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Electrically propelled mopeds and motorcycles — Test specifications and safety requirements for lithium-ion battery systems

Cyclomoteurs et motocycles à propulsion électrique — Spécifications d'essai et exigences de sécurité pour les systèmes de batterie au lithium-ion

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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 voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 38, *Motorcycles and mopeds*.

Introduction

Lithium-ion based battery systems are an efficient alternative energy storage system for electrically propelled mopeds and motorcycles. The requirements for lithium-ion based battery systems to be used as power source for the propulsion of electrically propelled mopeds and motorcycles are significantly different to those batteries used for consumer electronics or stationary usage.

This document provides specific test procedures for lithium-ion battery packs and systems specifically developed for propulsion of mopeds and motorcycles. This document specifies such tests and related requirements to ensure that a battery pack or system is able to meet the specific needs of the mopeds and motorcycles industry.

It enables mopeds and motorcycles manufacturers to choose test procedures to evaluate the characteristics of a battery pack or system for their specific requirements.

Electrically propelled mopeds and motorcycles — Test specifications and safety requirements for lithium-ion battery systems

1 Scope

This document specifies the test procedures for lithium-ion battery packs and systems used in electrically propelled mopeds and motorcycles.

The specified test procedures enable the user of this document to determine the essential characteristics on performance, safety and reliability of lithium-ion battery packs and systems. The user is also supported to compare the test results achieved for different battery packs or systems.

This document enables setting up a dedicated test plan for an individual battery pack or system subject to an agreement between customer and supplier. If required, the relevant test procedures and/or test conditions of lithium-ion battery packs and systems are selected from the standard tests provided in this document to configure a dedicated test plan.

NOTE 1 Electrically power-assisted cycles (EPAC) cannot be considered as mopeds. The definition of electrically power-assisted cycles can differ from country to country. An example of definition can be found in the EU Directive 2002/24/EC.

NOTE 2 Testing on cell level is specified in IEC 62660 (all parts).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 13063, *Electrically propelled mopeds and motorcycles — Safety specifications*

ISO 16750-1, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment — Part 1: General*

IEC 60068-2-30, *Environmental testing — Part 2-30: Tests – Test Db: Damp heat, cyclic (12 h + 12 h cycle)*

IEC 60068-2-47, *Environmental testing — Part 2-47: Tests – Mounting of specimens for vibration, impact and similar dynamic tests*

IEC 60068-2-52, *Environmental testing — Part 2-52: Tests – Test Kb: Salt mist, cyclic (sodium, chloride solution)*.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

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

3.2
battery pack
energy storage device that includes cells or cell assemblies normally connected with cell electronics, high voltage circuit and over current shut-off device including electrical interconnections, interfaces for external systems (e.g. cooling, high voltage, auxiliary low voltage and communication)

Note 1 to entry: See A.2 for further explanation.

3.3
battery system
energy storage device that includes cells or cell assemblies or battery pack(s) as well as electrical circuits and electronics (e.g. BCU, contactors)

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

3.4
capacity
total number of ampere-hours that can be withdrawn from a fully charged battery under specified conditions

3.5
cell electronics
electronic device that collects and possibly monitors thermal and electrical data of cells or cell assemblies and contains electronic 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.

3.6
energy round trip efficiency
ratio of the net DC energy (W·h discharge) delivered by a DUT during a discharge test to the total DC energy (W·h charge) required to restore the initial SOC by a standard charge

3.7
rated capacity
suppliers 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.

3.8
room temperature
RT
temperature of (25 ± 2) °C

3.9
device under test
DUT
battery pack or battery system

3.10
sign of battery current
discharge current is specified as positive and the charge current as negative

3.11
state of charge
SOC
available capacity in a battery pack or system expressed as a percentage of rated capacity

3.12
standard charge for top off
SCH
additional charge which eliminates possible SOC reduction after SCH at RT followed by thermal equilibration at a different temperature

3.13
voltage class A
classification of an electric component or circuit with a maximum working voltage of ≤30 V a.c. or ≤60 V d.c., respectively

Note 1 to entry: For more details, see ISO 6469-3.

3.14
voltage class B
classification of an electric component or circuit with a maximum voltage of (>30 and ≤1 000) V a.c. or (>60 and ≤1 500) V d.c., respectively

3.15
maximum working voltage
highest value of a.c. voltage (r.m.s.) or of d.c. voltage which may occur in an electrical system under any normal operating conditions according to the manufacturer's specifications, disregarding transients

3.16
isolation resistance
resistance between live parts of voltage class B electric circuit and the electric chassis as well as the voltage class A system

3.17
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

3.18
explosion
sudden release of energy sufficient to cause pressure waves and/or projectiles that may cause structural and/or physical damage to the surrounding of the DUT

Note 1 to entry: The kinetic energy of flying debris from the battery back or system may be sufficient to cause damage as well.

3.19
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.

3.20
venting
release of excessive pressure from a DUT intended by design

3.21
leakage
escape of liquid or gas from a DUT regardless of venting (pressure release device for cell) or not

3.22
customer
party interested in using the battery pack or system and, therefore, orders or performs the test

EXAMPLE A moped/motorcycle manufacturer.

3.23
supplier
party that provides battery systems and packs

EXAMPLE A battery manufacturer.

3.24
thermal equilibration
DUT achieving the thermal target

3.25
thermal equilibrium
thermal balance of the cell among the DUT

3.26
battery pack subsystem
representative portion of the battery pack

4 Symbols and abbreviated terms

BCU	battery control unit
C	capacity, expressed in ampere-hours (A·h)
*n*C	current rate equal to *n* times the 1 h discharge capacity expressed in ampere (e.g. 5C is equal to five times the 1 h current discharge rate, expressed in A)
DUT	device under test
EODV	end of discharge voltage
$I_{d\ max}$	maximum continuous discharge current specified by the manufacturer for energy and capacity testing
$I_{dp\ max}$	maximum discharge pulse current specified by the manufacturer for power, internal resistance and energy efficiency testing
r.m.s.	root mean square
RT	room temperature (25 ± 2) °C
SC	standard cycle
SCH	standard charge
SDCH	standard discharge
SOC	state of charge

5 General requirements

5.1 General conditions

A battery pack or system to be tested according to this document shall fulfil the following requirements:

— electrical safety design shall be approved according to the requirements given in ISO 13063; and

— 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, i.e. via specified test modes implemented in the BCU and shall be able to communicate with the test bench via common communication buses.

If not otherwise specified, the tests described apply to battery packs/systems. The status of the DUT, e.g. new product, tested or used, shall be agreed upon between customer and supplier before testing. The history of the DUT shall be documented.

If not otherwise specified, before each test the DUT shall be stabilized at the test temperature for a minimum of 12 h and the BCU, if any, shall be switched off. This period may be reduced if the thermal equilibration of the DUT is reached. Thermal equilibration is fulfilled when, after a period of 1 h, the change among all available cell temperature measuring points is lower than 4 °C .

If not otherwise specified, each charge and each SOC change shall be followed by a rest period of 30 min.

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

— voltage: ±0,5 %;

— current: ±0,5 %; and

— 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 %; and

— dimensions: ±0,1 %.

All values (time, temperature, current and voltage) shall be recorded at least every 1 % of the estimated discharge and charge time, except if it is noted otherwise in the individual test procedure.

5.2 Tests

An overview about the tests is given in Figure 1, where the references to the specific clauses are also given.

Overview of tests

General tests	Performance tests	Safety and reliability tests
Pre-conditioning cycles (6.1) Standard cycle (6.2) Standard discharge (6.2.2.2) Standard charge (6.2.2.3)	Energy and capacity at RT (7.1) Energy and capacity at different temperature and discharge rates (7.2) Power and internal resistance (7.3) No load SOC loss (7.4) SOC loss at storage (7.5) Cycle life (7.6)	Vibration (8.1) Mechanical shock (8.2) Drop (8.3) Thermal shock (8.4) Water immersion (8.5) Fire (8.6) Overtemperature condition (8.7) Short circuit protection (8.8) Overcharge protection (8.9) Over discharge protection (8.10) Dewing (8.11) Salt spray (8.12)

Figure 1 — Overview of the tests

5.3 Test procedure

The test sequence and sample numbers for an individual battery pack or system, or a battery pack subsystem, shall be based on agreement between customer and supplier. The basic suggestion of test procedure is listed in Table 1.

Table 1 — Test procedure

Seq	Test type	Test procedure	Sample SN
1	**General tests**	Pre-conditioning cycles (6.1)	1#–20#
2		Standard cycle (6.2)	1#–20#
3		Standard discharge (6.2.2.2)	1#–20#
4		Standard charge (6.2.2.3)	1#–20#
5	**Performance tests**	Energy and capacity at RT (7.1)	1#–20#
6		Energy and capacity at different temperature and discharge rates (7.2)	1#
7		Power and internal resistance (7.3)	2#
8		No load SOC loss (7.4)	3#
9		SOC loss at storage (7.5)	4#
10		Cycle life (7.6)	5#
11	**Safety and reliability tests**	Vibration (8.1)	6#
12		Mechanical shock (8.2)	7#
13		Drop (8.3)	8#
14		Thermal shock (cycle) (8.4)	9#
15		Water immersion (8.5)	10#
16		Fire (8.6)	11#
17		Overtemperature condition (8.7)	12#
18		Short circuit protection (8.8)	13#
19		Overcharge protection (8.9)	14#
20		Over discharge Protection (8.10)	15#
21		Dewing (8.11)	16#
22		Salt spray (8.12)	17#

5.4 Preparation of the DUT for testing

5.4.1 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.

5.4.2 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