Regulation Proposal for Battery Durability for Battery Swap Electric Vehicles (BSEV)

Prepared by China

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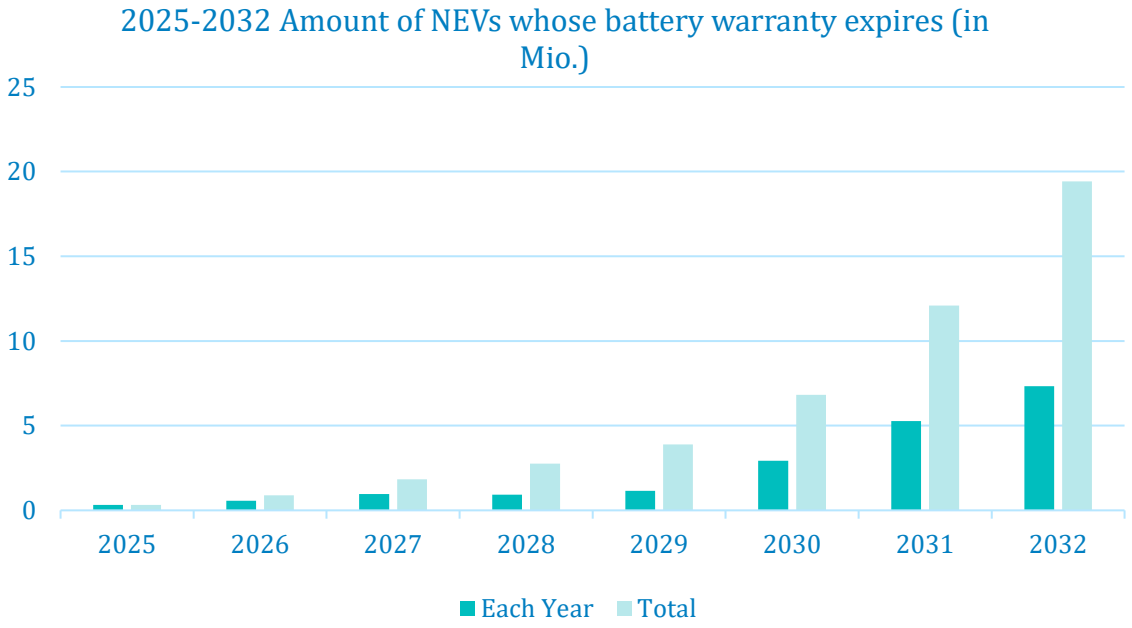
Background

- By the end of 2023, China saw a total of **20.41 million** new energy vehicles (NEVs) going on the road. During 2023, around **7.43 million** NEVs were registered.
- By 2032, in total over **19 million** NEV batteries will expire 8 years of warranty in China.
- How to improve battery durability and extend battery life is a great challenge for the whole EV industry.

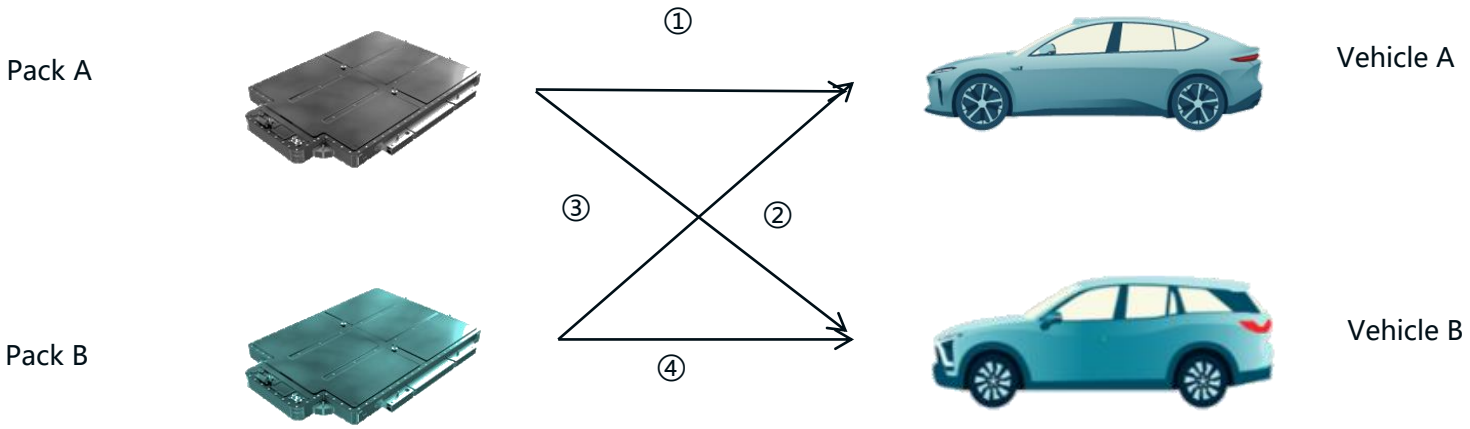


- From 2019, battery swap mode has entered a rapid development stage in China after years of exploration. By the end of 2022, there were over **2,000** swap stations in China. It is expected that by 2025, the total number of swap stations will reach more than **30,000.**
- Battery swap mode is especially suitable for private cars, taxis, and also commercial vehicles. **20%~30%** heavy duty electric trucks are in battery swap mode.
- As for battery durability, battery swap mode has advantage to optimize performance through **balanced operation** in swap stations:

  - ✓ Balancing battery usage frequency
  - ✓ Optimizing fast charge proportion
  - ✓ Order-based control of battery SOC during storage
  - ✓ Intelligent thermal management
  - ✓ …

Characteristic of Battery Durability Evaluation for BSEV

- The battery pack is not fixed on one specific vehicle/vehicle type during its service life. Battery aging is not synchronized with vehicle aging.
- For battery swap electric vehicles (BSEV), the investigation object of in-vehicle battery durability should be **"battery"** instead of "vehicle".



- How to verify the battery durability based on different vehicles?
- How to evaluate if the swap batteries meet the performance requirements?

Need to be clarified in a new regulation

Regulation Framework Proposal for BSEV

GTR 22	Proposal for BSEV
5. Requirements	
5.1 State-of-Certified Range and State-of Certified Energy (SOCR and SOCE) monitors	Follow GTR 22
5.2 Battery Performance Requirements	Table 1/2: Vehicle age/km should be modified as REESS age/km
6. In-use Verification	
6.1 Definition of Families	Follow GTR 22
6.2 Information Gathering	Follow GTR 22
6.3 Part A: Verification of SOCR/SOCE monitors	Propose a test method using battery pack to verify SOCE
6.4 Part B: Verification of Battery Durability	Follow GTR 22
Annex 1 Vehicle Survey	Add REESS Survey
Annex 2 Values to be read from vehicles	Add/Adjust parameters for battery swap vehicles
Annex 3 Determination of Performance Parameter during Part A Test Procedure	Propose a test method using battery pack to verify SOCE

Proposal 1 – Battery Performance Requirements for Swap Batteries

- Table 1/2: Vehicle age/km should be modified as REESS age/km

Table 1

Battery Energy based (SOCE) MPR

REESS age/km for categories 1-1 and 1-2 in the scope of this GTR	*PEV*
From REESS start of life to 5 years or 100,000 km accumulated driven, whichever comes first	80 per cent
REESS more than 5 years or 100,000 km accumulated driven, and up to whichever comes first of 8 years or 160,000 km	70 per cent

REESS age/km for category 2 in the scope of this GTR	*PEV*
From REESS start of life to 5 years or 100,000 km accumulated driven, whichever comes first	(Reserved)
REESS more than 5 years or 100,000 km accumulated driven, and up to whichever comes first of 8 years or 160,000 km	(Reserved)

Table 2

Range based (SOCR) MPR

REESS age/km for categories 1-1 and 1-2 in the scope of this GTR	*PEV*
From REESS start of life to 5 years or 100,000 km accumulated driven, whichever comes first	(Reserved)A
REESS more than 5 years or 100,000 km accumulated driven, and up to whichever comes first of 8 years or 160,000 km	(Reserved)

REESS age/km for category 2 in the scope of this GTR	*PEV*
From REESS start of life to 5 years or 100,000 km accumulated driven, whichever comes first	(Reserved)
REESS more than 5 years or 100,000 km accumulated driven, and up to whichever comes first of 8 years or 160,000 km	(Reserved)

Proposal 2 – Values to be read from vehicles for Swap Batteries

- In the following list the value 3, 5, 6 should be the accumulated distance of the swap battery while serving different vehicles
- Add "Date of manufacture of the swap battery" to identify the battery service time

Values to be read from vehicles

1. On board SOCE value (in %)
2. On board SOCR value (in %)
3. Odometer (in km) → Battery accumulated driving distance (in km)
4. Date of manufacture of the vehicle

4a. Date of manufacture of the swap battery

5. Total distance (sum of the distance driven and the virtual distance) [km], if applicable → Total distance (sum of the battery accumulated distance driven and the battery accumulated virtual distance) [km], if applicable
6. Virtual distance (in km), if applicable → Battery accumulated virtual distance (in km), if applicable
7. Worst case certified energy consumption of PART B family [Wh/km], if applicable
8. Total discharge energy in V2X [kWh], if applicable
9. Elapsed time since last charged by more than 50 per cent SOC swing [Days]
10. Average battery temperature while propulsion system is active, during charging and (if equipped) during non-usage of the vehicles (i.e. non-propulsion system active, non-charging)
11. Total discharge energy for non-traction purposes [Wh], if applicable Values that may be required by regional regulations:
12. Energy throughput [Wh]

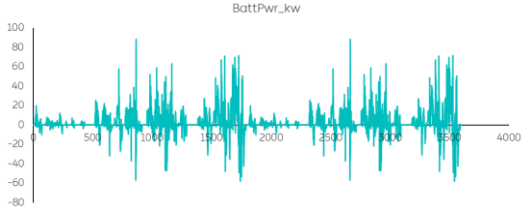
Proposal 3 – SOCE Battery Pack Level Test

Test Procedure

Homologation WLTC dynamometer test

Record:

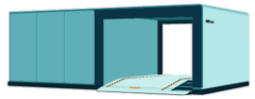
- ✓ Certified range for the same battery model on different vehicle types
- ✓ UBE $_{certified}$ for the same battery model on different vehicle types
- ✓ Power spectrum during homologation WLTC/CLTC test for the same battery model on different vehicle types



Select 3~16 battery samples

Mode test system

or



Battery swap station

Using power spectrum recorded during homo

Battery UBE measured

$$SOCE_{measure} = \text{UBE}_{measured}/\text{UBE}_{certified}$$

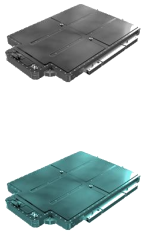
Verification for SOCE Battery Pack Level Test

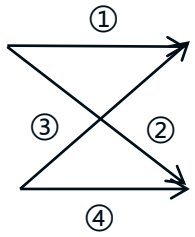
- A comparative study of vehicle level test and battery pack level test was conducted. 8 groups of cross-comparison test verification results are as follows:

Vehicle CLTC dynamometer test

LFP REESS

NCM REESS





Low energy consumption vehicle

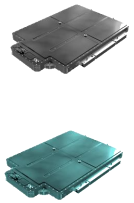
High energy consumption vehicle

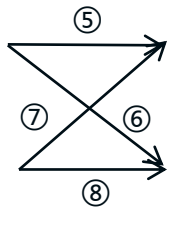
VS

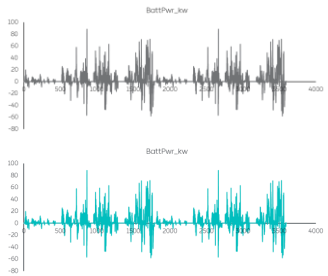
Pack CLTC mode test

LFP REESS

NCM REESS







Low energy consumption vehicle Power spectrum

High energy consumption vehicle Power spectrum

	Service Time	**Range**
LFP REESS	820 days	28,922km
NCM REESS	273 days	14,639km
Low EC vehicle	574 days	24,421km
High EC vehicle	346 days	17,849km

Verification for SOCE Battery Pack Level Test

LFP REESS 75kWh
BMS $SOCE_{read}$ = 92.2%

Test method	Parameter	Low EC vehicle	High EC vehicle	Comparison
Homo	$UBE_{certified}$ /kWh	73.87	73.86	-0.01%
Vehicle test	$UBE_{measured}$	① 68.12	② 68.24	0.18%
	$SOCE_{measured}$	92.22%	92.4%	/
Battery test	$UBE_{measured}$ /kWh	⑤ 68.62	⑥ 68.16	-0.67%
	$SOCE_{measured}$	92.89%	92.28%	/
Comparison	$UBE_{measured}$	0.73%	-0.12%	

NCM REESS 100kWh
BMS $SOCE_{read}$ = 98.7%

Test method	Parameter	Low EC vehicle	High EC vehicle	Comparison
Homo	$UBE_{certified}$ /kWh	95.42	94.31	-1.18%
Vehicle test	$UBE_{measured}$	③ 91.73	④ 92.03	0.33%
	$SOCE_{measured}$	96.13%	97.59%	/
Battery test	$UBE_{measured}$ /kWh	⑦ 92.09	⑧ 91.93	-0.17%
	$SOCE_{measured}$	96.51%	97.48%	/
Comparison	$UBE_{measured}$	0.39%	-0.11%	

- ✓ $UBE_{measured}$ of battery pack level test is basically the same as that of vehicle level test, no matter LFP or NCM batteries. The difference of test results is less than 0.73%.
- ✓ Battery pack level test can be regarded as equivalent to vehicle level test.

Advantages of Battery Level Test

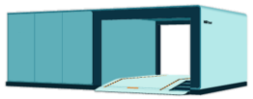
- No issue about the source of sample vehicles
- No issue about the cooperation willingness of vehicle users
- Convenient test in battery swap station
- Lower test cost for OEMs, save public resources

Homologation WLTC dynamometer test

Select 3~16 battery samples

Mode test system

or



Battery swap station

Using power spectrum recorded during homo

Battery UBE

measured

Appeal to the EVE Working Group

- Evaluation of battery durability for BSEV has its own particularity. It’ s necessary to formulate specified checking rules for BSEV, in order to eliminate possible implementation issues of GTR 22 for BSEV OEMs and test authorities.

- **A consensus should be reached within the working group:**
  - Draft a new GTR regulation regarding battery durability for battery swap electric vehicles, or
  - Form an intra-group resolution as GTR 22 implementation guideline for battery swap electric vehicles

China working group is willing to conduct further study and draft related documents

Thank you