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BSI Standards Publication

Secondary lithium batteries for light EV (electric vehicle) applications

Part 1: General safety requirements and test methods

bsi.

National foreword

This British Standard is the UK implementation of EN 50604-1:2016.

The UK participation in its preparation was entrusted to Technical Committee PEL/21, Secondary cells and batteries.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Secondary lithium batteries for light EV (electric vehicle) applications - Part 1: General safety requirements and test methods

Batteries d'accumulateurs au lithium pour applications liées aux véhicules électriques légers - Partie 1 : Exigences générales de sécurité et méthodes d'essai

Lithium-Sekundärbatterien für Anwendungen in leichten Elektrofahrzeugen - Teil 1: Allgemeine Sicherheitsanforderungen und Prüfverfahren

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European foreword

This document (EN 50604-1:2016) has been prepared by CLC/TC 21X “Secondary cells and batteries”.

The following dates are fixed:

• latest date by which the existence of this document has to be announced at national level	(doa)	2017–01–04
• latest date by which this document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2017–07–04
• latest date by which the national standards conflicting with this document have to be withdrawn	(dow)	2019–07–04

The goal of this standard is to increase safety of battery packs/ systems which contain lithium battery technologies in combination with their voltage converter unit for use in light electric vehicles.

Part 1 sets definitions, safety issues and test procedures.

This standard was designed to assess aspects on battery pack/system level.

This standard covers the Principal Elements of the Safety Objectives for Electrical Equipment Designed for Use within Certain Voltage Limits (LVD - 2006/95/EC).

This standard covers the Principal Elements of the Safety Objectives for battery packs/systems Designed for Use by Light EVs (Directive 2002/24/EC, Regulation (EU) 168/2013).

Light EV includes all electrically propelled two, three and four wheeled vehicles of category L1 up to Category L7 according to the definition of ECE/TR ANS-WP29-78r2e and all electrically propelled or assisted cycles including plug-in hybrid road vehicles (PHEV), that derive all or part of their energy from on-board rechargeable energy storage systems (RESS).

This standard covers issues mentioned in EU Mandate M/468 and M/533.

This part is to be used in conjunction with the appropriate part of the ISO 12405- series.

NOTE The following print types are used:

– requirements: in roman type;

– test specifications: in italic type;

– notes: in small roman type.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC shall not be held responsible for identifying any or all such patent rights.

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 may 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 “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.

EN 50604-1 will be read in conjunction with ISO 12405-3. The clauses of the particular requirements in EN 50604-1 supplement or modify the corresponding clauses in ISO 12405-3. Where the text indicates an “addition” to or a “replacement” of the relevant requirement, test specification or explanation of ISO 12405-3, these changes are made to the relevant text of ISO 12405-3, which then becomes part of the standard. Where no change is necessary, the words “This (sub)clause of ISO 12405-3:2014 is applicable” are used.

Test items were selected to simulate conditions likely to occur during handling (e.g. removal or replacement) or during operation. They cover conditions of normal operation, rough handling and as well likely conditions of misuse or negligent handling. For electric vehicles operating under extreme conditions (e.g. off-road, extreme climate, etc.) additional requirements may be necessary which are not covered by this standard.

Additional requirements might also apply to battery system after the integration into the vehicle resulting from national or regional regulations and are not dealt within this standard. Same applies to hazards from electric shock.

This European Standard 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.

This standard refers to the UN Recommendations on the Transport of Dangerous Goods – Manual of Tests and Criteria: Section 38.3 which are performed independently from this testing program. Test reports issued by an ILAC, APLAC or similar accredited party are acceptable for the battery system complying with all aspects of Section 38.3 of Manual of Tests and Criteria of UN Recommendations on the Transport of Dangerous Goods for this test option.

1 Scope

This European Standard specifies test procedures and provides acceptable safety requirements for voltage class A and voltage class B removable lithium-ion battery (packs and) systems, to be used as traction batteries of or for electrically propelled road vehicles. This European Standard is related to the testing of safety performance of battery packs and systems for their intended use for a vehicle.

This European Standard is not intended to be applied for the evaluation of the safety of battery packs/systems storage, vehicle production, repair and maintenance services.

Light EV includes all electrically propelled two, three and four wheeled vehicles of category L1 up to Category L7 according to the definition of ECE/TR ANS-WP29-78r2e and all electrically propelled or assisted cycles including plug-in hybrid road vehicles (PHEV), that derive all or part of their energy from on-board rechargeable energy storage systems (RESS).

This European Standard enables setting up a dedicated test plan for an individual battery pack/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 may be selected from the standard tests provided in this standard to configure a dedicated test plan.

This European Standard applies to all battery systems intended to be used in conjunction with products or systems described in the IEC/TS 61851-3 series.

NOTE Testing on cell level is specified in the IEC 62660 series.

This European Standard does not apply to:

– lithium cells;

– batteries other than lithium ion types;

– primary Batteries(including lithium types);

– batteries covered by the ISO 12405- series.

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 12405-3:2014, *Electrically propelled road vehicles — Test specification for lithium-ion traction battery packs and systems — Part 3: Safety performance requirements*

This clause of ISO 12405-3:2014 is applicable except as follows:

Additions:

EN 60068-2-47, *Environmental testing — Part 2-47: Test — Mounting of specimens for vibration, impact and similar dynamic tests (IEC 60068-2-47)*

EN 60335-2-29, *Household and similar electrical appliances — Safety — Part 2-29: Particular requirements for battery chargers (IEC 60335-2-29)*

EN ISO 14021, *Environmental labels and declarations — Self-declared environmental claims (Type II environmental labelling) (ISO 14021)*

EN ISO 4892-2, *Plastics — Methods of exposure to laboratory light sources — Part 2: Xenon-arc lamps (ISO 4892-2)*

EN ISO 7010:2012, *Graphical symbols - Safety colours and safety signs - Registered safety signs (ISO 7010:2011)*

EN ISO 13849 (all parts), *Safety of machinery — Safety-related parts of control systems (ISO 13849, all parts)*

IEC 60335-1, *Household and similar electrical appliances — Safety — Part 1: General requirements*

IEC 60417:2002, *Graphical symbols for use on equipment — 12-month subscription to online database comprising all graphical symbols published in IEC 60417*

IEC/TS 60479-2:2007, *Effects of current on human beings and livestock — Part 2: Special aspects*

IEC 61140, *Protection against electric shock — Common aspects for installation and equipment*

IEC 61508 (all parts), *Functional safety of electrical/electronic/programmable electronic safety-related systems*

IEC/TS 61851-3-1:2016[1)], *Electric Vehicles conductive power supply system — Part 3-1: General Requirements for Light Electric Vehicles (LEV) AC and DC conductive power supply systems*

IEC/TS 61851-3[2)], *Electric Vehicles conductive power supply system*

IEC/TS 62196-4[3)], *Plugs, socket-outlets, and vehicle couplers — Conductive charging of electric vehicles — Part 4: Dimensional compatibility and interchangeability requirements for a.c., d.c. and a.c./ d.c. vehicle couplers for Class II or Class III light electric vehicles (LEV)*

IEC 62660 (all parts), *Secondary lithium-ion cells for the propulsion of electric road vehicles*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/TR 8713 and ISO 12405-3 and the following apply.

Addition:

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 vehicle controllers

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

[SOURCE: ISO 12405-3:2014, 3.1]

1) Under consideration.

2) Under consideration.

3) Under consideration.

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

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

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

[SOURCE: ISO 12405-3:2014, 3.2, modified — The original definition mentioned voltage class B circuit only.]

3.3
battery pack subsystem
representative portion of the battery pack

[SOURCE: ISO 12405-3:2014, 3.3]

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 Annex AA. 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.

[SOURCE: ISO 12405-3:2014, 3.4, modified — The former cross-reference to “A.3.1 and A.3.2” has been updated as “Annex AA” here.]

3.5
battery management system
BMS
local energy management system (EMS Unit) for the battery system, protecting the battery system from damage, monitoring and increasing the lifetime, and maintaining the functional state

Note 1 to entry: BMS and BCU according to the ISO 12405- series do not have the same functions.

[SOURCE: IEC/TS 61851-3-4]

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

[SOURCE: ISO 12405-3:2014, 3.6, modified — “And/or watt-hours” has been added in the present definition.]

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 may include a cell controller. The functionality of cell balancing may be controlled by the cell electronics or it may be controlled by the BCU.

[SOURCE: ISO 12405-3:2014, 3.7, modified — The verb “may” is used three times in the present definition instead of “can” in the original one.]

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.

[SOURCE: ISO 12405-3:2014, 3.8]

3.9
device under test
DUT
battery pack or battery system, within EN 50604-1

[SOURCE: ISO 12405-3:2014, 3.9, modified — The definition was updated so as to mention “within EN 50604-1” instead of “in this part of ISO 12405” in the original one.]

3.10
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 pack or system may be sufficient to cause damage to the surrounding of the DUT as well.

[SOURCE: ISO 12405-3:2014, 3.10, modified — The verb “may” is used in the Note 1 to entry instead of “can” in the NOTE in the original definition.]

3.11
fire
continuous emission of flames from a DUT (approximately more than one second)

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

Note 2 to entry: Smoke is not considered as fire.

[SOURCE: ISO 12405-3:2014, 3.11, modified — Note 2 to entry was added.]

3.12
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 less than 10 C

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

[SOURCE: ISO 12405-3:2014, 3.13, modified — “Typically lower than 10” was replaced with “typically less than 10 C” in the present definition.]

3.13
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 or greater than 10 C

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

[SOURCE: ISO 12405-3:2014, 3.14, modified — “Or higher than 10” was replaced with “or greater than 10 C” in the present definition.]

3.14
isolation resistance
resistance between live parts of voltage class B electric circuit and the electric chassis as well as the voltage class A system

[SOURCE: ISO 12405-3:2014, 3.15]

3.15
leakage
escape of liquid or gas from a DUT except for venting

[SOURCE: ISO 12405-3:2014, 3.16]

3.16
maximum working voltage
highest value of a.c. voltage (rms) or of d.c. voltage which may occur in an electrical system under any normal operating conditions according to the supplier's specifications, disregarding transients

[SOURCE: ISO 12405-3:2014, 3.17, modified — "According to the battery manufacturer's specifications" was replaced with "according to the supplier's specifications" in the present definition.]

3.17
rated capacity
supplier's specification of the total number of ampere-hours and/or watt-hour 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

[SOURCE: ISO 12405-3:2014, 3.20, modified — "And/or watt-hour" was added into the present definition.]

3.18
removable RESS (battery system/pack)
RESS that can be moved /removed from an EV by hand (portable RESS) or with the assistance of an installation/device (mobile RESS)

[SOURCE: IEC/TS 61851-3-4]

3.19
portable RESS (battery system/pack)
RESS that may be moved /removed from an EV while in operation, having a mass less than 12 kg

[SOURCE: IEC/TS 61851-3 series, modified — "Equipment" was replaced with "RESS".]

3.20
mobile RESS
RESS that may be moved while not in operation, having a mass greater than 12 kg and equipped with wheels for moving or by using an assistance equipment or inside of a battery swap system

[SOURCE: IEC/TS 61851-3 series, modified — "Equipment" was replaced with "RESS".]

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

[SOURCE: ISO 12405-3:2014, 3.21]

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.

[SOURCE: ISO 12405-3:2014, 3.22]

3.23
sign of battery current
discharge current is specified as positive and the charge current as negative

3.24
specific energy
amount of stored energy related to the battery pack or system mass and expressed in Wh/kg

Note 1 to entry: The battery pack or system needs to include the cooling system, if any, to the point of a reversible attachment of the coolant lines or air ducts, respectively. For liquid cooled systems the coolant mass inside the battery pack or system needs to be included.

3.25
state of charge
SOC
available capacity in a battery pack or system expressed as a percentage of rated capacity

[SOURCE: ISO 12405-3:2014, 3.23]

3.26
supplier
party that provides battery systems and packs

EXAMPLE A battery manufacturer.

[SOURCE: ISO 12405-3:2014, 3.24]

3.27
venting
release of excessive pressure from a DUT intended by design to preclude rupture or disassembly

[SOURCE: ISO 12405-3:2014, 3.25, modified — “Explosion” was replaced with “disassembly” into the present definition.]

3.28
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: For more details, see ISO 6469-3.

[SOURCE: ISO 12405-3:2014, 3.26, modified — “For more details” was added into the present Note 1 to entry.]

3.29
voltage class B
classification of an electric component or circuit with a maximum voltage of (> 30 and ≤ 1000) V a.c. (rms) or (> 60 and ≤ 1 500) V d.c., respectively

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

[SOURCE: ISO 12405-3:2014, 3.27, modified — "For more details" was added into the present Note 1 to entry.]

3.30
voltage converter unit
VCU
voltage converter, local EMS and communication interface

[SOURCE: IEC/TS 61851-3-4]

3.31
active protective device
devices integral to the battery pack or the VCU requiring active external controls, that are intended for protection from or mitigation of abusive, out of range conditions experienced by the cell or battery

Note 1 to entry: The active device cuts the connection to the VCU or to a consumer (e.g. a motor) if the controls detect a situation under which the battery pack/system could be damaged or become dangerous.

EXAMPLE: MOSFET, integrated circuits.

3.32
passive protective device
devices that do not require active external control for operation and which are either integral or external to the cell

EXAMPLE: Over-current fuse links, circuit breaker, thermal releases.

Note 1 to entry: Protective devices, which were not tested according to the relevant component standard, are not considered as protective devices.

Note 2 to entry: Semiconductor devices with no interface for external control can be permitted if they are subject to testing according to the relevant component standard, e.g. IEC 61643–321 for avalanche breakdown.

4 Symbols and abbreviated terms

For the purposes of this document, the following symbols and abbreviated terms and the symbols and abbreviated terms given in the ISO 12405- series and ISO/TR 8713 apply.

Abbreviation	Explanation
a.c.	alternating current
BCU	battery control unit
BMS	battery management system
BEV	battery electric vehicle
BOL	beginning of life
C	capacity, expressed in ampere hours (Ah)
nC	Current rate equal to n times the one hour discharge capacity expressed in ampere (e.g. 5C is equal five times the 1h current discharge rate, expressed in A)
d.c.	direct current
DUT	device under test

EODV	end of discharge voltage
EV	electric vehicle
FCV	fuel cell vehicle
HEV	hybrid electric vehicle
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
PSD	Power Spectral Density
RESS	rechargeable energy storage system
RMS	root mean square
RT	room temperature (25 ± 2) °C
SC	Standard cycle
SCH	Standard charge
SDCH	Standard discharge
SOC	state of charge
UNECE	United Nations Economic Commission for Europe
VCU	voltage converter unit
η	efficiency

5 General requirements

This clause of ISO 12405-3:2014 is applicable except as follows:

5.1 General

Replacement:

5.1.101 General conditions

A battery pack/system to be tested according to this standard shall fulfil the following requirements:

– Electrical safety design shall be approved according 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/BMS, and shall be able to communicate with the test bench via e.g. common communication buses;

– The DUT may also be equipped with additional sensors, wires, support which are necessary to conduct the specific test or to obtain the required data for such 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/ 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.

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;

– 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 customer and 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 standard is performed on vehicle, the same test on battery pack or system level is not necessary.

5.2 Test sequence plan

This subclause of ISO 12405-3:2014 is applicable.

Addition:

If the battery system can only be provided with energy according to the IEC/TS 61851-3 series the following test shall not be performed:

– Overcharge test

5.3 Preparation of the DUT for testing

This subclause of ISO 12405-3:2014 is applicable.

5.4 Pre-conditioning cycles

This subclause of ISO 12405-3:2014 is applicable.

5.5 General safety requirements

This subclause of ISO 12405-3:2014 is applicable.

Addition:

5.101 Battery pack/system requirements

General requirements for battery packs/systems for light EVs are shown in Table 1.

Table 1 — Battery system requirements

Subsystem	Requirement
cell	Compliance with UN Recommendations on the Transport of Dangerous Goods - Manual of Tests and Criteria: Section 38.3 [b], and one of the following: – relevant international battery cell standard IEC 62660 (all parts) [a]; – other battery cell standards ensuring corresponding safety levels [a].
protective devices	Corresponding ISO/IEC component standards [a]; – other component standards ensuring corresponding safety levels [a]; – controlling of charging/discharging process avoiding overcharge/overdischarge, detection of internal short-circuits, respecting temperature limits; – the device may be integrated in VCU or battery pack/system.
Enclosure of mobile and portable battery packs/systems	– mechanical strength to withstand stress caused by normal use and rough handling; – sufficiently resistant to degradation caused by sunlight radiation; – reducing the possibility of ignition and spread of flame; – providing suitable insulation characteristics; – protection against ingress of foreign objects and water: IP54 – the battery pack/system housing constructed in a way that it cannot be opened without the use of tools and any opening should be easily detectible by a broken seal; – at least one temperature sensor which measures the temperature of the interior of the battery pack/system at the most critical spot.
VCU	For charging/discharging of the battery pack/system a VCU shall be used according to: – the IEC/TS 61851–3 series; – IEC 60335–1 and EN 60335–2-29 fulfilling the additional requirements of the IEC/TS 61851–3 series; – protection against ingress of foreign objects and water: see IEC/TS 61851–3–2 – VCU and battery pack/system are constructed in a way that they can undoubtedly identify each other. The identification can be realized by mechanical, electrical or electronically means.
Battery pack/system	– the terminals of the battery pack/system shall be protected against accidental short circuit; – battery coupler shall be in accordance with the Draft IEC 62196–4 and the IEC/TS 61851–3 series.
a Valid component certificate shall be available. b Test reports issued by an ILAC, APLAC or equivalent accredited party are acceptable.	

5.102 Thermoplastic materials exposed to sunlight

All non-metallic materials exposed to UV radiation (sunlight) shall be tested according to EN ISO 4892-2, condition A. The test has to be performed without cells in the housing, but the temperature inside the housing shall be recorded. See also clause 6.104.

NOTE Examples of materials that could be affected: thermoplastic enclosure materials, wire and cable insulation, thermoplastic parts of connectors.

5.103 Safety considerations

5.103.1 Special considerations

All tests, which could be influenced by integration of the battery pack/system into the vehicle (e.g. installation into the frame), shall carried out with the battery pack / system integrated into the vehicle. Such tests can be conducted on specially prepared samples (e.g. parts of frames of vehicle) provided that the results are representative for the results of testing the assembled product (battery pack/system installed).

Battery packs/ system which can be easily separated from the vehicle (e.g. portable/ mobile RESS) shall be tested without the vehicle or parts of it:

– Removable RESS:

In a battery system with two or more packs, it is necessary to protect the elements by thermally isolating material or a stable gap.

The elements inside the housing shall not have direct contact to the housing. This can be realized by thermally isolating material or a stable air gap.

The enclosure of a removable battery pack/system shall provide at least IP54.

Crush test according to 8.101 is used for vehicles with a maximum speed equal or less than 45 km/h. For vehicles with maximum speed more than 45 km/h this test will be substituted by a vehicle crash-test with battery in place.

– Built in RESS:

Crush test according to 8.101 if used for vehicles with a maximum speed equal or less than 45 km/h

The DUT is the part of the vehicle where the batteries are included. For vehicles with maximum speed more than 45 km/h this test will be substituted by a vehicle crash-test with battery in place.

Crash tests for vehicles with maximum speed more than 45 km/h are defined by the countries where the vehicles are released.

5.103.2 Precautions when conducting tests

Some of the tests specified can be hazardous to the persons carrying them out; all appropriate measures to protect personnel and affected environment from possible chemical, burn or explosion hazards should be taken.

NOTE More details are provided in BB.2.

5.104 Evaluation of protective devices and electronic circuits

5.104.1 Evaluation option 1:

Active protective devices bypassed.

Protective devices which have not been tested according to or do not comply with the functional safety standard series IEC 61508 or EN ISO 13849 (all parts) (Performance Level C).

On request of the applicant also passive protective devices which comply with the functional safety standard can be bypassed in addition. This condition shall be stated in the corresponding test report.

NOTE For affected test items refer to Subclauses 10.1 and 9.1.

5.104.2 Evaluation option 2:

All protective circuits operating.

Protective devices which are considered to be reliable according to the functional safety standard of the IEC 61508 series or EN ISO 13849 (all parts) (Performance Level C).

NOTE Single fault tests are conducted for components and assembly.

5.105 Voltage classes

Battery packs/systems according to EN 50604 can be rated for voltage class A or voltage class B up to a maximum voltage of 200 V DC. Battery packs/systems intended to be used in conjunction with products or systems described in the IEC/TS 61851-3 series shall fulfil the requirements according to the Draft IEC/TS 61851-3-1:2016 (under consideration), 6.3.

5.106 Battery management system

Battery systems intended to be used in conjunction with products or systems described in the IEC/TS 61851-3 series shall provide a BMS according to the Draft IEC/TS 61851-3-4. A BMS represents the local EMS according to the Draft IEC/TS 61851-3-4 that protects the battery system, source or sink from damage, monitoring and increasing the lifetime of the battery system, source or sink, maintaining the battery system, and source or sink in a functional state.

5.107 Charging/discharging

The terms charging or discharging are used according to the IEC/TS 61851-3 series very carefully, only if the situation is absolutely related to this issue the terms are used, In a more general way only the term power transfer is used because the direction and purpose of the power transfer is not known and not relevant for the requirement or considerations.

5.108 Test result explosion

Rupturing occurred where solid parts of the DUT have penetrated a wire mesh screen (annealed aluminium wire with a diameter of 0,25 mm and a grid density of 6 to 7 wires per cm) placed 25 cm away from the DUT.

NOTE In other publications the term explosion is used in the same meaning.

[SOURCE: Batso 1]

5.109 Test result fire

Cheesecloth shall be placed in 100 mm distance above the DUT. After the test, this cheesecloth shall remain intact.

NOTE Cheesecloth: bleached cotton cloth of approximately 40 g/m^2 (derived from IEC 62368–1:2010).

5.110 Test result leakage

No visible escape of electrolyte or other material, or the loss of material (except battery casing, handling devices or labels) such that the mass loss of the DUT exceeds 0,1 % calculated as following:

$$\Delta m = \frac{m_1 - m_2}{m_1} x\, 100\%$$

where

m_1 is the mass before the test

m_2 is the mass after the test

NOTE 1 DUT tested in orientation(s) as described by the supplier.

NOTE 2 Leakage is evidenced by liquid or condensed electrolyte composition external to the DUT.

[SOURCE: Batso 1]

6 Mechanical tests

Replacement:

6.101 Vibration

6.101.1 Purpose

The purpose of this test is to verify the safety performance of the DUTs under a mechanical load due to vibration which the DUT will likely experience during the normal operation of the vehicle.

6.101.2 Test procedure

Adjust the SOC to 100 % before starting the vibration test.

While vibrated, each fully charged DUT shall be discharged according to the supplier's recommended minimum discharge voltage at the supplier's recommended maximum continuous discharge current.

The given test parameters are valid for DUT designed for mounting on sprung masses of a vehicle. The DUT shall be mounted on a shaker test bench according to the designed vehicle mounting position and according to the requirements given in EN 60068-2-47.

The vibration test shall be a sinusoidal waveform with a logarithmic sweep between 7Hz and 200 Hz and back to 7 Hz traversed in 15 min. This cycle shall be repeated 12 times for a total of 3 h for each of three mutually perpendicular mounting positions of the DUT. One of the directions of vibration shall be perpendicular to the terminal face.

The logarithmic frequency sweep for DUT with a gross mass of not more than 12 kg is as follows from 7Hz a peak acceleration of 1 gn is maintained until 18Hz is reached. The amplitude is then maintained at 0,8 mm (1,6 mm total excursion) and the frequency increased until a peak acceleration of 8gn occurs (approximately 50 Hz). A peak acceleration of 8 gn is then maintained until the frequency is increased to 200 Hz.

The logarithmic frequency sweep for DUT with a gross mass of more than 12 kg, is as follows: from 7 Hz to a peak acceleration of 1 gn is maintained until 18 Hz is reached. The amplitude is then maintained at 0,8 mm (1,6 mm total excursion) and the frequency increased until a peak acceleration of 2 gn occurs (approximately 25 Hz). A peak acceleration of 2 gn is then maintained until the frequency is increased to 200 Hz.

After vibration testing, the DUT capacity shall be evaluated by performing two standard cycles according to ISO 12405-1:2011, 6.2, or ISO 12405-2.

6.101.3 Requirements

During the test and for a 1 h post-test observation period, the DUT shall exhibit no evidence of leakage or battery enclosure rupture, fire, or explosion, and voltage class B DUT shall maintain an isolation resistance of at least 100 Ω/V.

6.102 Mechanical shock

This subclause of ISO 12405-3:2014 is applicable.

6.102.1 Purpose

The purpose of this test is to verify the safety performance of DUT under a mechanical load due to mechanical shock which the DUT will likely experience during the normal operation of the vehicle.

NOTE Mechanical shock considers driving operations such as deceleration in sudden braking situations, driving over road bumps or pot holes. It does not include a vehicle crash scenario.

6.102.2 Test procedure

Adjust the SOC to 100 % before starting the vibration test.

DUT with a gross mass of not more than 12 kg, shall be secured to the testing machine by means of a rigid mount which will support all mounting surfaces of each test battery. DUT shall be subjected to a half-sine shock of peak acceleration of 150 gn and pulse duration of 6 ms. DUT shall be subjected to three shocks in the positive direction followed by three shocks in the negative direction of three mutually perpendicular mounting positions of the battery for a total of 18 shocks.

DUT with a gross mass of more than 12 kg, shall be subjected to a half-sine shock of peak acceleration of 50 gn and pulse duration of 11 ms. Each cell or battery is subjected to three shocks in the positive direction followed by three shocks in the negative direction of each of three mutually perpendicular mounting positions of the cell for a total of 18 shocks.

6.102.3 Requirements

Replacement:

During the test and for a 1 h post-test observation period, the DUT shall exhibit no evidence of leakage or DUT enclosure rupture, fire, or explosion, and voltage class B DUT shall maintain an isolation resistance of at least 100 Ω/V.

Addition:

6.103 Drop Test

6.103.1 Purpose

Test simulates a mechanical impact load, which may occur at an unintended drop during exchange or repair of a battery pack/system.

This test is only for removable battery pack/systems.

6.103.2 Test procedure

DUT shall be placed in a climate chamber at the lowest operation temperature specified by the supplier for minimum 2h until thermal equilibrium. Adjust the SOC to 100 % before starting the Drop test.

– Fall down DUT freely from height 1m to the concrete floor, one time for each side;

or

– Each DUT shall be freely dropped from a height of 1 m on a flat surface made of concrete in the position that is most likely to produce the most severe result. Each DUT shall be dropped three times.

6.103.3 Requirements

During the test and for 6 h post-test observation period, the DUT shall exhibit no evidence of leakage, rupture, fire or explosion.

6.104 Thermoplastic materials exposed to sunlight

6.104.1 Purpose

See also 5.102.

The purpose of this test is to verify the mechanical stability of thermoplastic housings when exposed to sun light.

6.104.2 Test procedure

The test has to be performed without cells in the housing, but the temperature inside the housing shall be recorded.

NOTE Examples of materials that could be affected: thermoplastic enclosure materials wire and cable insulation, thermoplastic parts of connectors.

6.104.3 Requirements

All non-metallic materials exposed to UV radiation (sunlight) shall be tested according to EN ISO 4892-2, condition A.

7 Climatic tests

7.1 Dewing (temperature change)

This subclause of ISO 12405-3:2014 is applicable.

7.2 Thermal shock cycling

This subclause of ISO 12405-3:2014 is applicable.

7.2.101 Requirements

Replacement:

During the test and for a 1 h post-test observation period, the battery system shall exhibit no evidence of leakage or battery enclosure rupture, fire, or explosion, and voltage class B DUT shall maintain an isolation resistance of at least 100 Ω/V.

8 Simulated vehicle accidents

8.1 Inertial load at vehicle crash

This subclause of ISO 12405-3:2014 is NOT applicable.

8.2 Contact force at vehicle crash

This subclause of ISO 12405-3:2014 is NOT applicable.

Replacement:

8.101 Crush test

8.101.1 Purpose

This test evaluates the ability of a removable DUT to withstand a mechanical damage caused e.g. by a traffic accident, or being dropped during transport between the vehicle and the charge location, or the battery pack/system exposed to external forces like in a trash compactor.

8.101.2 Test

This test shall be conducted with two DUT orientations. Fully charged DUTs shall be used. A test stamp (Figure CC.3) is used to crush the DUT. The width of the test stamp shall be at least 10 % larger than the width W (see Figure CC.4) of the tested DUT. In the first orientation the DUTs (one fresh DUT, and

one DUT after 50 cycles, see Table GG.1) will be placed with the longest side flat on the test stand (as pictured in Figure CC.4) and crushed with the test stamp in the centre with a speed of 15 mm/s ± 5 mm/s not exceeding a peak force on the test stamp of 1000 times weight-force or 50 % deformation whatever comes first. In the second orientation the test will be repeated with the DUT (one fresh DUT, and one DUT after 50 cycles, see Table GG.1) „standing“ on the narrower side as shown in Figure CC.1 up to Figure CC.3.

The voltage of DUTs and the crush force shall be recorded. The temperature shall be measured on the DUT enclosure. The test shall be continued until:

– the test stamp has compressed the enclosure by max. 50 % depth, the temperature of the outer enclosure reaches steady-state conditions or returns to ambient temperature; or

– the DUT explodes or vents;

– observation time 6 h.

8.101.3 Requirements

The DUT shall not exhibit any evidence of rupture, fire or disassembly.

8.3 Water immersion

This subclause of ISO 12405-3:2014 is not applicable.

Replacement:

8.3.101 Purpose

Simulates a water immersion which may occur when a vehicle is flooded.

8.3.102 Test procedure

With the DUT in its normal operating orientation and at full state of charge, immerse the DUT in ambient temperature salt water (5 % by weight NaCl in H_2O) for a minimum of 2 h or until any visible reactions have stopped. The water depth shall be enough to completely submerge the DUT. The DUT may be placed into a tank filled with water or may be placed in an empty tank and water pumped into the tank to fully submerge the DUT.

DUT can be tested by vehicle emulated condition (e.g. battery pack/system with actual part of vehicle).

– water temperature: 20 °C ± 5 °C;

– ambient temperature: RT.

8.3.103 Requirements

During the test and for a 1 h post-test observation period, the DUT shall exhibit no evidence of fire or explosion.

NOTE If a battery pack/system is immersed in conductive water, flammable or toxic gases can be produced.

8.4 Exposure to fire

Addition:

This subclause of ISO 12405-3:2014 is only applicable for battery systems to be used in vehicles with passenger compartments which can be closed or locked or in vehicles where the use of safety belts is compulsory.

NOTE The fire exposure test makes sense in a hybrid automotive battery system usage scenario where the passengers are inside the vehicle and may not be able to escape during an accident quickly. It is not considered as applicable for pedelecs as well for electric scooters an motor cycles since they are not enclosed and the passengers are not fixed inside a vehicle and usually separate immediately form the vehicle in an accident.

Addition:

8.102 Over-temperature condition test

8.102.1 Purpose

Tests the safe behaviour of the battery system in a condition of over temperature. Validates function of the protection measures against internal overheating, if applicable.

8.102.2 Test procedure

The DUT shall be placed in a convective oven or climatic chamber. The temperature of the DUT shall be set to 50°C, that is 10°K above the maximum temperature for performance testing (40°C). A rest period of 2 h or until thermal equilibration has been reached shall be performed.

Perform a discharge and then a charge at the maximum current rate according to the specifications of the supplier.

Repeat the discharge and charge cycle until the intervention of the over-temperature protection measure or at the thermal stabilization of the DUT. The DUT‟s temperature shall be monitored by the measurement devices which are integrated in the DUT by the supplier.

NOTE Disconnection of the electrical load is considered an effective protection measure.

8.102.3 Requirements

The DUT shall not exhibit any evidence of leakage, rupture, fire, or explosion.

8.103 Under-temperature condition test

8.103.1 Purpose

Tests the safe behaviour of the battery system in a condition of under temperature. Validates function of the protection measures against charging at temperatures below limit according to the specifications of the supplier.

8.103.2 Test procedure

Perform a discharge according to the specification of the supplier to 80 ± 10 % SOC

The DUT shall then be placed in a climate chamber. The temperature shall be set 10 K under the low temperature limit set by the supplier. Rest period in the chamber to reach thermal equilibrium 2 h.

Perform a charge at the maximum current rate according to the specification of the supplier.

This test shall be performed for option 1 and 2.

8.103.3 Requirements

The DUT shall not accept any charge under these conditions. If a charging current can be detected, the DUT has failed.

The DUT shall not exhibit any evidence of disassembly, venting or fire.

9 Electrical tests

This clause of ISO 12405-3:2014 is applicable except as follows:

9.1 Short circuit

9.1.1 Purpose

The purpose of the short circuit test is to check the functionality of the overcurrent protection device. This device shall interrupt the short circuit current in order to prevent the DUT from further related severe events caused by an external short circuit.

Replacement:

9.1.101 Test procedure

9.1.101.1 Option 1

The DUT shall be at RT, fully charged and under normal operating conditions. An appropriately sized conductor directly contacted to the battery cells of (20 +0/-10) mΩ shall be used to apply a “hard short” in less than one second for 10 min, or until another condition occurs that prevents completion of the test (e.g. component melting). The test shall be performed without integrated, passive and active protective devices for short circuit protection operational.

9.1.101.2 Option 2

The DUT shall be at RT, fully charged and under normal operating conditions (main contactors are closed, battery systems are controlled by the BCU/BMS). An appropriately sized conductor of (20 +0/-10) mΩ shall be used to apply a “hard short” in less than one second for 10 min, or until another condition occurs that prevents completion of the test (e.g. component melting). The test shall be performed with integrated, passive and active protective passive short circuit protection devices operational

The test shall be performed under test option 1 and 2 as described in 5.104.1 and 5.104.2 respectively.

9.1.102 Requirements

The overcurrent protection function for option 2, if any, shall disconnect the short circuit current.

The DUT shall not exhibit any evidence of: disassembly or fire. The temperature of the battery casing shall not exceed 150 °C within 6 h.

Addition:

9.101 Touch current

9.101.1 Purpose

The purpose of the touch current test is to check the functionality of the switch off device, if there are accessible conductive parts or contacts.

9.101.2 Test procedure

This test applies to battery packs and systems.

The DUT shall be at RT, fully charged and under normal operating conditions (main contactors are closed, battery systems are controlled by the BCU/BMS).

The test shall be performed with integrated, passive and active protective devices for short circuit protection operational.

9.101.3 Requirements

The touch current for stored energy in removable RESS available between simultaneously accessible conductive parts or contacts of the RESS coupler or the A-B coupler, the following values are proposed according to IEC 61140 and to IEC/TS 60479-2:2007, Figure 19:

a) a steady-state current flowing between simultaneously accessible conductive parts not exceeding the threshold of perception, 0,5 mA a.c. or 2 mA d.c. under normal operating conditions; values not exceeding the threshold of pain 3,5 mA a.c. or 10 mA d.c. may be specified under abnormal or fault conditions;

b) for stored energy available between simultaneously accessible conductive parts the following values are proposed according to IEC/TS 60479-2:2007, Figure 19:

    1) + 0,5 mJ corresponding to the threshold of pain and

2) +,5 uJ corresponding to the threshold of perception.

10 System functionality tests

This clause of ISO 12405-3:2014 is applicable except as follows:

10.1 Overcharge protection

Replacement:

10.1.101 Purpose

The purpose of the overcharge test is to check the functionality of the overcharge protection function.

Option 1:

– The VCU is directly connected to the cell assembly.

Option 2:

– This function shall interrupt the overcharge current in order to protect the DUT from any further related severe events caused by exceeding the upper SOC limit.

10.1.102 Test procedure

According to ISO 12405-1:2011, 9.3.2, or ISO 12405-2:2012, 9.3.2, as appropriate for the DUT.

This test applies to battery packs and systems. In all cases the relevant overcharge protection device as intended by the battery supplier shall be included in the DUT.

The test may be conducted at a higher temperature than specified in ISO 12405-1:2011, 9.3.2, or ISO 12405-2:2012, 9.3.2, as appropriate for the DUT, according to agreement between customer and supplier.

A standard cycle according to ISO 12405-1:2011, 6.2 or ISO 12405-2:2012, 6.2, as appropriate for the DUT, shall be performed if not inhibited by the DUT after the overcharge.

Each fully charged battery shall be subjected to a constant charging current at a maximum possible (max. of VCU output in single failure), but not exceeding, 1 C rate, using a supply voltage sufficient to maintain the before described current throughout the duration of the test. The voltage shall not exceed 6 V per cell connected in series inside the battery.

This test shall be performed for option 1 and option 2.

Overcharge until the DUT explodes, vents or the temperature of the outside of the enclosure reaches the steady-state conditions or returns to the ambient temperature.

10.1.103 Requirements

The DUT shall not exhibit any evidence of disassembly or fire.

10.2 Over-discharge protection

This clause of ISO 12405-3:2014 is not applicable.

Test is covered by short circuit test.

10.3 Loss of thermal control/cooling

This clause of ISO 12405-3:2014 is applicable.

Annex AA
(informative)

Battery Systems and related parts

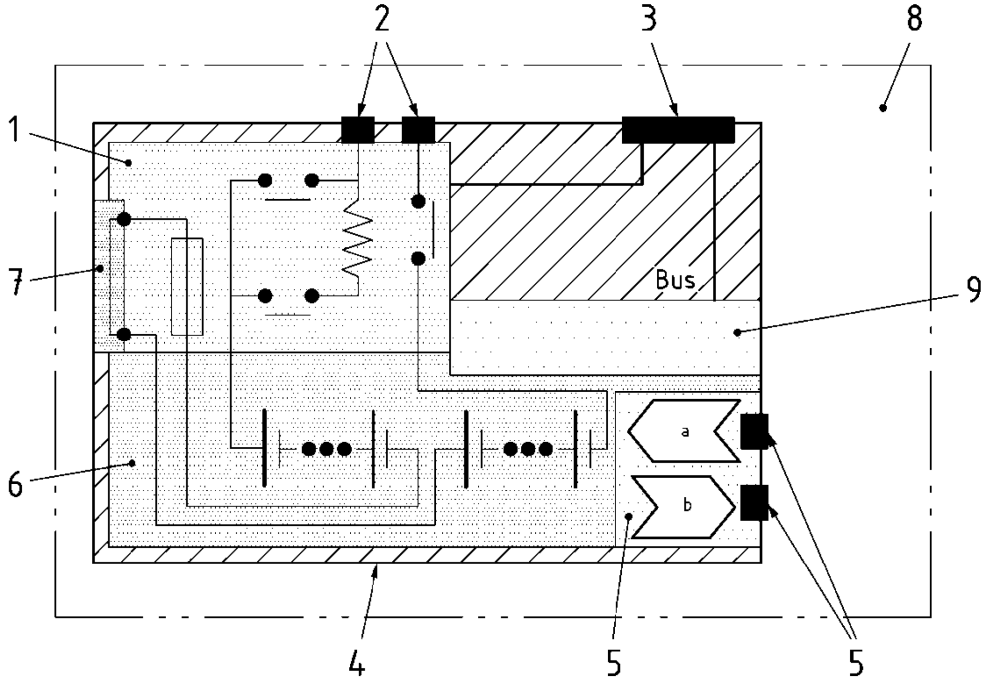
AA.1 General

This annex provides information how to distinguish between battery pack and battery system.

AA.2 Battery pack

This clause is not applicable for removable battery systems.

Figure AA.1 shows a typical configuration of a battery pack.



Key

1 voltage class A or B electric circuit (connectors, fuses, wiring)
2 voltage class A or B connections
3 voltage class A connections (only for class B battery systems)
4 casing
5 cooling device and connections (optional)
6 cell assembly (cells, sensors, cooling equipment)
7 service disconnect (only for class B battery systems)
8 battery pack
9 cell electronics (temperature sensors (optional))
a in
b out

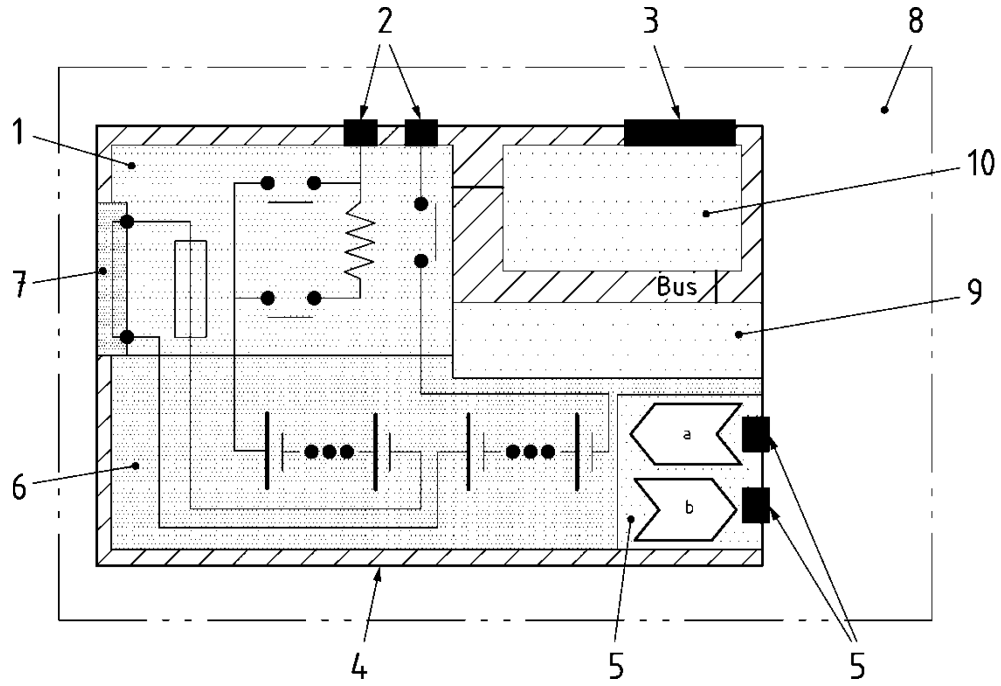
Figure AA.1 — Typical configuration of a battery pack

A battery pack represents an energy storage device that includes cells or cell assemblies, cell electronics, voltage class A or B circuit and overcurrent shut-off device including electrical interconnections, interfaces for cooling, voltage class A or B, auxiliary voltage class A and communication. The voltage class A or B circuit of the battery pack may include contactors. For a battery pack of 60 V d.c. or higher, a manual shut-off function (service disconnect) may be included. All components are typically placed in a normal use impact resistance case.

AA.3 Battery system

AA.3.1 Battery system with integrated BCU/BMS

Figure AA.2 shows a typical configuration of a battery system with integrated BCU/BMS.



Key

1 voltage class A or B electric circuit (connectors, fuses, wiring)
2 voltage class A or B connections
3 voltage class A connections
4 casing
5 cooling device and connections (optional)
6 cell assembly (cells, sensors, cooling equipment)
7 service disconnect
8 battery pack
9 cell electronics
10 battery control unit
a in
b out

Figure AA.2 — Typical configuration of a battery system with integrated BCU/BMS

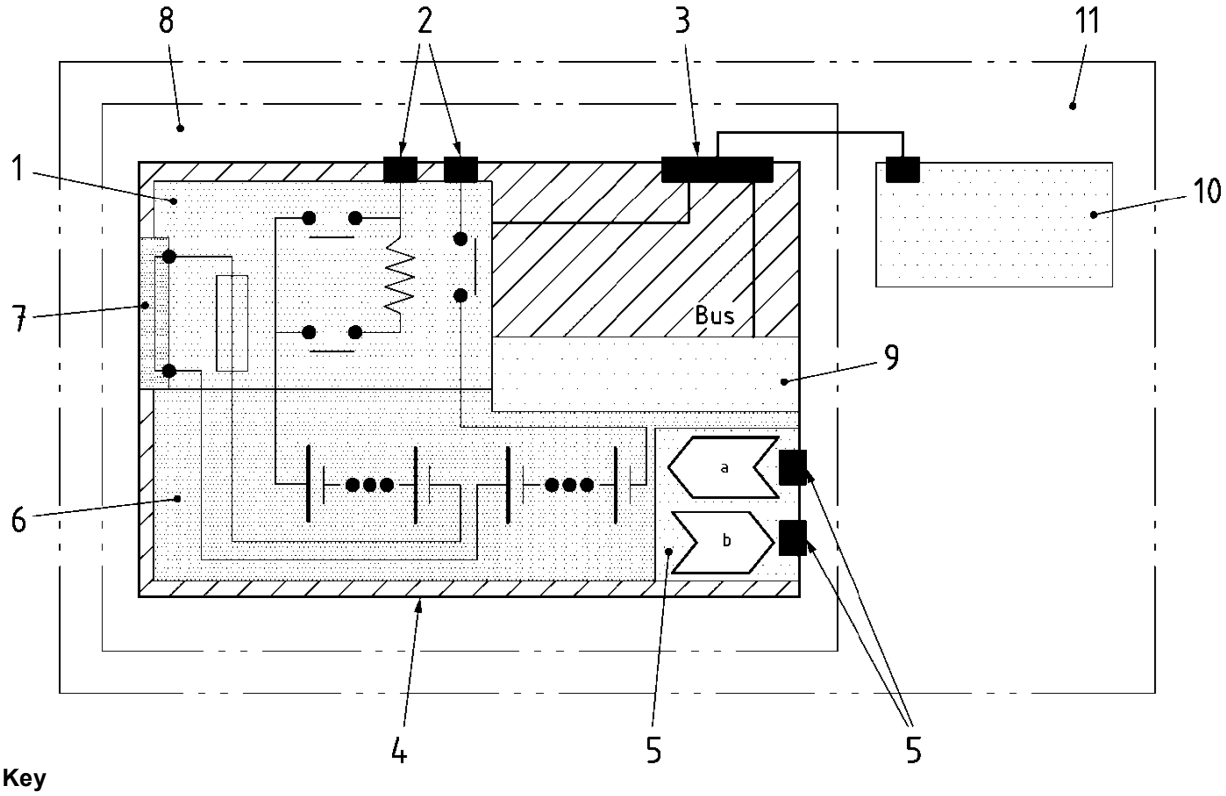
A battery system represents an energy storage device that includes cells or cell assemblies, cell electronics, BCU/BMS, voltage class A or B circuit with contactors and overcurrent shut-off device including electrical interconnections, interfaces for cooling, voltage class A or B, auxiliary voltage class A and communication. For a battery system of 60 V d.c. or higher, a manual shut-off function (service disconnect) may be included. All components are typically placed in a normal use impact resistance

case. In this example, the BCU/BMS is integrated inside the normal use impact resistance case and connected concerning its control functionalities to the battery pack.

AA.3.2 Battery system with external BCU/BMS

This clause is not applicable for removable battery systems.

Figure AA.3 shows the typical configuration of a battery system with external BCU/BMS.



Key

1 voltage class A or B electric circuit (connectors, fuses, wiring)
2 voltage class A or B connections
3 voltage class A connections
4 casing
5 cooling device and connections (optional)
6 cell assembly (cells, sensors, cooling equipment)
7 service disconnect
8 battery pack
9 cell electronics
10 battery control unit
11 battery system
a in
b out

Figure AA.3 — Typical configuration of a battery system with external BCU

NOTE Figure AA.3 is not applicable for removable battery systems.

A battery system represents an energy storage device that includes cells or cell assemblies, cell electronics, BCU/BMS, voltage class A or B circuit with contactors and overcurrent shut-off device including electrical interconnections, interfaces for cooling, voltage class A or B, auxiliary voltage class A and communication. For a battery system of 60 V d.c. or higher, a manual shut-off function (service disconnect) may be included. All components are typically placed in a normal use impact resistance case. In this example, the BCU/BMS is placed outside the normal use impact resistance case and connected concerning its control functionalities to the battery pack.

Annex BB
(normative)

General marking requirements

BB.1 Marking and instructions

BB.1.1 Removable (RESS) battery systems (packs) marking

Each removable (RESS) battery system (pack) shall carry clear and durable marking on the outer enclosure providing all of the following information:

– graphical symbol for rechargeable Li or Li-ion;

– graphical symbol Crossed Wheelie Bin;

– polarity of terminals (unless standardized, polarized connectors are used);

– nominal voltage;

– maximum charge current/voltage and maximum discharge current in A/V;

– nominal capacity in Ah, and nominal energy in Wh;

– name, trade mark or identification mark of the supplier or responsible vendor;

– serial number;

– model or type reference (optional);

– graphical symbol caution;

– graphical symbol read operator's manual;

– graphical symbol dangerous voltage (for voltage class B);

– graphical symbol hot surface (if the temperature exceeds 60 °C);

– graphical symbol keep away from open flame and great heat;

– graphical symbol danger of explosion and fire due to short circuit, overheating or other electrical/ mechanical misuse;

– text transport under UN-T 38-3, graphical symbol BATSO optional;

– text: “Do not open”, “Do not expose to water”, “Damaged batteries are not allowed to transport”(optional).

NOTE 1 Additional marking are allowed provided they do not give rise to misunderstanding.

NOTE 2 Graphical symbol making reference to the accompanying documents for providing there further details, see ISO 7010 (Graphical symbols for use on equipment).

Compliance is checked by inspection.

BB.1.2 Graphical symbols

When graphical symbols are used, they shall be as shown in Table BB.1:

Table BB.1 — Graphical symbols

Graphical symbol	Reference	Description
	ISO 7010-W001	General warning sign
	ISO 7010-M002	Refer to instruction manual/booklet
	ISO 7010-W012	Warning: Electricity
 Li-ion	Graphical symbol ISO 14021	Li or Li-ion battery symbol
	Graphical symbol Waste Electrical and Electronic Equipment Directive.	The Crossed Wheelie Bin Symbol European Community Directive 2012/19/EU on waste electrical and electronic equipment (WEEE)
	ISO 7010-W017	Warning; Hot surface
	ISO 7010-P003	No open flame; Fire, open ignition source and smoking prohibited
	ISO 7010-W002	Warning; Explosive material
BATSO	Other graphical symbols of proven safety optional e.g. BATSO	Test marks signals to buyers, retailers, service personnel that the chosen battery, it's manual for use and/or installation have been tested by an authorized laboratory, and the production (process) has been inspected.

Units of physical quantities and their graphical symbols shall be those of the international standardized system.

NOTE Additional graphical symbols are allowed provided that they do not give rise to misunderstanding.

Graphical symbols specified in IEC 60617 and ISO 7010 may be used.

Compliance is checked by inspection.

BB.2 Instructions

Instructions shall be provided with the battery system so that the battery system can be used safely.

Instructions may be marked on the battery system.

If it is necessary to take precautions during user maintenance, appropriate details shall be given.

The instructions shall state the substance of the following:

a) this battery system is not intended for use by persons (including children) with reduced physical, sensory or mental capabilities, or lack of experience and knowledge, unless they have been given supervision or instruction concerning use of the battery system by a person responsible for their safety;

b) children should be supervised to ensure that they do not play with the battery system;

c) for battery system s intended for use at altitudes exceeding 2 000 m, the maximum altitude of use shall be stated;

d) The instructions for battery system incorporating a functional earth shall state the substance of the following:

e) this battery system incorporates an earth connection for functional purposes only;

f) do not open, chop up or disassemble rechargeable battery systems at any times;

g) do not expose battery systems to great heat or fire;

h) do not short circuit battery system;

i) do not expose battery systems to strong mechanical impacts;

j) do not use a charging device other than the one made for use with your device;

k) keep batteries systems dry and clean;

l) battery systems shall not be in contact with solvent materials (i.e. dilution, alcohol, oil, anti-corrosive) or chemicals that impact surfaces (i.e. detergents);

m) rechargeable Battery systems shall be charged before being used. Only the proper, correct charging device may be used. For charging, please heed the producer’s instructions or the instructions in the manual of the device;

n) after a prolonged storage time, it may be necessary to charge and discharge the battery system multiple times to get back to performance;

o) rechargeable battery systems have the greatest performance when kept and used at normal room temperature (20 °C ± 5 K);

p) keep original printed papers with product information for later consultation;

q) only put battery systems to applications that they were designed for;

r) if possible, remove battery systems from device, if they are not being needed;

s) please heed enclosed special disposal instructions about battery system;

t) for battery systems with more than 100 Wh a safety instruction according to UN-T 3480 is needed. Such battery system shall only be transported by professionals as dangerous goods;

u) recommended storage temperature: −10 °C to below 30 °C (if not otherwise specified by the supplier);

v) store at dry places, away from open flames and food;

w) avoid big temperature changes;

x) do not store close to heating devices, avoid direct sunlight;

y) preferred storage at 50 % of the nominal capacity (if not otherwise specified by the supplier);

z) temperature above 70 °C may result in battery leakage and rupture (if not otherwise specified by the supplier);

aa) medical aid will be required in case of symptoms obviously caused by respiration or swallowing of combustion gases or contact with skin or eyes;

bb) after inhalation: leave area immediately. Fresh air. Seek for medical assistance;

cc) after skin contact: remove solid particles immediately. Flush affected areas with plenty of water (at least for 15 min). Remove contaminated clothes immediately. Seek for medical attention;

dd) after eye contact: flush the eye gently with plenty of water (at least for 15 min). Shield unaffected eye. Seek for medical assistance;

ee) after ingestion: drink plenty of milk or water and induce vomiting. Seek for medical attention;

ff) fire:

1) cautiously remove other batteries if possible;

2) evacuate all persons from immediate area of fire;

3) use plenty of cold water (min. 10 times pack weight).

Compliance is checked by inspection.

BB.3 Instructions for built-in battery system

The instructions for built-in battery system shall include information with regard to the following:

– dimensions of the space to be provided for the battery system;

– dimensions and position of the means for supporting and fixing the battery system within this space;

– minimum distances between the various parts of the battery system and the surrounding structure;

– minimum dimensions of ventilating openings and their correct arrangement;

– connection of the battery system to the supply mains and the interconnection of any separate components.

Compliance is checked by inspection.

BB.4 Language

Instructions and other text required by this standard shall be written in an official language of the country in which the appliance is to be sold.

Compliance is checked by inspection.

BB.5 Label test

The markings required by the standard shall be clearly legible and durable.

Compliance is checked by inspection and by rubbing the marking by hand for 15 s with a piece of cloth soaked with water and again for 15 s with a piece of cloth soaked with petroleum spirit. The petroleum spirit to be used for the test is aliphatic solvent hexane.

After all the tests of this standard, the marking shall be clearly legible. It shall not be easily possible to remove marking plates nor shall they show curling.

NOTE In considering the durability of the marking, the effect of normal use is taken into account. For example, marking by means of paint or enamel, other than vitreous enamel, on containers that are likely to be cleaned frequently, is not considered to be durable.

BB.6 Markings

The markings specified in BB.2 shall be on a main part of the battery system.

Markings on the battery system shall be clearly discernible from the outside of the battery system but if necessary after removal of a cover. For portable battery system, it shall be possible to remove or open this cover without the aid of a tool.

Indications for switches and controls shall be placed on or near these components. They shall not be placed on parts which can be positioned or repositioned in such a way that the marking is misleading.

The graphical symbol IEC 60417-5018:2011 shall be placed next to the graphical symbol IEC 60417-5172:2003 or the graphical symbol IEC 60417-5180:2003 as appropriate.

Compliance is checked by inspection.

Annex CC
(normative)

Test stamp for crush test

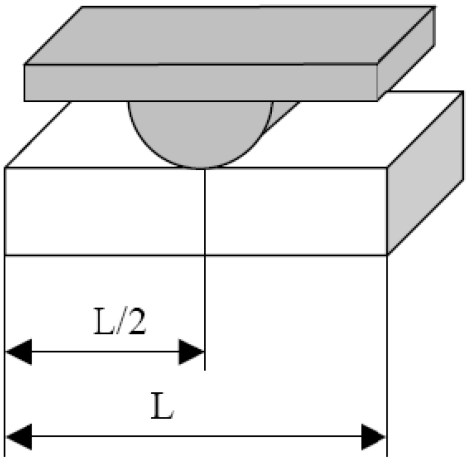


Figure CC.1 — Test stamp

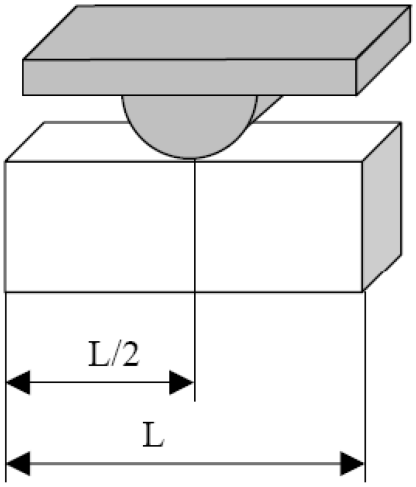
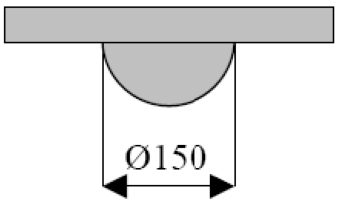


Figure CC.2 — Test stamp

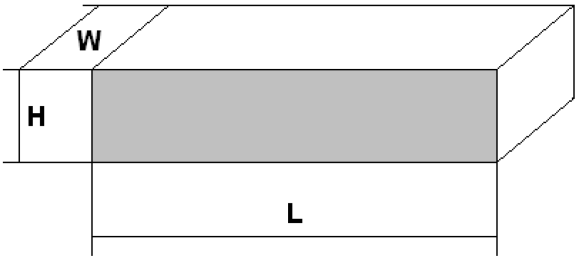
Dimension in millimetres



The surface of the (half-) cylinder shall be made of non-conductive material.

EXAMPLE Glass-fibre epoxy coating on a steel stamp.

Figure CC.3 — Test stamp



Definition of terms applying to the enclosure of a battery pack/ system: Length L, width W and height H are assigned in such way that following applies:

$L \geq W \geq H$

Figure CC.4 — Test stamp

Annex DD
(normative)

Test probe

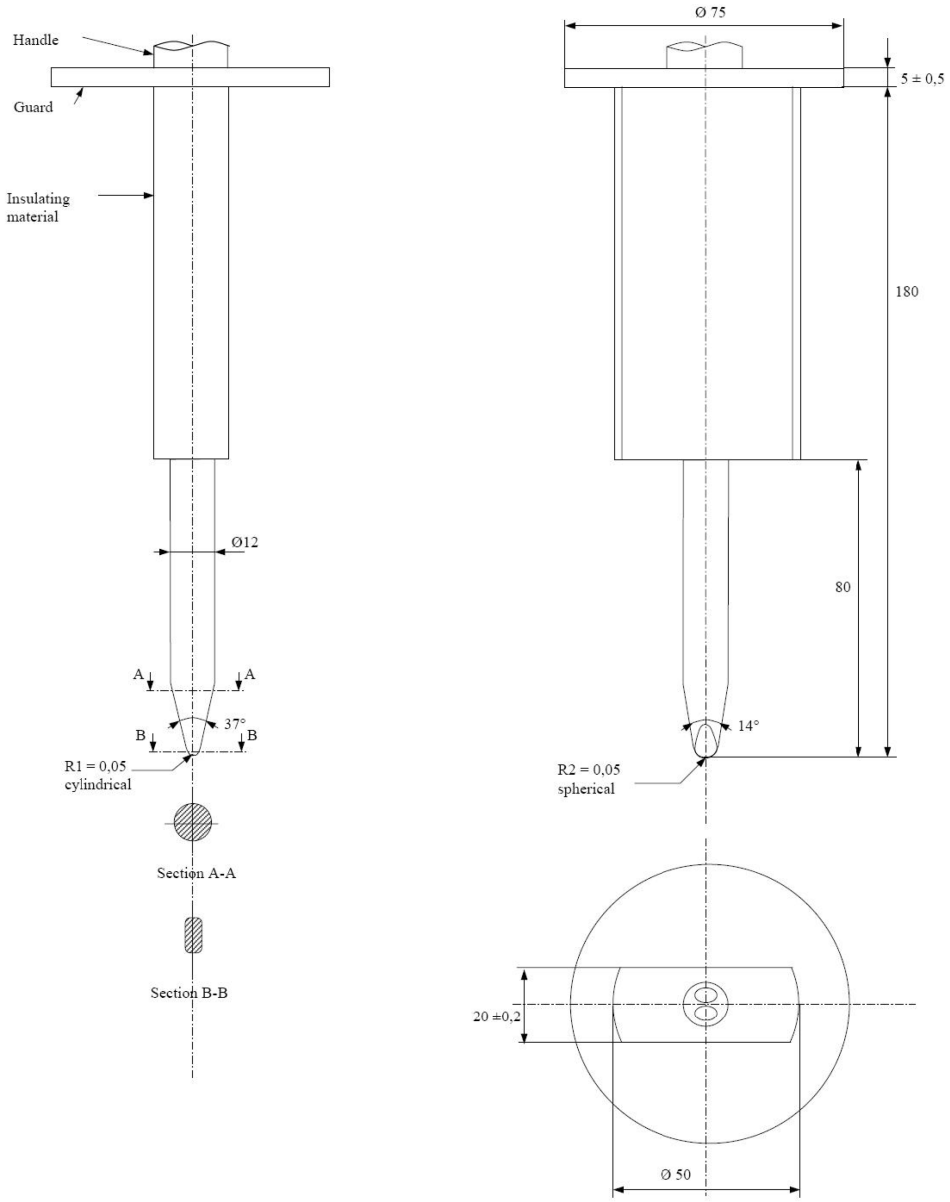


Figure DD.1 — Test probe "test finger"

NOTE 1 The test finger is derived from EN 61032:1998, Figure 2, test probe B. However, no joints are provided.

NOTE 2 Linear dimensions are in millimetres.

NOTE 3 Material of finger: metal, except where otherwise specified.

NOTE 4 Tolerances on dimensions without specified tolerances:

- on angles: +0 / −10°
- on linear dimensions:

≤ 25 mm: +0 mm / −0,05 mm

> 25 mm: ±0,2 mm

Annex EE
(informative)

Packaging and transportation for not tested battery samples

EE.1 Information regarding packaging and transportation

EE.1.1 Sample classification

Battery samples that have not been previously tested for compliance with this manual or the relevant tests of UN Recommendations on the Transport of Dangerous Goods – Manual of Tests and Criteria, shall not be shipped via air.

NOTE More details are provided in Annex A and related UN Special Provisions.

For UN-*t*-tested and compliant battery samples, the samples should be classified and labelled as UN 3480 lithium ion battery.

EE.1.2 Labelling

Follow the regulations of UN 3480.

EE.1.3 Packaging

Follow the regulations of UN 3480.

EE.1.4 Transport or shipper's declaration

Follow the regulations of UN 3480.

EE.1.5 List of content of package

List of package contents, including item names and quantity.

EE.2 Documents

EE.2.1 Form with data regarding the properties of substances of cells

EXAMPLE 1 Material Safety Data Sheets (MSDS), Risk and Safety Statements, UN numbers identifying hazardous substances.

EE.2.2 Handling instructions and guidelines for cells and battery packs

Handling instructions and guidelines for cells and battery packs shall be delivered with the DUT. Such data should be provided in form of datasheets containing following data:

– technical documents (e.g. circuit-drawing, mechanical layout);

– nominal voltage;

– nominal capacity;

– nominal weight;

– minimum discharge voltage and temperature;

– maximum charge voltage and temperature;

– operating and storage temperature range;

– standard charge procedure or pattern;

– discharge cut-off voltage.

EE.2.3 Operation manual of battery packs, chargers (VCUs), PCB or BMS

Operation manuals for all devices needed for charging/discharging of the battery pack/system shall be delivered with the DUT.

EE.2.4 Certificates for components and subsystems

Certificates for components and subsystems shall be delivered with the DUT. See Table 1 for details about required certificates.

EE.2.5 Quality examination report of samples

The samples should have passed the quality control procedure of the supplier. The supplier should provide a quality examination report.

EE.2.6 Overview about provided samples and their respective cycle history

An overview about provided samples with their serial numbers and their respective cycle history shall be delivered with the DUT.

EE.3 Additional information

EE.3.1 Instructions on bypassing protective devices

The supplier should provide following information or deliver prepared samples on request:

– Procedure to open and re-assemble the battery case with highlighting points of special attention;

– Type, location and bypassing method of protective devices.

NOTE Such information can be provided in form of drawings, graphs or photographs.

EE.3.2 Other information

The supplier is suggested to provide following information to help laboratories understand the samples and conduct tests:

– cycling data measured by the supplier;

– intended application(s) or use of the battery;

– additional information needed by test laboratories to understand the battery in order to setup and conduct tests of this manual.

Annex FF
(informative)

Transport regulations

FF.1 Regulatory information

The regulations that govern the transport of lithium ion cells and batteries include the International Civil Aviation Organization (ICAO) Technical Instructions and corresponding International Air Transport Association (IATA) Dangerous Goods Regulations, and the International Maritime Dangerous Goods (IMDG) Code, and amongst others as well the following:

– International: ICAO TI/IATA DGR, IMDG Code;

– Europe: ADR / RID;

– Germany: GGVSE, GGVSea;

– USA: 49 CFR Ch. 1 §173–185.

FF.2 UN-Numbers

– Lithium ion batteries UN 3480;

– lithium ion batteries contained in equipment UN 3481;

– lithium ion batteries packed with equipment UN 3481;

– battery powered vehicle UN 3171;

– hybrid electric vehicle (HEV) UN 3166;

NOTE UN 3171 “Battery-powered vehicle or battery powered equipment“ applies as well to light EVs.

FF.3 Transport information

For the single cell batteries and multi-cell battery packs that are non-restricted to transport, use lithium ion batteries inside label.

For the single cell batteries and multi-cell battery packs that are restricted to transport (assigned to Class 9 Miscellaneous Dangerous Substances), use Class 9 Miscellaneous Dangerous Substances and UN Identification Number labels.

Transportation within the US-DOT, 49 Code of Federal Regulations applies.

In all cases, refer to the product transport certificate issued by the supplier.

UN number:

– UN 3480, for lithium ion batteries transported in bulk;

– UN 3481, for lithium ion batteries contained in equipment

or packed with it.

Shipping name: Lithium ion batteries

UN 3480 Lithium ion batteries class 9 package group II

Packing group: II (ADR/RID Tunnel Cat. E)

NOTE 1 When manufacturing a new battery pack, the supplier will ensure that it is tested in accordance with the UN Model Regulations, Manual of Tests and Criteria of UN Recommendations on the Transport of Dangerous Goods, section 38.3. However, if those batteries are packed with or in equipment, then it is the responsibility of the shipper to ensure that the consignment is packed in compliance to the latest edition of the relevant governing regulations.

EXAMPLE	Ground
Transport Description:	Lithium ion batteries, secondary
UN-N°:	3480
Classification:	9

NOTE 2 Class 9 is one of nine hazardous materials shipping classifications defined by the UN HMR and other transportation regulations. Class 9 defines the specification packaging, markings, labelling, and shipping paper requirements for miscellaneous hazardous materials, which include lithium and lithium ion cells and batteries, among other materials.

Packaging Class:	II
Packaging Order:	P903
Special Provisions:	310, 230, 188, (Chapter 3.3 ADR (for Europe)) 348 (UN Model Regulations, 16th v.)
LQ/EQ:	0/E0

UN 3090 / UN 3091 concern lithium metal batteries (including lithium alloy). The UN number 3481 includes all lithium ion systems defined in UN 3480, e.g. all lithium ion systems that are part of or packed together with equipment.

FF.4 UN Recommendations on the Transport of Dangerous Goods

Tests and conditions as specified in UN Recommendations on the Transport of Dangerous Goods – Manual of Tests and Criteria: Section 38.3 are covered as part of the testing of this Manual when test option 1 (see Table FF.1) is chosen.

As these tests address primarily the behaviour of the battery during transport conditions, additional tests were defined which are either not covered by UN Recommendations on the Transport of Dangerous Goods - Manual of Tests and Criteria: Section 38.3 or which are modified in conditions or compliance criteria.

Table FF.1 provides a quick overview about covered test items. Tests of the UN Recommendations on the Transport of Dangerous Goods – Manual of Tests and Criteria: Section 38.3 are shown in column “UN-T”.

Table FF.1 — Comparison of test items

Test name	EN 50604–1	ISO 12405-3:2014	UN-T
Vibration	6.101	–	Test T.3
Mechanical Shock	6.102	–	Test T.4
Drop test	6.103	–	Test T.4
Thermoplastic materials exposed to sunlight	6.104	–	–
Dewing (temperature change)	7.1	7.1	Test T.2
Thermal-shock cycling	7.2	7.2	Test T.2
Crush	8.101	–	–
Water immersion	8.3	8.3	–
Exposure to fire	8.4	8.4	–
Over-temperature condition	8.102	–	Test T.2
Under-temperature condition	8.103	–	Test T.2
Short circuit	9.1	9.1	Test T.5
Overcharge protection	10.1	10.1	Test T.7
Loss of thermal control	10.3	10.3	–
NOTE Test T.1 (Altitude simulation) of UN Recommendations on the Transport of Dangerous Goods – Manual of Tests and Criteria: Section 38.3 is typical for air transport. T.6, and T.8 UN-T 38.3 apply only to cells and not to a battery pack/system.			

FF.5 UN Recommendations on the Transport of Dangerous Goods – Manual of Test and Criteria

All cells and batteries shall be tested in accordance with the applicable requirements of the UN T – Tests (T1 - T8) specified in Section 38.3 of the UN Recommendations on the Transport of Dangerous Goods – Manual of Test and Criteria.

FF.6 Overview about UN-T Tests T.1 - T.8 lithium, lithium ion and lithium polymer cells and batteries

FF.6.1 Test T.1: Altitude simulation

FF.6.1.1 Purpose

Simulates air transport under low pressure conditions. Store at 11,6 kPa or less for at least 6 h at ambient temperature (20 ± 5 °C).

FF.6.1.2 Requirement

Cells and batteries meet this requirement if there is no mass loss, no leakage, no venting, no disassembly, no rupture and no fire and if the open circuit voltage of each test cell or battery after testing is not less than 90 % of its voltage immediately prior to this procedure. The requirement relating to voltage is not applicable to test cells and batteries at fully discharged states.

FF.6.2 Test T.2: Thermal test

FF.6.2.1 Purpose

Assesses cell and battery seal integrity and internal electrical connections using thermal cycling to simulate rapid and extreme temperature changes. Perform 10 cycles between 75 ± 2 °C and

−40 ± 2 °C, at least 6 h per cycle with no more than 30 min. between cycles, and then observe for 24 h at ambient temperature (20 ± 5 °C).

FF.6.2.2 Requirement

Cells and batteries meet this requirement if there is no mass loss, no leakage, no venting, no disassembly, no rupture and no fire and if the open circuit voltage of each test cell or battery after testing is not less than 90 % of its voltage immediately prior to this procedure. The requirement relating to voltage is not applicable to test cells and batteries at fully discharged states.

FF.6.3Test T.3: Vibration

FF.6.3.1 Purpose

Simulates vibration during transport. Sinusoidal waveform with a logarithmic sweep between 7 Hz and 200 Hz and back to 7 Hz in 15 min. This cycle shall be repeated 12 times for a total of 3 h for each of three mutually perpendicular mounting positions of the cell or battery.

FF.6.3.2 Requirement

Cells and batteries meet this requirement if there is no mass loss, no leakage, no venting, no disassembly, no rupture and no fire and if the open circuit voltage of each test cell or battery after testing is not less than 90 % of its voltage immediately prior to this procedure. The requirement relating to voltage is not applicable to test cells and batteries at fully discharged states.

FF.6.4Test T.4: Shock

FF.6.4.1 Purpose

Simulates possible impacts during transport. Half-sine shock of peak acceleration of 150 gn and pulse duration of 6 ms. Each cell or battery shall be subjected to 3 shocks in the positive direction and 3 shocks in the negative direction of three mutually perpendicular mounting positions for a total of 18 shocks.

FF.6.4.2 Requirement

Cells and batteries meet this requirement if there is no mass loss, no leakage, no venting, no disassembly, no rupture and no fire and if the open circuit voltage of each test cell and battery after testing is not less than 90 % of its voltage immediately prior to this procedure. The requirement relating to voltage is not applicable to test cells and batteries at fully discharged states.

FF.6.5Test T.5: External Short Circuit

FF.6.5.1 Procedure

Simulates an external short circuit. After stabilizing at 55 ± 2 °C apply an external resistance of less than 0,1 Ω for 1 h and then observe for 6 h.

FF.6.5.2 Requirement

Cells and batteries meet this requirement if their external temperature does not exceed 170 °C and there is no disassembly, no rupture and no fire within 6 h of this test.

FF.6.6Test T.6: Impact

FF.6.6.1 Procedure

Simulates an impact. A 15,8 mm diameter bar is placed across the test sample cell or component cell and then a 9.1 kg mass is dropped from a height of 61 cm onto the bar, and then observed for 6 h.

FF.6.6.2 Requirement

Cells and component cells meet this requirement if their external temperature does not exceed 170 °C and there is no disassembly and no fire within 6 h of this test.

FF.6.7Test T.7: Overcharge

FF.6.7.1 Procedure

Evaluates the ability of a rechargeable battery to withstand overcharge. A charge current of twice the supplier’s recommended maximum continuous charge current is applied at a voltage depending on the supplier's recommended charge voltage for 24 h, and then observed for 7 d.

FF.6.7.2 Requirement

Rechargeable batteries meet this requirement if there is no disassembly and no fire within 7 d of the test.

FF.6.8Test T.8: Forced Discharge

FF.6.8.1 Procedure

Evaluates the ability of a primary or a rechargeable cell to withstand forced discharge. Force discharged is applied at an initial current equal to the maximum discharge current specified by the supplier for a specified time, and then observed for 7 days.

FF.6.8.2 Requirement

Primary or rechargeable cells meet this requirement if there is no disassembly and no fire within 7 d of the test.

Annex GG
(normative)

Test sequences and number of samples

The number of samples to be used in each test is shown in Table GG.1. DUT which are fully functional without mechanical damage are allowed to be used in further tests.

Table GG.1 — Number of samples required

Test category	Clause	Test item	Number of samples at first cycle fully charged	Number of samples after 50 cycles fully charged
Mechanical	6.101	Vibration	3	3
	6.102	Mechanical Shock	4	4
	6.103	Drop test	3	3
	6.104	Thermoplastic materials exposed to sunlight	1[a]	-
Climatic	7.1	Dewing (temperature change)	3	3
	7.2	Thermal-shock cycling	4	4
Simulated vehicle accidents	8.101	Crush	2[b]	2[b]
	8.3	Water immersion	2	2
	8.4	Exposure to fire	2[b]	2[b]
	8.102	Over-temperature condition	3	3
	8.103	Under-temperature condition	3	3
Electrical	9.1	Short circuit	3[c]	3[c]
System functionality	10.1	Overcharge protection	3[c]	3[c]
	10.3	Loss of thermal control	3	3

[a] This test is performed without cells.

[b] It is not allowed to use battery samples in further tests.

[c] It is only allowed to use battery samples in further test for option 2.

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