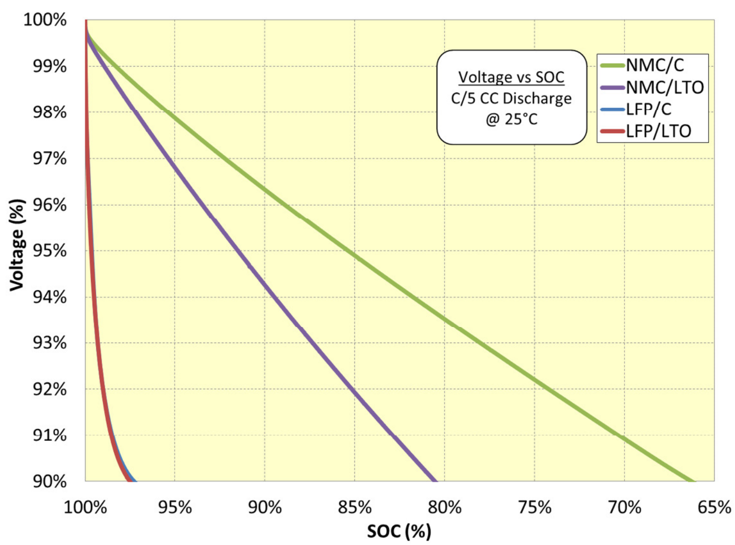

Figure 2: Voltage (%) vs State of Charge (%) for Various Lithium Ion Battery Cathode/Anode Couples (Source: Ford Motor Company, published at 2015 Battery Symposium Japan 56, Nagoya, JP, November 11, 2015)

Alternatively an available vehicle BMS/CAN-interface would directly provide internal SOC data. The assessment of the SOC level within the BMS is however not standardized and is a product of many factors and parameters. So this data, if accessible and available within the tested system, will generally be a good SOC-indicator but not a directly physically measured quantity.

Max. Voltage Drop pre-Test:

Basically the original and the NHTSA proposals lead to very similar final test conditions, except the slightly less generous SOC drop of 5% for external chargeable systems as proposed by NHTSA. The TF did not see the need to further complicate the procedure by defining different thresholds for externally and non-externally chargeable systems as externally chargeable systems have typically much larger capacity, so the relative discharge has been expected to be much lower anyway.

Robustness Margins for Regulatory Thresholds:

While OICA understands NHTSA's desire to define the SOC as high as possible, we are concerned that generally SOC levels of 95% or higher are difficult to guarantee for type approval situations: In order to robustly meet the defined SOC thresholds manufacturers and technical services need to target even higher levels within their own procedures. The pre-test voltage table provided by NHTSA with variations up to 4.2% (externally chargeable vehicles) gives indication that pre-test SOC-loss actually exceeded the proposed 5% limit.

Dependency of Peak Heating Rate from SOC:

In NHTSA's justification, an exponential behavior of lithium ion battery thermal peak power is cited as the motivation for the SOC set point of 95%. Peak power is one of only several factors that can be used to describe a thermal event, along with duration, average power, energy, etc. Notwithstanding the many ways to characterize the thermal intensity of a thermal event, several other published tests of lithium ion batteries have shown a linear relationship between peak power and SOC, not exponential as NHTSA has shown (see Figure 3 and Figure 4).

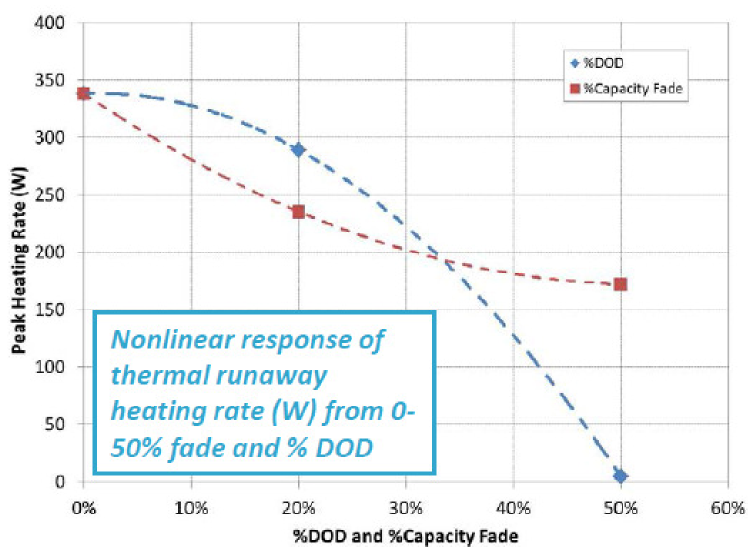

Figure 3: Peak Heat Rate (W) vs. Depth of Discharge (%) (Source: Sandia National Lab, Published at 2015 US DOE Annual Merit Review, #ES203)

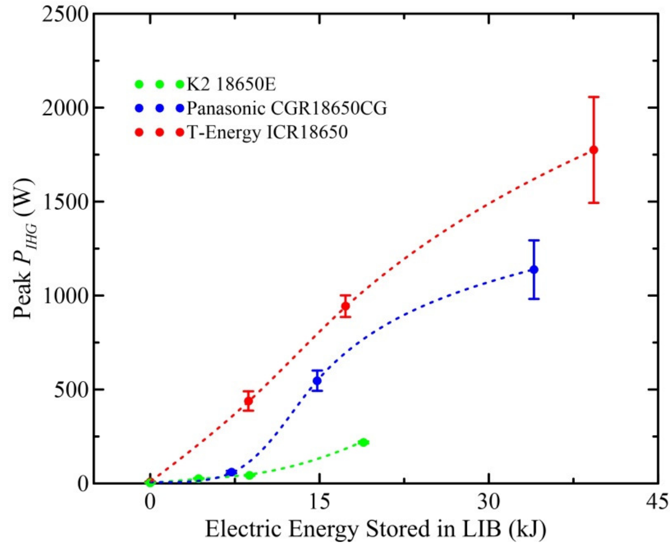

Figure 4: Peak Power of Internal Heat Generation (W) vs Electrical Energy Stored (kJ) (Source: University of Maryland, data from Published Paper in Journal of Power Sources, 280 (2015) 516-525)

Summary:

OICA has general concerns about the pre-test charge loss reduced from 10% to 5% (for externally chargeable devices).

OICA understands NHTSA's concerns regarding the proposed post-charge procedure being applied to self-certification standards, however sees the necessity for leaving the already described procedure in the text for type approval applications.

Given the expected very similar end results OICA would therefore suggest to think about a compromise potentially leaving it open to the contracting party to either transpose the pre-test procedure in line with the NHTSA proposal or with the original TF proposal, depending on the general approval scheme.

We would be happy to discuss such options within the TF.