TÜV VERBAND

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Assessment of Vehicle Batteries

Data Requirements for Determining a State-of-Health (SoH) of Vehicle Batteries

Creating trust in vehicle batteries

Alternative drive systems are on the rise: In August 2021, with 28,860 newly registered vehicles[1] the market share of electric passenger cars was 14.9 percent, an increase of 79.5 percent compared to August 2020.

The vehicle battery is of particular importance when making a purchase decision for an electric car. Potential buyers and car owners need to know what condition the battery is in and what total capacity it (still) has at all times. An objective and comparable assessment of the state of health (SoH) of vehicle batteries can strengthen the confidence in electromobility and increase acceptance of electromobility sustainably and persistently. In a catalog of requirements, the TÜV Association formulates which data is necessary to be able to determine the SoH reliably.

The vehicle battery is the most expensive component of electric vehicles. In particular, vehicle owners must be able to rely on the information regarding battery quality, remaining battery capacity and the associated range. This also means that when vehicle batteries have fallen below the capacity where they no longer meet the everyday needs of a private customer and are on the threshold of second life use, it must be possible to determine a valid SoH that ensures the battery still meets the requirements for use in buffer storage systems, for example. In the course of second life use, certain data must be known about the condition of the former traction battery, because the entire system must be re-examined in the event of a change of use. Going forward, there must therefore be a reliable determination of a SoH, for any use of a battery.

The product "battery" must be assessable over its entire life cycle in order to be of maximum economic and ecological benefit. To date, however, there are no reliable, manufacturer-independent benchmarks for evaluating the SoH. For the battery assessment or the determination of the battery condition, there is a need for concrete requirements in the handling of the battery management system (BMS) data and their interpretation. To this end, the TÜV Association has defined minimum requirements as to which data would have to be made available by the vehicle manufacturer on a non-discriminatory basis so that a SoH can be reliably determined.

[1] Federal Motor Transport Authority (KBA): Press release: Issue 37/2021 – Licensing of vehicles in August 2021.

Requirements catalog to determine a State-of-Health

Parameter	Granularity/quality/time interval	Comment
Cell voltage / total voltage (cell-, module-, pack voltage) (voltage over time)	Resolution at least at 1mV, sampling rate 10Hz	Required for statement about battery state of charge
Temperature sensors (cell-, module-, pack temperature) (temperature over time)	Resolution at 0.1°C, sampling rate min. 0.01Hz	Temperature influences battery voltage, available battery capacity and battery internal resistance / battery impedance
Cell-, module current (current over time)	Resolution 5 mA, Sampling rate 10Hz	Measure for charge/discharge and for charge/discharge capability. Ideal case: Current and voltage values are available at the same time stamps (synchronously).
State of Charge (SoC)	Resolution 0.01 %, sampling rate min. 0.01Hz	Describes available electrical charge in relation to nominal capacity. Given as a percentage.
SoH from BMS	Resolution 0.1%, hourly sampling rate	Battery condition = remaining capacity at full charge. 100% corresponds to remaining capacity = nominal capacity of the battery. A statement at module level helps to make a differentiated statement about the REESS. Value may require charge/discharge scenarios.
Charge throughput	Resolution 1 Ah, Sampling rate 1 Hz	Describes the electrical utilization of the battery (amount of charge passed through). It is a measure for determining the cyclic aging of the battery.
Number/time of quick charges/amount of energy charged during quick charges (cumulative)	Resolution 1 Ah, energy quantity in Wh, Time in sec., medium fast charging power	Fast charging leads to accelerated aging of the battery. The manufacturer should show in e.g. a "battery passport" how many quick charges are possible. If monitoring is not continuous, the data should ideally be made available.

Internal resistance	Resolution at least 0.5% of the nominal resistance in Ohm or mOhm	Important factor in terms of possible power output. Aging usually correlates with the internal resistance. Would be a supporting tool for sorting in database and plausibility check of the SoH output by the battery.
Remaining capacity	Resolution at least 0.5% of the manufacturer's specification of the gross capacity in Ah or mAh	The remaining capacity is one of the factors for the percentage SoH calculation.
Depth of Charge (DoD) (average)	Quantity DoD (SoC <30%) & Duration "How long was the battery below x %), Number DoD (SoC <10%), Number of DoD (SoC >90%), Histogram	The depth of charge/discharge (DoD) is a crucial parameter for determining the state of charge and state of health. It can either be calculated from the SOC signal or be provided.
Assumed nominal capacity	Constant value, Ah or mAh	The nominal capacity must be known in order to determine the relative state of health from the current capacity and nominal capacity.

Key demands

- **Non-discriminatory access to battery data required**
  Data used to determine a State-of-Health must be provided in a legally standardized form by vehicle manufacturers to independent organizations on a non-discriminatory basis.

- **Enable data sharing as early as possible in the life cycle of the vehicle**
  To assess how a vehicle compares to the overall fleet always requires a variety of data input from multiple sources. For this reason, the TÜVs are demanding to begin a data elicitation as early as possible in the vehicle's life cycle so that a sufficiently comprehensive data pool can be created as quickly as possible for meaningful statements on a SoH - across manufacturers and models.

- **Link carbon footprint to the number of cycles of a battery**
  Cycle stability plays a decisive role in the carbon footprint (CF) of vehicle batteries. Thus, even batteries with a larger CF during production can also be operated in an ecologically sensible manner through increased cycle stability. The current revision of the EU Battery Directive does not yet address this issue. In the future, a CF must therefore also be linked to the number of cycles of the battery, because the service life has a major influence on the CO_2 footprint. For a neutral evaluation of the CF of batteries from different vehicle manufacturers over the entire life cycle, non-discriminatory access would offer decisive advantages.

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The TÜV-Association (VdTÜV) represents the political and professional interests of its members vis-à-vis politics, administration, business and the public. The association is committed to technical and digital safety in products, systems and services through independent testing and qualified further training. With its members, the TÜV association pursues the goal of maintaining the high level of technical safety in our society and creating trust for the digital world.

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