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Electrically propelled road vehicles — Test specification for lithium-ion traction battery packs and systems —

Part 3: Safety performance requirements

Véhicules routiers à propulsion électrique — Spécifications d'essai pour packs et systèmes de batterie de traction aux ions lithium — Partie 3: Exigences de performance de sécurité

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 22, *Road vehicles*, Subcommittee SC 21, *Electrically propelled road vehicles*.

ISO 12405 consists of the following parts, under the general title *Electrically propelled road vehicles — Test specification for lithium-ion traction battery packs and systems*:

— *Part 1: High-power applications*

— *Part 2: High-energy applications*

— *Part 3: Safety performance requirements*

Introduction

Lithium-ion battery systems are efficient rechargeable energy storage systems for electrically propelled road vehicles. The requirements for lithium-ion battery systems to be used as power source for the propulsion of electric road vehicles are significantly different to those batteries used for consumer electronics or for stationary applications.

Lithium-ion batteries can store electricity at relatively high-energy density compared to other battery chemistries currently available. Under current state of art, most lithium-ion batteries use organic electrolytes which are classified as Class 3 “flammable liquid” under the “UN Recommendations on the Transport of Dangerous Goods — Model Regulations”. Therefore, mitigating potential hazards associated with fire or explosion of lithium-ion batteries is considered an important issue.

This part of ISO 12405 provides specific test procedures and related requirements to ensure an appropriate and acceptable level of safety of lithium-ion battery systems specifically developed for propulsion of road vehicles.

Electrically propelled road vehicles — Test specification for lithium-ion traction battery packs and systems —

Part 3: Safety performance requirements

1 Scope

This part of ISO 12405 specifies test procedures and provides acceptable safety requirements for voltage class B lithium-ion battery packs and systems, to be used as traction batteries in electrically propelled road vehicles. Traction battery packs and systems used for two-wheel or three-wheel vehicles are not covered by this part of ISO 12405. This part of ISO 12405 is related to the testing of safety performance of battery packs and systems for their intended use in a vehicle. This part of ISO 12405 is not intended to be applied for the evaluation of the safety of battery packs and systems during transport, storage, vehicle production, repair, and maintenance services.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 6469-1, *Electrically propelled road vehicles — Safety specifications — Part 1: On-board rechargeable energy storage system (RESS)*

ISO 6469-3, *Electrically propelled road vehicles — Safety specifications — Part 3: Protection of persons against electric shock*

ISO/TR 8713, *Electrically propelled road vehicles — Vocabulary*

ISO 12405-1:2011, *Electrically propelled road vehicles — Test specification for lithium-ion traction battery packs and systems — Part 1: High-power applications*

ISO 12405-2:2012, *Electrically propelled road vehicles — Test specification for lithium-ion traction battery packs and systems — Part 2: High-energy applications*

ISO 20653, *Road vehicles — Degrees of protection (IP code) — Protection of electrical equipment against foreign objects, water and access*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/TR 8713 and the following apply.

3.1
battery control unit
BCU
electronic device that controls, manages, detects, or calculates electric and thermal functions of the battery system that provides communication between the battery system and other vehicle controllers

Note 1 to entry: See also Annex A for further explanation.

3.2
battery pack
energy storage device that includes cells or cell assemblies normally connected with cell electronics, voltage class B circuit, and overcurrent shut-off device, including electrical interconnections and interfaces for external systems

Note 1 to entry: For further explanation, see A.2.

Note 2 to entry: Examples of external systems are cooling, voltage class B, auxiliary voltage class A, and communication.

3.3
battery pack subsystem
representative portion of the battery pack

3.4
battery system
energy storage device that includes cells or cell assemblies or battery pack(s), as well as electrical circuits and electronics

Note 1 to entry: For further explanation, see A.3.1 and A.3.2. Battery system components can also be distributed in different devices within the vehicle.

Note 2 to entry: Examples of electronics are the BCU and contactors.

3.5
bus
vehicles designed and constructed for the carriage of passengers, comprising more than eight seats in addition to the driver's seat, and having a maximum mass exceeding 5 t

3.6
capacity
total number of ampere-hours that can be withdrawn from a fully charged battery under specified conditions

3.7
cell electronics
electronic device that collects and possibly monitors thermal or electric data of cells or cell assemblies and contains electronics for cell balancing, if necessary

Note 1 to entry: The cell electronics can include a cell controller. The functionality of cell balancing can be controlled by the cell electronics or it can be controlled by the BCU.

3.8
customer
party that is interested in using the battery pack or system and, therefore, orders or performs the test

EXAMPLE A vehicle manufacturer.

3.9
device under test
DUT
in this part of ISO 12405, a battery pack or battery system

3.10
explosion
sudden release of energy sufficient to cause pressure waves and/or projectiles that can cause structural and/or physical damage to the surroundings of the DUT

Note 1 to entry: The kinetic energy of flying debris from the battery pack or system can be sufficient to cause damage to the surroundings of the DUT as well.

3.11
fire
continuous emission of flames from a DUT (approximately more than 1 s)

Note 1 to entry: Sparks and arcing are not considered as flames.

3.12
heavy-duty truck
vehicle designed and constructed for the carriage of goods and having a maximum mass exceeding 12 t

3.13
high-energy application
characteristic of device or application for which the numerical ratio between maximum allowed electric power output (power in W) and electric energy output (energy in Wh) at a 1 C discharge rate at RT for a battery pack or system is typically lower than 10

Note 1 to entry: Typically, high-energy battery packs and systems are designed for applications in BEVs.

3.14
high-power application
characteristic of device or application for which the numerical ratio between maximum allowed electric power output (power in W) and electric energy output (energy in Wh) at a 1 C discharge rate at RT for a battery pack or system is typically equal to or higher than 10

Note 1 to entry: Typically, high-power battery packs and systems are designed for application in HEVs and FCVs.

3.15
isolation resistance
resistance between live parts of the voltage class B electric circuit and the electric chassis, as well as the voltage class A system

3.16
leakage
escape of liquid or gas from a DUT except for venting

3.17
maximum working voltage
highest value of a.c. voltage (rms) or of d.c. voltage, which can occur in an electrical system under any normal operating conditions according to the battery manufacturer's specifications, disregarding transients

3.18
medium-duty truck
vehicle designed and constructed for the carriage of goods and having a maximum mass exceeding 3,5 t but not exceeding 12 t

3.19
midi bus
vehicle designed and constructed for the carriage of passengers, comprising more than eight seats in addition to the driver's seat, and having a maximum mass not exceeding 5 t

3.20
rated capacity
supplier's specification of the total number of ampere-hours that can be withdrawn from a fully charged battery pack or system for a specified set of test conditions such as discharge rate, temperature, discharge cut-off voltage, etc.

3.21
room temperature
RT
temperature of (25 ± 2) °C

3.22
rupture
loss of mechanical integrity of the enclosure of the DUT resulting in openings that do not fulfil protection degree IPXXB according to ISO 20653

Note 1 to entry: The kinetic energy of released material is not sufficient to cause structural and/or physical damage to the surrounding of the DUT.

3.23
state of charge
SOC
available capacity in a battery pack or system expressed as a percentage of rated capacity

3.24
supplier
party that provides battery systems and packs

EXAMPLE A battery manufacturer.

3.25
venting
release of excessive pressure from a DUT intended by design to preclude rupture or explosion

3.26
voltage class A
classification of an electric component or circuit with a maximum working voltage of ≤30 V a.c. (rms) or ≤60 V d.c., respectively

Note 1 to entry: See ISO 6469-3.

3.27
voltage class B
classification of an electric component or circuit with a maximum voltage of (>30 and ≤1 000) V a.c. (rms) or (>60 and ≤1 500) V d.c., respectively

Note 1 to entry: See ISO 6469-3.

4 Symbols and abbreviated terms

a.c. alternating current

BCU battery control unit

BEV battery electric vehicle

d.c. direct current

DUT device under test

FCV fuel cell vehicle

HEV hybrid electric vehicle

RESS rechargeable energy storage system

RT room temperature [(25 ± 2) °C]

SOC state of charge

UNECE United Nations Economic Commission for Europe

5 General requirements

5.1 General conditions

A battery pack or system to be tested according to this part of ISO 12405 shall fulfil the following requirements.

— Electrical safety design shall be approved according to the requirements given in ISO 6469-1 and ISO 6469-3.

— The necessary documentation for operation and needed interface parts for connection to the test equipment (i.e. connectors, plugs including cooling) shall be delivered together with the DUT.

— A battery system shall enable the specified tests, e.g. by specified test modes implemented in the BCU, and shall be able to communicate with the test bench *via* common communication buses.

— The DUT can also be equipped with additional sensors, wires, and support jig, which are necessary to conduct the specific test or to obtain the required data for such a test. Such additional devices shall not influence the result with respect to the intended purpose of the test.

If not otherwise specified, the tests described apply to battery packs and systems.

The battery pack subsystem as a DUT shall comprise all parts specified by the customer (e.g. including mechanical and electrical connecting points for mechanical test).

The status of the DUT, e.g. new product, tested, or used, shall be agreed upon between the customer and the supplier before testing. The history of the DUT shall be documented.

When reference to ISO 12405-1 and ISO 12405-2 is made, only the test procedure in the corresponding clause shall apply. In this case, the test procedures and pre-conditions (e.g. temperatures, SOC) shall be selected according to the battery packs or systems application. For high-power applications, refer to ISO 12405-1, and for high-energy applications, refer to ISO 12405-2.

If not otherwise specified, the following conditions shall apply.

— The test temperature shall be RT.

— Before each test, the DUT shall be equilibrated at the test temperature. The thermal equilibration is reached, if during a period of 1 h without active cooling the deviations between test temperature and temperature of all cell temperature measuring points are lower than ±2 K.

— Before each test, the SOC of the DUT shall be set to a value agreed upon between the customer and the supplier but at least 50 % SOC for high-power applications. For high-energy applications, the SOC shall be set to maximum SOC at normal operation.

— Each charge and each SOC change shall be followed by a rest period of 30 min.

— The conduction of component-based testing or vehicle-based testing is optional. The selection of either of the described options shall be according to the agreement between the customer and the supplier.

The accuracy of external measurement equipment shall be at least within the following tolerances:

— voltage: ±0,5 %;

— current: ±0,5 %;

— temperature: ±1 K.

The overall accuracy of externally controlled or measured values, relative to the specified or actual values, shall be at least within the following tolerances:

— voltage: ±1 %;

— current: ±1 %;

— temperature: ±2 K;

— time: ±0,1 %;

— mass: ±0,1 %;

— dimensions: ±0,1 %.

All values (time, temperature, current, and voltage) shall be noted at least every 5 % of the estimated discharge and charge time, except if it is noted otherwise in the individual test procedure.

If any test in this part of ISO 12405 is performed on the vehicle, the same test on battery pack or system level is not necessary.

5.2 Test sequence plan

5.2.1 General

The test sequence for an individual battery pack or system or a battery pack subsystem shall be based on the agreement between the customer and the supplier.

The re-use of the battery system and/or components in multiple tests is acceptable based on the agreement between the customer and the supplier.

5.3 Preparation of the DUT for testing

5.3.1 Preparation of battery pack

If not otherwise specified, the battery pack shall be connected with voltage class B and voltage class A connections to the test bench equipment. Contactors, available voltage, current, and temperature data shall be controlled according to the supplier's requirements and according to the given test specification by the test bench equipment. The passive overcurrent protection shall be maintained by the test bench equipment, if necessary *via* disconnection of the battery pack main contactors. The cooling device can be connected to the test bench equipment and operated according to the supplier's requirements.

5.3.2 Preparation of battery system

If not otherwise specified, the battery system shall be connected with voltage class B, voltage class A, and cooling system and BCU to the test bench equipment. The battery system shall be controlled by the BCU. The test bench equipment shall follow the operational limits provided by the BCU via bus communication. The test bench equipment shall maintain the on/off requirements for the main contactors and the voltage, current, and temperature profiles according to the requested requirements of the given test procedure. The battery system cooling device and the corresponding cooling loop at the test bench equipment shall be operational according to the given test specifications and the controls by the BCU. The BCU shall enable the test bench equipment to perform the requested test procedure within the battery system operational limits. If necessary, the BCU program shall be adapted by the supplier for the requested test procedure. The active and passive overcurrent protection device shall be operational by the battery system. Active overcurrent protection shall be maintained by the test bench equipment, too, if necessary, *via* request of disconnection of the battery system main contactors.

