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Electric vehicles traction battery safety requirements

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Foreword

This document is drafted in accordance with the provisions of GB/T 1.1 — 2020 Directives for Standardization—Part 1: Structure and Drafting Rules of Standardization Documents.

This document replaces GB 38031 — 2020 Safety Requirements for Traction Batteries Used in Electric Vehicles. Compared with GB 38031 — 2020, in addition to structural adjustments and editorial revisions, the main technical changes are as follows:

- Revised the scope (see Clause 1, Clause 1 of the 2020 edition);
- Added the definition of battery subsystem (see 3.5);
- Revised the definition of leakage (see 3.14, 3.13 of the 2020 edition);
- Added the definition of thermal event (see 3.15);
- Added safety requirements and test methods for battery cells after fast-charge cycling (see 5.1.7 and 8.1.8);
- Revised the safety requirements and test methods for vibration of battery packs or systems (see 5.2.1 and 8.2.1, 5.2.1 and 8.2.1 of the 2020 edition);
- Revised the safety requirements for mechanical shock of battery packs or systems (see 5.2.2, 5.2.2 of the 2020 edition);
- Revised the safety requirements for simulated crash of battery packs or systems (see 5.2.3, 5.2.3 of the 2020 edition);
- Revised the safety requirements and test methods for crush of battery packs or systems (see 5.2.4 and 8.2.4, 5.2.4 and 8.2.4 of the 2020 edition);
- Revised the safety requirements for damp heat cycling of battery packs or systems (see 5.2.5, 5.2.5 of the 2020 edition);
- Revised the safety requirements for immersion of battery packs or systems (see 5.2.6, 5.2.6 of the 2020 edition);
- Revised the safety requirements and test methods for thermal stability of battery packs or systems (see 5.2.7, 8.2.7 and Annex C, 5.2.7, 8.2.7 and Annex C of the 2020 edition);
- Revised the safety requirements and test methods for temperature shock of battery packs or systems (see 5.2.8 and 8.2.8, 5.2.8 and 8.2.8 of the 2020 edition);
- Revised the safety requirements and test methods for salt spray of battery packs or systems (see 5.2.9 and 8.2.9, 5.2.9 and 8.2.9 of the 2020 edition);
- Revised the safety requirements and test methods for high altitude of battery packs or systems (see 5.2.10 and 8.2.10, 5.2.10 and 8.2.10 of the 2020 edition);
- Revised the safety requirements and test methods for overtemperature protection of battery packs or systems (see 5.2.11 and 8.2.11, 5.2.11 and 8.2.11 of the 2020 edition);
- Revised the safety requirements and test methods for overcurrent protection of battery packs or systems (see 5.2.12 and 8.2.12, 5.2.12 and 8.2.12 of the 2020 edition);
- Revised the safety requirements for external short-circuit protection of battery packs or systems (see 5.2.13, 5.2.13

of the 2020 edition);

- Revised the safety requirements and test methods for overcharge protection of battery packs or systems (see 5.2.14 and 8.2.14, 5.2.14 and 8.2.14 of the 2020 edition);
- Revised the safety requirements for overdischarge protection of battery packs or systems (see 5.2.15, 5.2.15 of the 2020 edition);
- Added safety requirements and test methods for under-ride impact of battery packs, systems or complete vehicles (see 5.2.16 and 8.2.16);
- Revised the requirements for actual capacity (see 6.1.9, 6.1.9 of the 2020 edition);
- Revised the accuracy of measuring instruments and meters, test procedure error, data recording and recording interval (see 6.2, 6.3 and 6.4, 6.2, 6.3 and 6.4 of the 2020 edition);
- Revised the preconditioning requirements for battery cells, battery packs or systems (see 7.1.2 and 7.2.2, 7.1.2 and 7.2.2 of the 2020 edition);
- Revised the test method for overdischarge of battery cells (see 8.1.2, 8.1.2 of the 2020 edition);
- Revised the test method for heating of battery cells (see 8.1.5, 8.1.5 of the 2020 edition);
- Revised the test method for crush of battery cells (see 8.1.7, 8.1.7 of the 2020 edition);
- Added conformity of type assessment (see Clause 9);
- Revised the insulation resistance test method for battery packs or systems (see Annex B, Annex B of the 2020 edition).

Attention is drawn to the fact that some contents of this document may be subject to patent rights. The issuing body of this document shall not be liable for identifying any such patents.

This document is proposed and administered by the Ministry of Industry and Information Technology of the People's Republic of China.

The historical versions of this document and the document it replaces are issued as follows:

- First issued as GB 38031—2020 in 2020;
- This is the first revision.

Introduction

This document specifies the fundamental safety requirements for traction batteries used in electric vehicles, so as to provide protection of personal safety and property security. This document does not cover safety aspects related to production, transportation, maintenance and recycling, nor does it address performance and functional characteristics.

The safety of traction batteries used in electric vehicles is associated with their design and service conditions. Service conditions include normal service conditions, foreseeable misuse conditions and foreseeable fault conditions, as well as environmental conditions such as temperature and altitude that may affect their safety.

This document will be revised in light of further advancements in technology and manufacturing processes.

Safety Requirements for Traction Batteries Used in Electric Vehicles

1 Scope

This document specifies the safety requirements for battery cells, battery packs, or battery systems of traction batteries used in electric vehicles (hereinafter referred to as "batteries"), and describes the corresponding test methods.

This document applies to traction batteries used in electric vehicles.

2 Normative References

The contents of the following documents are incorporated as indispensable provisions of this document through normative reference in the text. For dated reference documents, only the edition corresponding to the specified date shall apply to this document; for undated reference documents, the latest version (including all amendments) shall apply to this document.

GB/T 2423.4 Environmental Testing for Electric and Electronic Products - Part 2: Test Methods - Test Db: Damp Heat, Cyclic (12h + 12h Cycle)

GB/T 2423.17—2024 Environmental Testing - Part 2: Test Methods - Test Ka: Salt Spray

GB/T 2423.43 Environmental Testing for Electric and Electronic Products - Part 2: Test Methods - Mounting of Test Samples for Vibration, Shock and Similar Dynamic Tests

GB/T 2423.56 Environmental Testing - Part 2: Test Methods - Test Fh: Broadband Random Vibration and Guidance

GB/T 4208—2017 Degrees of Protection Provided by Enclosures (IP Code)

GB/T 19596 Terminology for Electric Vehicles

GB/T 28046.4—2011 Road Vehicles - Environmental Conditions and Testing for Electrical and Electronic Equipment - Part 4: Climatic Loads

3 Terms and Definitions

The terms and definitions specified in GB/T 19596 and the following apply to this document.

3.1 battery cell

A basic unit device that converts chemical energy and electrical energy to each other.

Note: It usually consists of electrodes, a separator, electrolyte, a casing, and terminals, and is designed to be rechargeable.

3.2 battery module

An assembly composed of more than one battery cell connected in series, parallel, or series-parallel for use as a power source.

3.3 battery pack

A unit that receives electrical energy from an external source and can output electrical energy externally.

Note: It usually includes battery cells, a battery management module (excluding the Battery Control Unit, BCU), a battery case, and corresponding accessories (such as cooling components, connecting cables, etc.).

3.4 battery system

An energy storage device consisting of one or more battery packs and corresponding accessories (such as a management system, high-voltage circuit, low-voltage circuit, and mechanical assembly, etc.).

3.5 battery subsystem

Any energy storage assembly composed of components of a battery pack or battery system.

3.6 battery electronics

An electronic device that acquires or simultaneously monitors electrical and thermal data of a battery pack.

Note: Battery electronics may include cell controllers and electronic components used for balancing among battery cells. Balancing among battery cells is controlled either by battery electronics or via a battery control unit.

3.7 battery control unit (BCU)

An electronic device that controls, manages, monitors, or calculates electrical and thermal parameters related to a battery system, and enables communication between the battery system and other vehicle controllers.

3.8 rated capacity

The capacity value of a battery cell, module, pack, or system, measured under conditions specified by the manufacturer and declared by the manufacturer.

Note: Rated capacity is typically expressed in ampere-hours (Ah) or milliampere-hours (mAh).

3.9 practical capacity

The capacity value discharged from a fully charged battery cell, module, pack, or system under conditions specified by the manufacturer.

3.10 state-of-charge (SOC)

The percentage of the practical capacity that can be discharged from a battery cell, module, pack, or system under

discharge conditions specified by the manufacturer.

3.11 explosion

The sudden release of energy sufficient to generate a pressure wave or projectiles.

Note: The pressure wave or projectiles may cause structural or physical damage to the surrounding area.

3.12 fire

Sustained combustion (with flame duration exceeding 1 second) occurring at any part of a battery cell, module, pack, or system.

Note 1: Flame duration exceeding 1 second refers to a single continuous flame duration, not the cumulative duration of multiple flame events.

Note 2: Judgment shall be made by visual inspection without disassembling the test object. Sparks and arcing are not classified as combustion.

3.13 housing crack

A mechanical damage to the housing of a battery cell, module, pack, or system caused by internal or external factors, resulting in the exposure or leakage of internal substances.

3.14 leakage

A phenomenon in which visible substances leak out of a battery cell, module, pack, or system to the exterior of the test object.

3.15 thermal event

A phenomenon in which the temperature inside a battery pack or system is significantly higher than the maximum operating temperature (as defined by the manufacturer).

3.16 thermal runaway

A phenomenon in which an uncontrollable temperature rise of a battery cell is caused by an exothermic chain reaction.

3.17 thermal propagation

A phenomenon in which thermal runaway of one battery cell inside a battery pack or system triggers successive thermal runaway of other battery cells.

3.18 end-of-charge voltage

The maximum permissible voltage that a battery cell, module, pack, or system may reach when charged under conditions specified by the manufacturer.

3.19 end-of-discharge voltage

The minimum permissible voltage that a battery cell, module, pack, or system may reach when discharged under conditions specified by the manufacturer.

3.20 body frame

A spatial frame structure designed to ensure the strength and rigidity of a vehicle body.

[Source: GB/T 4780—2020, 4.4.3]

4 Symbols and Abbreviations

4.1 Symbols

The following symbols apply to this document.

I₁: 1-hour rate discharge current (A), whose value is equal to the rated capacity value.

I₃: 3-hour rate discharge current (A), whose value is equal to one-third of the rated capacity value.

4.2 Abbreviations

The following abbreviations apply to this document.

BCU: Battery Control Unit

FS: Full Scale

PSD: Power Spectral Density

RMS: Root Mean Square

SOC: State of Charge

5 Safety Requirements

5.1 Cell Safety Requirements

5.1.1 When a cell is subjected to the over-discharge test in accordance with 8.1.2, it shall neither ignite nor explode.

5.1.2 When a cell is subjected to the over-charge test in accordance with 8.1.3, it shall neither ignite nor explode.

5.1.3 When a cell is subjected to the external short-circuit test in accordance with 8.1.4, it shall neither ignite nor explode.

5.1.4 When a cell is subjected to the heating test in accordance with 8.1.5, it shall neither ignite nor explode.

5.1.5 When a cell is subjected to the temperature cycle test in accordance with 8.1.6, it shall neither ignite nor explode.

5.1.6 When a cell is subjected to the crush test in accordance with 8.1.7, it shall neither ignite nor explode.

5.1.7 When a cell is subjected to the safety test after fast charge cycling in accordance with 8.1.8, it shall neither ignite nor explode.

5.2 Battery Pack or System Safety Requirements

5.2.1 When a battery pack or system is subjected to the vibration test in accordance with 8.2.1, it shall show no signs of leakage, case rupture, ignition or explosion. The insulation resistance after the test shall be not less than 100 Ω/V . If equipped with AC circuits, the insulation resistance shall be not less than 500 Ω/V .

5.2.2 When a battery pack or system is subjected to the mechanical shock test in accordance with 8.2.2, it shall show no

signs of leakage, case rupture, ignition or explosion. The insulation resistance after the test shall be not less than 100 Ω/V . If equipped with AC circuits, the insulation resistance shall be not less than 500 Ω/V .

5.2.3 When a battery pack or system is subjected to the simulated crash test in accordance with 8.2.3, it shall show no signs of leakage, case rupture, ignition or explosion. The insulation resistance after the test shall be not less than 100 Ω/V . If equipped with AC circuits, the insulation resistance shall be not less than 500 Ω/V .

5.2.4 When a battery pack or system is subjected to the crush test in accordance with 8.2.4, it shall neither ignite nor explode. The insulation resistance after the test shall be not less than 100 Ω/V . If equipped with AC circuits, the insulation resistance shall be not less than 500 Ω/V .

5.2.5 When a battery pack or system is subjected to the damp heat cycle test in accordance with 8.2.5, it shall show no signs of leakage, case rupture, ignition or explosion. The insulation resistance within 30 minutes after the test shall be not less than 100 Ω/V . If equipped with AC circuits, the insulation resistance shall be not less than 500 Ω/V .

5.2.6 Battery Pack or System Safety Requirements

When a battery pack or system is subjected to the immersion test in accordance with 8.2.6, it shall meet one of the following requirements:

- a) When tested in accordance with Method 1, it shall neither ignite nor explode.
- b) When tested in accordance with Method 2, it shall comply with the IPX7 requirements specified in GB/T 4208—2017 after the test, and show no signs of leakage, case rupture, ignition or explosion. The insulation resistance after the test shall be not less than 100 Ω/V . If equipped with AC circuits, the insulation resistance shall be not less than 500 Ω/V .

5.2.7 Thermal Stability Test Requirements

(Applicable to all battery packs or systems except nickel-metal hydride battery packs or systems)

When tested in accordance with 8.2.7, the following requirements shall be met:

- a) When a battery pack or system is subjected to the external fire test in accordance with 8.2.7.1, it shall not explode.
- b) When a battery pack, system or complete vehicle is subjected to the thermal propagation analysis and verification in accordance with 8.2.7.2, it shall satisfy the following criteria:
 1. It shall neither ignite nor explode;
 2. It shall provide a thermal event alarm signal, and the alarm signal shall be issued no later than 5 minutes after the trigger of cell thermal runaway;
 3. For battery pack or system-level tests: Technical documentation shall be provided to demonstrate that the smoke does not pose a hazard to the occupant compartment before the thermal event alarm signal is issued and within 5 minutes after the alarm signal is issued.

For complete vehicle-level tests: No smoke shall enter the occupant compartment before the thermal event alarm signal is issued and within 5 minutes after the alarm signal is issued.

5.2.8 Temperature Shock Test Requirement

When a battery pack or system is subjected to the temperature shock test in accordance with 8.2.8, it shall show no signs of leakage, case rupture, ignition or explosion. The insulation resistance after the test shall be not less than 100 Ω/V . If equipped with AC circuits, the insulation resistance shall be not less than 500 Ω/V .

5.2.9 Salt Spray Test Requirement

When a battery pack or system is subjected to the salt spray test in accordance with 8.2.9, it shall show no signs of leakage, case rupture, ignition or explosion. The insulation resistance after the test shall be not less than 100 Ω/V . If equipped with AC circuits, the insulation resistance shall be not less than 500 Ω/V .

5.2.10 High-Altitude Test Requirement

When a battery pack or system is subjected to the high-altitude test in accordance with 8.2.10, it shall show no signs of leakage, case rupture, ignition or explosion. The insulation resistance after the test shall be not less than 100 Ω/V . If equipped with AC circuits, the insulation resistance shall be not less than 500 Ω/V .

5.2.11 Overtemperature Protection Test Requirement

When a battery system is subjected to the overtemperature protection test in accordance with 8.2.11, it shall show no signs of leakage, case rupture, ignition or explosion. The insulation resistance after the test shall be not less than 100 Ω/V . If equipped with AC circuits, the insulation resistance shall be not less than 500 Ω/V .

5.2.12 Overcurrent Protection Test Requirement

When a battery system is subjected to the overcurrent protection test in accordance with 8.2.12, it shall show no signs of leakage, case rupture, ignition or explosion. The insulation resistance after the test shall be not less than 100 Ω/V . If equipped with AC circuits, the insulation resistance shall be not less than 500 Ω/V .

5.2.13 External Short-Circuit Protection Test Requirement

When a battery system is subjected to the external short-circuit protection test in accordance with 8.2.13, it shall show no signs of leakage, case rupture, ignition or explosion. The insulation resistance after the test shall be not less than 100 Ω/V . If equipped with AC circuits, the insulation resistance shall be not less than 500 Ω/V .

5.2.14 Overcharge Protection Test Requirement

When a battery system is subjected to the overcharge protection test in accordance with 8.2.14, it shall show no signs of leakage, case rupture, ignition or explosion. The insulation resistance after the test shall be not less than 100 Ω/V . If equipped with AC circuits, the insulation resistance shall be not less than 500 Ω/V .

5.2.15 Overdischarge Protection Test Requirement

When a battery system is subjected to the overdischarge protection test in accordance with 8.2.15, it shall show no signs of leakage, case rupture, ignition or explosion. The insulation resistance after the test shall be not less than 100 Ω/V . If

equipped with AC circuits, the insulation resistance shall be not less than 500 Ω/V .

5.2.16 Bottom Impact Test Requirement

When a battery pack, system or complete vehicle is subjected to the bottom impact test in accordance with 8.2.16, it shall show no signs of leakage, case rupture, ignition or explosion. The insulation resistance after the test shall be not less than 100 Ω/V . If equipped with AC circuits, the insulation resistance shall be not less than 500 Ω/V .

6 Test Conditions

6.1 General Conditions

6.1.1 Unless otherwise specified, the test ambient temperature shall be $22\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$, the relative humidity shall be 10%–90%, and the atmospheric pressure shall be 86 kPa–106 kPa.

6.1.2 If the test object is a cell, the test may be conducted with fixtures installed. If a cell is unable to operate independently, the test shall be performed using a battery module, which shall meet the safety requirements specified in 5.1.

6.1.3 For a battery pack or system enclosed by and integrated with the vehicle body frame, the test may be conducted with the enclosure or vehicle body frame installed.

6.1.4 The delivery of a battery pack or system for testing shall include the necessary operating documents and interface components required for connection to the test equipment, such as connectors, plugs, and cooling system interfaces. The typical structure of the battery pack or system is given in Appendix A. In addition, any additional sensors, wires, and fixtures shall not affect the test results. The manufacturer shall provide the safe operating limits of the battery pack or system.

6.1.5 The insulation resistance test of a battery pack or system shall be performed before all tests and after some tests. The test shall be conducted between the positive and negative output terminals and the electrical ground. The specific test method shall be implemented in accordance with Appendix B.

6.1.6 If a battery pack or system is not suitable for some tests due to size, weight, or other factors, the manufacturer may, after reaching an agreement with the testing organization, use a battery subsystem as the test object to perform all or part of the tests. However, the battery subsystem used as the test object shall include all components related to the vehicle-level requirements (e.g., connection components or protection components), and may incorporate the battery management system. If a battery subsystem is selected for testing, it shall be demonstrated that the test results are representative of the safety performance of the battery pack or system under the same conditions.

6.1.7 Method for adjusting the SOC to the target test value of $n\%$: Charge the cell, battery pack, or system to full capacity in accordance with the charging method provided by the manufacturer, allow it to rest for 1 hour, then discharge it at a constant current of $1I_3$ for a duration of t . The value of t shall be calculated in accordance with Formula (1), or the SOC may be adjusted using the method provided by the manufacturer. After each SOC adjustment, the test object shall rest for 30 minutes before the start of a new test, or in accordance with the conditions specified by the manufacturer.

$$t = \frac{100 - n}{100} \times 3 \dots\dots\dots (1)$$

Where:

t — Discharge time, in hours (h);

n — Percentage value of the target test value.

6.1.8 The charge-discharge rates, charge-discharge methods, and charge-discharge termination conditions during testing shall be provided by the manufacturer.

6.1.9 The actual capacity of a cell shall not be less than its rated capacity, and shall not exceed 110% of the rated capacity. The absolute value of the difference between the actual capacity and rated capacity of a battery pack or system shall not exceed 5% of the rated capacity.

6.1.10 Unless otherwise specified, all test objects shall be tested at the maximum operating state of charge (SOC) specified by the manufacturer.

6.1.11 The discharge current of cells, battery packs or systems shall be designated as positive, and the charge current shall be designated as negative.

6.2 Accuracy of Measuring Instruments and Meters

The accuracy of measuring instruments and meters shall meet no less than the following requirements:

- a) Voltage measuring device: $\pm 0.5\%$ FS;
- b) Current measuring device: $\pm 0.5\%$ FS;
- c) Temperature measuring device: ± 1 °C;
- d) Humidity measuring device: $\pm 2\%$ (relative humidity, RH);
- e) Time measuring device: ± 0.1 s;
- f) Dimension measuring device: $\pm 0.1\%$ FS;
- g) Mass measuring device: $\pm 0.1\%$ FS;
- h) Pressure measuring device: $\pm 1\%$ FS.