ACEA PROPOSAL

HEAVY-DUTY INDUSTRY ADAPTATION OF THE GTR N.22 ON IN-VEHICLE BATTERY DURABILITY

- General concept
- Definitions
- Certification test
- In-service verification test

GENERAL CONCEPT

FUNDAMENTAL CHANGES COMPARED TO GTR N.22

- **The durability parameter is based on energy or capacity**
  - The durability parameter is based on UBE, but can be measured on UBC, where discharge measurement is not possible
    - Capacity can be measured directly.
    - Capacity could in a better way include all system variants for HDV – pack to multipack systems
    - Capacity can be measured directly where measuring of energy is more complex when considering system design and configuration
  - The internal certified current sensor of the REES shall be taken for the measurement.
    - No influence of PTOs → simple measurement → No external device with additional inaccuracies/ need for calibration.
    - Accuracy has to be proven by a certification/ reference measurement
- **Measurements based on charge or discharge events**
  - E.g.: UBE measurement based on discharge and/or charge event, UBC measurement based upon on charge event.
  - Simple measurement reduces failures
  - Less influencing factors compared to a driving based generic cycle
- **It *is* required to use the same test method for certification test and in-service test**
  - In-vehicle test for certification test and in-service test needed to ensure comparability of results!
  - influencing factors on test bench and in driving cycle very different
  - In-vehicle test for customer-oriented/ practical results

DEFINITIONS

SIMILAR DEFINITIONS AS IN THE GTR N.22 BUT ADAPTED TO HDV

*"**Battery system**"* means, in the context of this GTR, a rechargeable electrical energy storage system (REESS) installed in an electrified vehicle and used mainly for traction purposes and may also be used for auxiliary purposes in vehicles.

"Battery" means any sub-system of the assembly of the "battery system".

"Originally installed battery" means the battery that is installed in the vehicle at the time of manufacture, or if the vehicle is manufactured without an installed battery, the battery that is installed in the vehicle when it is first operated on the road.

"Originally installed battery system" means the battery system that is installed in the vehicle at the time of manufacture, or if the vehicle is manufactured without an installed battery system, the battery system that is installed in the vehicle when it is first operated on the road.

"Usable Battery capacity" *(UBC)* means the amount of charged capacity received by the battery or battery system from the beginning of the test procedure used for certification until the applicable break-off criterion of the test procedure used for certification is reached.

"Certified usable battery capacity" ($UBC_{certified}$) refers to the UBC that was determined during the certification of the battery or battery system, according to "[*test for certifying battery capacity"]*

"Measured usable battery capacity" ($UBC_{measured}$) means the UBC determined at the present point in the lifetime of the battery or battery system by the test procedure used for in-service verification

"State of certified capacity" (SOCC) means the measured or on-board UBC performance at a specific point in its lifetime, expressed as a percentage of the certified usable battery capacity.

New*:* ***"Charge counter"*** means the system including eventual hardware and software that accumulates the amount of charge in Ah during all charge events.

New: ***"Charge event"*** means the in-service operation and refers to the sequence start of charging to end of charging as defined by the manufacturer and includes both charging from a stationary external charging station and recuperation.

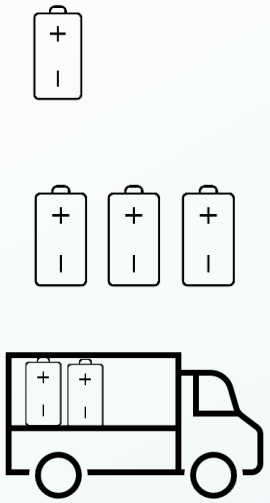
New: ***"Equivalent full charge cycles"*** means the value obtained when dividing the value of the Charge counter with $UBC_{certified}$.

"SOCC monitor" means an apparatus that maintains an estimate of the state of certified capacity by means of an algorithm operating on data collected from the battery or battery systems.

"Measured SOCC" means the state of certified capacity as determined by the measured usable battery capacity divided by the certified usable battery capacity.

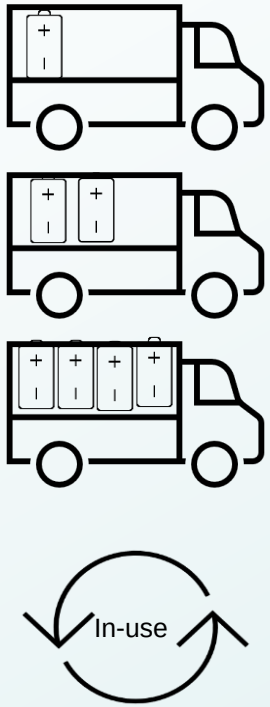
TEST PROCEDURE

Certification test



UBC/E$_{certified}$
Sensor
Counter

In-service verification test

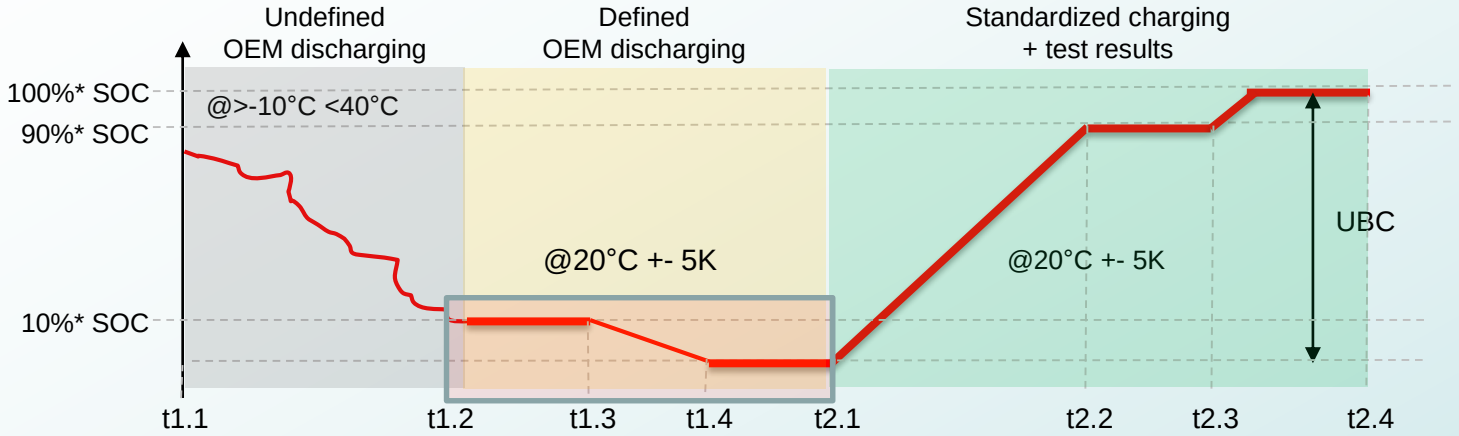


UBC/E$_{measured}$

High variation of battery and battery systems for the HDV industry

- Same test method for certification test and in-service test to ensure comparability of results but adapted to the configuration
- HDV solution is modular and scalable which also needs to be reflected in the test method
- Upper and lower charge and discharge limits according to detailed technical description of manufacturer

TEST PROCEDURE



- *Values needs to be applicable for a variety of systems and technologies
- Yellow phase needs to establish an initial state of the battery/battery system in such way that $UBC_{certified}$ can be compared to $UBC_{measured}$
- Tolerances need to be defined and considered since the test might be performed in different test environments throughout (t1.2-t2.1)

Step	Procedure	Method/ comments
Procedure: @ >-10°C <40°C / Preconditioning @ ambient temperature 20 °C +- 5K		
1.1-1.4	1. Discharge according to manufacturer specified until SoC < 10% 2. Rest time to ensure relaxation/ recalibration 3. Discharge according to manufacturer specified limit value 4. Rest time to ensure relaxation/ recalibration	1. Chassis dynamometer/ on road 2. Wait for 1h (exact time to be evaluated) - To avoid inaccuracies due to over-/ under shooting - Limits influence of different manufacturer procedures 3. Chassis dynamometer/ on road/ via auxiliaries 4. Wait for 1h
Start of test @ ambient temperature 20°C +- 5K		
2.1 -2. 4	1. Charge procedure until SoC > 90% (physical) with charger 2. Rest time to ensure relaxation/ recalibration 3. Charge procedure until manufacturer specified limit value 4. Rest time to ensure relaxation/ recalibration	1. At least C/5 (system) and according to manufacturers procedure at low/high SoC 2. Wait for 1h, (exact time to be evaluated) - To avoid inaccuracies due to over-/ under shooting - Limits influence of different manufacturer procedures 3. According to manufacturers procedure 4. Wait for 3h
End of test		

@OPTION FOR SMALL N2 LIKE

Proposal of UBE measurement method “*Self-discharging test*” without chassis dynamo or Bidi charging device

General Concept

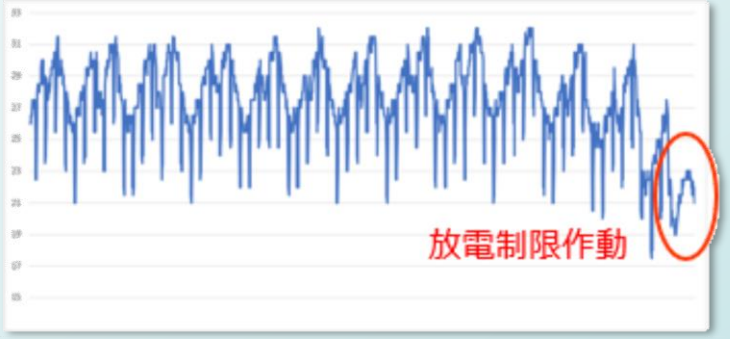
- Equipment investment such as HD chassis dynamo and charging/discharging equipment for UBE measurement is expensive but the operating for certification testing is at low rate.
- Discharge control settings for the electric power consumption cases (auxiliary equipment and/or PTO output) necessary for UBE measurement with a charging/discharging device using a DC charging port Considering the characteristics of heavy vehicles with many energy supply cases for devices other than running.

<u>Proposal for N2 vehicles with small batteries and on-board discharging capability</u>

Electricity consumption is not constant, but continuous electric power consumption is greater than the normal charging output of 3-6kW.

- Vehicle side (air conditioner, heater, lamp, etc.)
- Equipment

With the above operation, the new GTR22b test method enables UBE measurement from “SOC max” to “SOC min” in the same way as certification/ISC.



Especially for small N2 like category vehicles with small REESS

←Discharge limit control operation start

SUMMARY FOR UBE/UBC

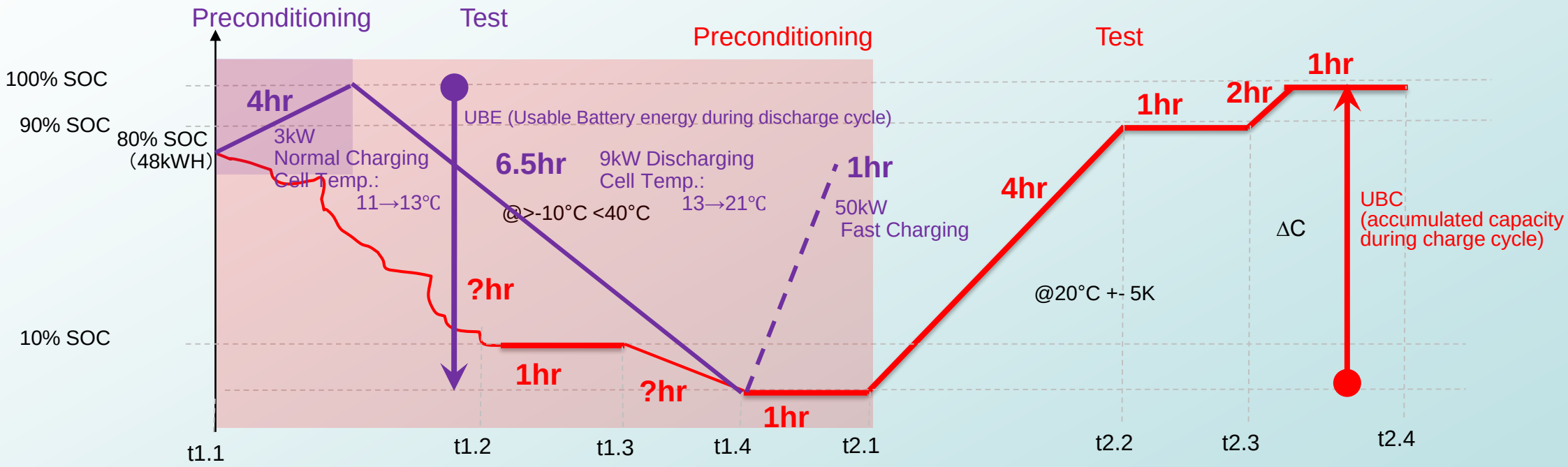
- UBC and UBE method still under discussion for N3/M3 (due to missing results from tests, but first data available)
  - UBC or UBE as optional applicable method
- Procedures for N2 vehicles:
  - Option 1: Application of the LD chassis dyno method for N2, as far as possible for the vehicle or e.g. up to a GVW of [xx] tons (further discussions for a appropriate GVW limit needed)
  - Option 2: Application of UBE and vehicle self-discharge for vehicles that are not "bench compatible"
- *OICA is planning to deliver test results until next EVE IWG session during Summer 23' and come to a conclusion at Ottawa meeting Autumn 23' latest*

TEST PROCEDURE UBE VS UBC

EXAMPLE: JAMA_60KWH-REES REFRIGERATOR TRUCK

JAMA proposal Real test result (Option 2)

ACEA proposal (Option 1)



Test duration UBE@Discharge with 60 kWh: 4hr+6,5hr = ~11hr

Test duration UBC@Charge with 600 kWh: 4,5hr+1hr+8hr = ~14hr

@POSITION ON VIRTUAL MILEAGE

In the „e-HEVS GTR“: V2X, PTO, … virtual mileage concept [EVE-60-05e]

- e-HDVs GTR: V2X, PTO, …

$$\boldsymbol{Virtual\ km(V2X + PTO + \cdots)} = Odometer\ km \times \left(\frac{total\ discharge\ energy\ during\ V2X + PTO + \cdots\ [Wh]}{total\ discharge\ energy\ while\ driving\ [Wh]}\right)$$

$$\text{Total distance km} = \text{Odometer km} + \text{virtual km}$$

- Requires two counters: Total discharge energy while driving or total discharge energy during V2X+ PTO+.., etc.
- Counts all energy usage i.e., while parked and extreme use cases
- ***As per GTR 22 the total distance used for confirming the compliance with the minimum performance requirements will consist of the sum of the distance driven and the virtual distance**. The total percentage of the virtual distance shall be recorded and monitored.*

Considering the unique configurations and/or functionalities of HD vehicles:

Based on expert discussions, it is not feasible to differentiate all the seperate vehicle-internal energy flows.

OICA prefers to apply the whole battery energy/capacity throughput instead of mileage for MPR criteria.