

Nederlandse norm

# **NEN-EN 50604-1/A1 (en)**

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

Oplaadbare lithium accu's voor toepassingen op LEV (Licht Elektrisch Voertuig) - Deel 1: Algemene veiligheidseisen en beproefingsmethoden

Vervangt NEN-EN 50604-1:2016/Ontw. AA:2019

ICS 29.220.30  
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Koninklijk Nederlands Elektrotechnisch Comité  
Normcommissie 361021 'Cellen en Batterijen NEC 21-35'



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EUROPEAN STANDARD

**EN 50604-1:2016/A1**

NORME EUROPÉENNE

EUROPÄISCHE NORM

July 2021

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## English Version

**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

This amendment A1 modifies the European Standard EN 50604-1:2016; it was approved by CENELEC on 2021-06-21. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this amendment the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

This amendment exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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European Committee for Electrotechnical Standardization  
Comité Européen de Normalisation Electrotechnique  
Europäisches Komitee für Elektrotechnische Normung

**CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels**

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Ref. No. EN 50604-1:2016/A1:2021 E

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## European foreword

This document (EN 50604-1:2016/A1:2021) 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) 2021-12-21
- latest date by which this document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2022-06-21
- latest date by which the national standards conflicting with this document have to be withdrawn (dow) 2024-06-21

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.

This part is read in conjunction with the appropriate part of the withdrawn ISO 12405-1, ISO 12405-2 and ISO 12405-3 and novel ISO 6469-1:2019. Remark: the 1<sup>st</sup> Ed of EN 50604-1 is referencing to ISO 12405-3.

NOTE 1 The following print types are used:

- requirements: in roman type;
- test specifications: *in italic type*;
- notes: in small roman type.

This document has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association.

Any feedback and questions on this document should be directed to the users' national committee. A complete listing of these bodies can be found on the CENELEC website.

**EN 50604-1:2016/A1:2021 (E)**

## **Introduction**

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

Lithium-ion batteries can store electricity at relatively high-energy density compared to other battery chemistries currently available. Under current state of art, most lithium-ion batteries use organic electrolytes 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 are considered as an important issue.

The EN 50604-1 series is read in conjunction with ISO 12405-3:2014 (withdrawn) and ISO 6469-1:2019 (for this amendment). The clauses of the particular requirements in EN 50604-1 supplement or modify the corresponding clauses in ISO 12405-3:2014 (withdrawn) and ISO 6469-1:2019 (for this amendment). Where the text indicates an “addition” to or a “replacement” of the relevant requirement, test specification or explanation of ISO 12405-3:2014 (withdrawn) and ISO 6469-1:2019 (for this amendment), these changes are made to the relevant text of ISO 12405-3:2014 (withdrawn) and ISO 6469-1:2019 (for this amendment), which then becomes part of the standard. Where no change is necessary, the words “This 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 could be necessary which are not covered by this document.

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

This document provides specific test procedures and related requirements to ensure an appropriate and acceptable level of safety of lithium-ion (Li-ion) battery systems specifically developed for propulsion of road vehicles. Propositions for other chemistries are given in informative Annex HH.

This document indicates references 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. Test reports issued and verified by in house testing according to UN 38.3 are also accepted.

## 1 Modification to Clause 1, “Scope”

*Replace the 3rd paragraph by the following:*

“Light EV includes all electrically propelled vehicles of category L1 up to category L7 according to the definition of ECE-TRANS-WP29-78r6e 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).”

*Delete the 5th paragraph.*

*Add after NOTE and renumber it NOTE 1:*

“This document also applies to:

- built-in battery packs/systems in EVs.

NOTE 2 Informative Annex HH gives information on possible tests for other chemistries.“

*Replace the first and second point of the last paragraph by:*

“

- individual cells;
- non-removable battery systems;“

## 2 Modification to Clause 2, “Normative references”

*Add the following new references:*

“

EN IEC 60812:2018, *Failure modes and effects analysis (FMEA and FMECA) (IEC 60812:2018)*

EN 60529:1991<sup>1</sup>, *Degrees of protection provided by enclosures (IP Code)*

EN 61000-6-7:2015, *Electromagnetic compatibility (EMC) - Part 6-7: Generic standards - Immunity requirements for equipment intended to perform functions in a safety-related system (functional safety) in industrial locations (IEC 61000-6-7:2014)*

EN 61326-3-1:2017, *Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 3-1: Immunity requirements for safety-related systems and for equipment intended to perform safety-related functions (functional safety) - General industrial applications (IEC 61326-3-1:2017)*

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

EN 62133-2, *Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications - Part 2: Lithium systems (IEC 62133-2:2017)*

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<sup>1</sup> As impacted by EN 60529:1991/A1:2000, EN 60529:1991/A2:2013, EN 60529:1991/A2:2013/AC:2019-02, EN 60529:1991/AC:2016-12, and EN 60529:1991/corrigendum May 1993.

## **EN 50604-1:2016/A1:2021 (E)**

EN ISO 178:2010<sup>2</sup>, *Plastics – Determination of flexural properties (ISO 178:2010)*

EN ISO 179 (series), *Plastics – Determination of Charpy impact properties (ISO 179 series)*

EN ISO 2409:2013<sup>3</sup>, *Paints and varnishes – Cross-cut test (ISO 2409:2013)*

EN ISO 4892-2:2013, *Plastics - Methods of exposure to laboratory light sources - Part 2: Xenon-arc lamps (ISO 4892-2:2013)*

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

ISO 6469-1:2019, *Electrically propelled road vehicles — Safety specifications — Part 1: Rechargeable energy storage system (RESS)*

IEC 60695-11-10, *Fire hazard testing - Part 11-10: Test flames - 50 W horizontal and vertical flame test methods*

SAE J 1739:2009, *Potential Failure Mode and Effects Analysis in Design (Design FMEA), Potential Failure Mode and Effects Analysis in Manufacturing and Assembly Processes (Process FMEA)"*

### **3 Modification to Clause 3, “Terms and definitions”**

*Replace term entry 3.5 by:*

“

**3.5**

**battery management system**

**BMS**

local energy management system 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 do not have the same functions.

[SOURCE: IEC/TS 61851-3-4]“

*Add note to entry to 3.14:*

“

Note 1 to entry: In the context of this document, “electric chassis” can be replaced by “enclosure”."

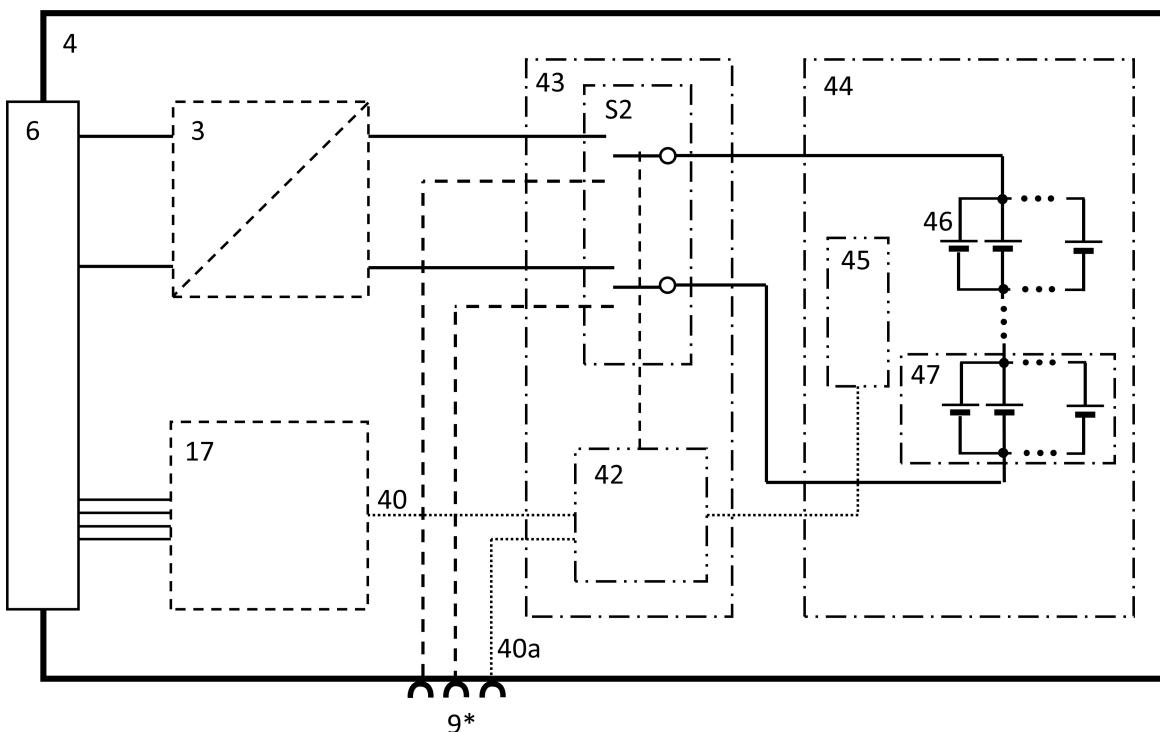
*Add the following figure at the end of 3.18:*

---

<sup>2</sup> A newer edition exists: EN ISO 178:2019.

<sup>3</sup> A newer edition exists: EN ISO 2409:2020.

“

**Key**

- 3 DC/DC converter for removable battery systems
- 4 Removable battery system
- 6 RESS inlet
- 9\* A/B coupler (optional)
- 17 Gateway
- 40 Manufacturer specific communication circuit
- 42 Protective device(s) (active and/or passive)
- 43 Battery Management System
- 44 Battery Pack
- 45 Sensing and balancing electronics/equipment
- 46 Cells
- 47 Cell block
- S2 Switch

**Figure 1 — Example of a removable battery system”***Replace the term entry of 3.31:*

“

**3.31****active protective device**

device integral to the battery pack requiring active control, that is intended for protection from or mitigation of abusive, out of range conditions experienced by the cell or battery

**EXAMPLE** MOSFET.

**Note 1 to entry:** The active protective device disconnects source or sink if the BMS detects parameters outside of the normal operating conditions.”

**EN 50604-1:2016/A1:2021 (E)***Add new term entries:*

“

**3.33****local energy management system****local EMS**

active device's internal system that protects the energy buffer, source or load from damage, monitors and increases the lifetime of the buffer, source or load, maintains the buffer, and source or load in a functional state

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

**3.34****A/B coupler**

means enabling the connection and disconnection of RESS to an EV

[SOURCE: IEC/TS 61851-3-1]

**3.35****RESS coupler**

means enabling the connection of RESS to an EV or a DRI EV supply equipment

[SOURCE: IEC PAS 62840-3]

**3.36****keyed connector**

part of coupler with a unique mechanical profile which can only be mated with each other in a particular orientation and which does not allow mating with the counterpart with a different design

**EXAMPLE 1** Hollow plugs of simple shape, where sockets-outlet compensate the variations of hollow plugs with a slightly different inner and/or outer diameter of the plug.

**EXAMPLE 2** Plugs for applications or charging systems that do not meet the electrical requirements of the specific interface. “

**4 Modification to subclause 5.2, “Test sequence plan”***Delete the 2<sup>nd</sup> paragraph.***“Addition”:***Add the following paragraph at the end of the subclause:*

“For details on test sequences and numbers of samples, see Annex GG, Table GG.1.

NOTE EMC could be subject to further tests.”

**5 Modification to subclause 5.101, “Battery pack/system requirements”***Replace Table 1 by:*

"

**Table 1 — Battery system requirements**

<b>Subsystem</b>	<b>Requirement</b>
cell	<p>Battery packs/systems shall contain only Li-ion cells which comply with the UN Recommendations on the Transport of Dangerous Goods - Manual of Tests and Criteria: Section 38.3, and with one of the following:</p> <ul style="list-style-type: none"> <li>— relevant Li-ion battery cell standard EN 62660-3; or</li> <li>— relevant Li-ion battery cell standard EN 62133-2.</li> </ul> <p>Compliance is checked by a valid certificate.</p> <p>NOTE Battery packs/systems containing cells with other chemistries are shown in Annex HH.</p>
BMS	<p>The BMS shall be an integral part of the removable battery system. The BMS shall provide (see 3.5 and 5.106):</p> <ul style="list-style-type: none"> <li>— controlling of charging/discharging process;</li> <li>— active or passive protective devices (see 5.104);</li> <li>— protective devices as part of BMS (see 5.104): <ul style="list-style-type: none"> <li>— avoiding overcharge/overdischarge,</li> <li>— detection of internal short-circuits,</li> <li>— respecting temperature limits at least one temperature sensor which measures the temperature of the interior of the battery pack/system as close as possible to the most critical spot according to the design,</li> </ul> </li> <li>— compatibility check between battery system and connected equipment.</li> </ul> <p><b><u>Manufacturer specific solutions:</u></b></p> <ul style="list-style-type: none"> <li>— Clear assignment of connected equipment with keyed connectors, which ensures to operate the battery within its voltage- and current specifications during charging and discharging and which prevents reverse polarity connections. Standard connectors (e.g. EN 60320 series) shall not be used.</li> <li>— compatibility check provided by manufacturer including the following minimum information / parameters: <ul style="list-style-type: none"> <li>— device type;</li> <li>— supported functionality;</li> <li>— device manufacturer or responsible vendor;</li> <li>— software version;</li> <li>— hardware version;</li> <li>— minimum voltage;</li> <li>— maximum voltage;</li> <li>— max. continuous input current;</li> <li>— max. continuous output current;</li> <li>— complete documentation of the compatibility check.</li> </ul> </li> </ul>

**EN 50604-1:2016/A1:2021 (E)**

Subsystem	Requirement
	<p>Compliance is checked by inspection.</p> <p><b><u>Interoperable solution using CANopen communication as described in CLC/prTS 61851-3-4 or any other communication solution proved to be equally suitable:</u></b></p> <ul style="list-style-type: none"> <li>— compatibility check according to IEC/TS 61851-3-4:—4, 8.2.3.4;</li> <li>— communication over gateway to CLC/prTS 61851-3 (series) products (optional).</li> </ul> <p>NOTE The term BMS is used to designate equipment intimately linked to the battery pack/system that provides all the relevant safety and control functions needed for a removable battery system.</p>
Enclosure of removable battery systems	<p>Enclosure of removable battery packs/systems shall provide at least:</p> <ul style="list-style-type: none"> <li>— mechanical strength to withstand stress caused by normal use and rough handling, see Clause 6;</li> <li>— sufficiently resistant to degradation caused by sunlight radiation, see 6.104;</li> <li>— reducing the possibility of ignition and spread of flame, see 8.4;</li> <li>— providing suitable insulation characteristics, at least basic insulation according to IEC 60664-1:2007, 5.3.3.2;</li> <li>— protection against ingress of foreign objects and water: IP54,—according to IEC 60529:1989+A1:1999+A2:2013;</li> <li>— the battery pack/system housing constructed in a way that it cannot be opened without the use of tools and any opening shall be easily detectable by a broken seal.</li> </ul>
Assembled removable battery system	<p><b><u>Manufacturer specific solution shall provide the following:</u></b></p> <ul style="list-style-type: none"> <li>— for RESS connector or RESS inlet, standard plug and standard socket-outlets and connectors (e.g. IEC 60320 series) shall not be used;</li> <li>— the RESS connector shall prevent reverse polarity connections;</li> <li>— the RESS connector shall not have a simple shape, which cannot grant a sufficiently unique mechanical profile (see NOTE 1);</li> <li>— an internal switch in the DC power circuit of the battery pack/system, controlled by the BMS, able to interrupt all power flow and ensure safety. The switch shall only be closed after a successful compatibility check;</li> <li>— a compatibility check between battery system and EV supply equipment shall be performed based on at least two of the following: <ul style="list-style-type: none"> <li>— mechanical;</li> <li>— electrical (e.g. additional contacts or voltages);</li> <li>— electronical;</li> <li>— communication means.</li> </ul> </li> </ul> <p>Bijective recognition of both sides is requirement for successful compatibility check. Compliance is checked by inspection, testing and design review.</p>

4 Under preparation. Stage at the time of publication: IEC/TS 61851-3-4:2021.

Subsystem	Requirement
	<p><b><u>Interoperable solution using CANopen communication as described in IEC/TS 61851-3-4:</u></b><sup>4</sup>:</p> <ul style="list-style-type: none"> <li>— RESS connector and RESS inlet shall be in accordance with IEC/TS 62196-4:<sup>5</sup>, IEC/TS 61851-3 (all parts) or IEC 62840 (all parts);</li> <li>— battery pack/system according to this interoperable solution are intended to be connected only to DRI EV supply equipment according to IEC 60335-2-29:2016: fulfilling the additional requirements of IEC/TS 61851-3-2:<sup>6</sup>;</li> <li>— an internal switch in the DC power circuit of the battery pack/system shall allow to disconnect the battery system from the RESS coupler or A/B coupler.</li> </ul> <p>Compliance is checked by inspection.</p>

## 6 Deletion of subclause 5.102, “Thermoplastic materials exposed to sunlight”

*Delete subclause 5.102 and renumber the following subclauses.*

## 7 Modification to subclause 5.103, “Safety considerations”

*Replace the title of subclause 5.103 by:*

### **“5.103 Battery pack/system safety considerations”**

*Replace the entire text of subclause 5.103.1 by:*

#### **“5.103.1 General**

All tests, which could be influenced by integration of the battery pack/system into the vehicle (e.g. installation into the frame), shall be 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).

Removable RESS can be tested without the vehicle or parts of it.

In a battery system consisting of two or more battery packs, each battery pack shall be isolated from each other battery pack by thermal isolation, protective barrier, or protective separation, or a stable gap from other battery packs and the enclosure.

NOTE This isolation can be an integral part of the battery pack.

Wire ways shall be smooth and free from sharp edges, and internal wiring shall be routed, supported, clamped or secured in a manner that reduces the likelihood of excessive strain on wire and on terminal connections.

Holes through which insulated wires pass shall have smooth well-rounded surfaces or be provided with bushings.

Wire insulation shall be sufficient to withstand the maximum anticipated voltage, current, temperature, altitude, humidity requirements and mechanical stress.

In connections by soldered terminations, the conductor shall be held in position additionally to the soldering to maintain it in position.

Connection to the cells shall be made according to the specification of the cell manufacturer in a manner that does not result in damage to the cells.

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<sup>5</sup> Under preparation. Stage at the time of publication: IEC/TS 62196-4:2021.

<sup>6</sup> Under preparation. Stage at the time of publication: IEC/TS 61851-3-2:2021.

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Compliance is checked by design review or inspection.

The enclosure of a removable battery pack/system shall provide at least IP54 according to EN 60529:1991.

A crush test is not required if the battery system in the EV is secured by double mechanical protection (e.g. latch and mechanical cover). Compliance shall be verified by inspection of a test report.

Only for battery systems permanently fixed to vehicles with maximum speed more than 45 km/h, crash tests which may replace a crush test are defined by the countries where the vehicles are released.

It is strongly recommended to extend the post-test observation period for destructive tests to 24h.“

## **8 Modification to subclause 5.104, “Evaluation of protective devices and electronic circuits”**

*Replace subclause and title of 5.104 by:*

### **“5.104 Options for tests for evaluation of protective devices**

#### **5.104.1 General**

The evaluation of active or passive protective devices including electronics and software depends on the design. The functionality of the active or passive protective devices shall be designed and tested according to option 1, option 2 or option 3.

NOTE The active or passive protective devices can be divided, and they can be found partially in the battery pack or in the battery system. See Figure 1.

Some of the tests described in Clauses 8, 9 and 10 give the possibility to the manufacturer to select one of the following options, that describe different ways of testing hardware and/or software, for the testing procedure:

- option 1 (5.104.2);
- option 2 (5.104.3);
- option 3 (5.104.4);

#### **5.104.2 Evaluation option 1**

All active protective devices are bypassed unless they comply with the functional safety standard as described in option 2. These active protective devices may also be bypassed at the demand of the manufacturer. This condition shall be stated in the corresponding test report.

#### **5.104.3 Evaluation option 2**

All protective devices are operating.

All protective devices shall be proven to be reliable according to the EN 61508 (series) or EN ISO 13849 (all parts) performance level c.

Compliance is given by evaluation of evidence.

#### **5.104.4 Evaluation Option 3**

Active protective devices in operation with all single faults injected and tested separately.

If protective devices which are not proven to reach performance level c according to the EN ISO 13849 (all parts) or EN 61508 (series) are used, a design review (e.g. FMEA according to EN IEC 60812:2018 or SAE J 1739:2009) shall be performed to identify failure modes taking in consideration also EMC conditions according to EN 61000-6-7:2015 or EN 61326-3-1:2017. All single faults which could influence the test result according to the design review shall be separately injected during the tests and separately tested for each fault injection.

Each protective device shall be rendered inoperative separately (common causes) e.g.:

- switches of DC power circuit;
- controllers/microcontrollers;
- software;
- communication circuit and its power supply;
- heartbeat/watchdog.

NOTE 1 Single fault tests are conducted for the assembly.

NOTE 2 If all switches of DC power circuit designed for redundancy are controlled by the same controller, then Option 3 is not applicable.“

## **9 Modification to subclause 5.105, “Voltage classes”**

*Replace the entire subclause by the following:*

“Battery packs/systems according to this document can be rated for voltage class A or voltage class B up to a maximum voltage of 200 V DC.“

## **10 Modification to subclause 5.106, “Battery management system”**

*Replace the entire subclause 5.106 by:*

### **“5.106 Requirements for the BMS**

The BMS evaluates and controls the condition of each cell, cell block and battery pack/system, and it maintains cells, cell blocks and battery pack/systems within the specified cell operating region as defined by the cell manufacturer (See IEC 62619:2017, Annex A).

Key factors of the cell operating region are voltage, temperature and current. (See IEC 62619:2017, Figures A.1 and A.2)

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 IEC/TS 61851-3-4.

NOTE 1 The function of the BMS can be assigned to the battery pack or to the battery system. See Figure 1.

NOTE 2 The BMS can be split and it can be found partially in the battery pack or in the battery system. See Figure 1.“

## **11 Modification to subclause 5.107, “Charging/discharging”**

*Replace the entire subclause by the following:*

“The terms charging or discharging are used only for specific situations the term power transfer is used because the direction and purpose of the power transfer is not defined.“

## **12 Modification to subclause 5.109, “Test result fire”**

*Replace the entire subclause by the following:*

“DUT shall be wrapped with cheesecloth e.g. see EN 60745-1:2009, Annex K. After the test, this cheesecloth shall remain intact.

NOTE 1 Cheesecloth: bleached cotton cloth of approximately 40 g/m<sup>2</sup> according to EN IEC 62368-1:2020.

For vibration tests according to 6.101, test result fire means no visible evidence of fire or extreme heat.

NOTE 2 The use of cheese cloth facilitates the detection of fire and/or extreme heat.“

**EN 50604-1:2016/A1:2021 (E)****13 Modification to subclause 5.110, “Test result leakage”**

*Change in first paragraph:*

“criterion for 0,1% mass loss” to “criterion for 1,0% mass loss”

**14 Addition of a new subclause, “Flammability of non-metallic materials”****“5.111 Flammability of non-metallic materials”**

Non metallic materials employed for the cell holder and outer enclosures of a battery pack/system, which are used in an amount of  $> 1 \text{ cm}^3$  shall have a minimum flame rating of V-2 in accordance with IEC 60695-11-10.

Compliance is checked by review of certificates provided by battery pack/system manufacturer or by test according to IEC 60695-11-10.”

**15 Modification to subclause 6.101.2, “Test procedure”**

*Replace the second paragraph by:*

“While vibrating, each fully charged DUT shall be discharged with a current typical to the application at least C/3 of the DUT over part of the vibration test duration up to a discharged capacity of 25 % SOC for each of three mounting positions mutually perpendicular (if applicable) of the DUT, recharge of DUT is not needed during the whole vibration test.”

**16 Modification to subclause 6.101.3, “Requirements”**

*Replace the entire subclause by the following:*

“During the test and for a 1 h post-test observation period, the DUT shall exhibit no evidence of leakage, rupture, fire or explosion, voltage class A or B DUT shall maintain an isolation resistance of at least  $100 \Omega/\text{V}$ .

The DUT shall accept any discharge under these conditions. If a discharging current cannot be detected, the DUT has failed.”

**17 Modification to subclause 6.104, “Thermoplastic materials exposed to sunlight”**

*Modification to subclause 6.104.1, “Purpose”*

*Delete the first paragraph.*

*Add at the end of the second paragraph:*

“and UV radiation (sunlight) ”

*Modification to subclause 6.104.2, “Test procedure”*

*Replace the entire subclause by the following:*

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

Alternatively, the test shall be performed with a part of the material at least  $3 \times 3 \text{ cm}$  produced by the same methods like the housing:

NOTE 1 Examples of materials that could be affected:

- thermoplastic enclosure materials;
- wire and cable insulation;

— thermoplastic parts of connectors.

UV test according to EN ISO 4892-2:2013 Method A, Cycle 1 providing a total test period of 500 h. For enclosures constructed of insulating materials compliance is checked by verification that the flexural strength (according to EN ISO 178:2010) and Charpy impact (according to EN ISO 179 (series)) of insulating materials have 70 % minimum retention.

For compliance, enclosures constructed of metals entirely coated by synthetic material, the adherence of the synthetic material shall have a minimum retention of category 3 according to EN ISO 2409:2013.

This test does not need to be carried out if the original manufacturer can provide data from the material supplier to demonstrate that material of the same type and thickness or thinner complies with this requirement.

NOTE 2 A test according to UL 746C:2018 is seen as equivalent.“

*Modification to subclause 6.104.3, “Requirements”*

*Replace the entire subclause by the following:*

“The DUT shall not exhibit any cracks, contour changes, waviness and delamination.”

## 18 Modification to subclause 8.101, “Crush test”

*Modification to subclause 8.101.1, “Purpose”*

*Delete at the end of the first paragraph:*

“like in a trash compactor”

*Modification to subclause 8.101.2, “Test”*

*Delete in the first paragraph twice:*

“(one fresh DUT, and one DUT after 50 cycles, see Table GG.1)“

*Modification to subclause 8.101.3, “Requirements”*

*Delete “or disassembly”:*

## 19 Modification to subclause 8.3.101, “Purpose”

*Replace the first paragraph by:*

“Test simulates a water immersion which may occur when a vehicle or a removable battery system is flooded.”

## 20 Modification to subclause 8.103.2, “Test procedure”

*Replace the entire subclause by the following:*

“Adjust the SOC to 100 % before starting the test. Perform a discharge to 80 % ± 5 % SOC according to the specification of the supplier.

The DUT shall then be placed in a climate chamber. The temperature shall be set 10 K under the low temperature limit for charging according to the specification of the supplier. A rest period of 2 h or until thermal equilibration has been reached shall be performed.

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

This test shall be performed under the conditions of option 1, 2 or 3 according to the specification of the supplier.“

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### 21 Modification to subclause 8.103.3, “Requirements”

*Replace the second paragraph by:*

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

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

### 22 Modification to subclause 9.1.101, “Test procedure”

*Replace Titles by:*

**9.1.101.1 Test procedure Option 1**

**9.1.101.2 Test procedure Option 2 or Option 3**

*Modification to subclause 9.1.101.2*

*Delete the last paragraph.*

### 23 Modifications to subclause 9.101, “Touch current”

*Replace title of 9.101 by:*

**“Leakage current of a battery system while switched-off”**

*Modification to subclause 9.101.2, “Test procedure”*

*Replace first paragraph by:*

“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 and protected by the BMS).“

*Modification to subclause 9.101.3, “Requirements”*

*Replace the first paragraph by:*

“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 shall be applied according to EN 61140:2016 and to IEC 60479-2:2019, Figure 19:“

### 24 Modification to subclause 10.1, “Overcharge protection”

*Modification to subclause 10.1.101, “Purpose”*

*Replace Option 2 by:*

“Option 2 or Option 3:“

*Modification to subclause 10.1.102, “Test procedure”*

*Replace the fifth and sixth paragraph by:*

“The DUT shall be charged at a constant current which is agreed between the supplier and customer, using a supply voltage sufficient to maintain the before described current throughout the duration of the test. The voltage shall not exceed 1,2 times the maximum allowed cell voltage as defined by the supplier unless EV supply equipment is limited in voltage.

Then the voltage applied to the DUT shall be set to the maximum output voltage of the EV supply equipment that can occur.

Compliance is checked by a valid certificate.

This test shall be performed for Option 1, Option 2 or Option 3.”

*Modification to subclause 10.1.103, "Requirements"*

*Replace text by:*

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

## 25 Modification to subclause 10.2, "Over-discharge protection"

*Replace text by:*

"For Option 2 or Option 3: ISO 6469-1:2019, 5.5.3 is applicable.

NOTE For further information see also ISO 12405-3:2014, 10.2."

## 26 Modification to subclause 10.3, "Loss of thermal control/cooling"

*Replace the 1<sup>st</sup> paragraph as follows:*

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

### 10.3.3 Requirements

Requirements as given in 5.5 shall apply.

The thermal control or cooling function, if any, shall interrupt the charge and discharge current.

*Compliance is checked by inspection.*"

*Add at the end of first paragraph:*

"ISO 6469-1:2019, 5.5.4 is applicable for thermal control under test condition option 1 and cooling under test condition options 1, 2 or 3, see 9.1.

NOTE 1 For information: topic "loss of thermal control/cooling" is covered by ISO 6469-1:2019, 5.5.4: "protection against internal overheating".

NOTE 2 For further information see also ISO 12405-3:2014, 10.3."

## 27 Modification to Clause 10, "System functionality tests"

*Add the following subclause:*

### 10.4 Deep discharge protection

#### 10.4.101 Purpose

The purpose of the deep discharge test is to limit the functionality of the battery pack/system after a deep discharge to avoid possible safety critical behaviour due to copper dendrites forming when charging the battery pack/system after a deep discharge of a cell / pack (e.g. due to self-discharge of cells, long storage time, connected electronics, malfunction, etc.).

The BMS shall not allow charging after deep discharge to prevent the DUT from further related severe events caused by internal shorts.

#### 10.4.102 Test procedure

##### 10.4.102.1 Test procedure Option 1 (see 5.104.2):

Over discharge cells with constant current defined by the supplier and up to 10 % below the minimum cell voltage of at least one cell.

Discharge shall be continued with constant voltage (10 % below the minimum cell voltage of at least one cell) and up to the point where the current falls below 10 % of the constant current as defined by the supplier.

##### 10.4.102.2 Test procedure Option 2 or 3 (see 5.104.3 or 5.104.4):

The construction / software of the DUT is reviewed to verify one of the following:

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- 1) A functionality shall exist in the BMS, which measures single cell voltages and permanently disables charging, if any single cell voltage is detected to be 10 % below the minimum cell voltage (as defined by the supplier) for more than 5 s; or
- 2) Test for possibility for re-charging and re-charge conditions:
  - a) if a single cell voltage is below 1V: charging of the battery pack/system shall be done with very small current (C/50 or smaller); and
  - b) when the single cell voltage reaches 2 V or is above 2 V, charging of the battery pack/system shall be done with a current equivalent to C/10.

NOTE 1 The cell voltage levels given correspond to those of common transition metal oxide cathode Li-ion technologies. For others, agreement between supplier and customer is needed.

NOTE 2 Voltage measurements of parallel connected cells are considered as voltage measurements on each cell.

**10.4.103 Requirements****10.4.103.1 Requirements Option 1 (see 5.104.2):**

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 rupture, explosion, venting or fire.

**10.4.103.2 Requirements Option 2 or 3 (see 5.104.3 or 5.104.4)**

The implementation of deep discharge protection shall be one of the following:

Test result of 1 of 10.4.102.2:

The analysis of the functionality of the BMS shall demonstrate that all the aspects of Test 1 are fulfilled and that they prevent battery pack/system from being charged and permanently disable it for further use.

Test result for 2a of 10.4.102.2:

- this shall result in the single cell voltage reaching the 1 V level after 30 s;
- if this is not the case, charging shall be terminated, and the battery pack/system permanently disabled for further use.

Test result for 2b of 10.4.102.2:

- this shall result in the single cell voltage reaching the 3 V level after 6 min.

NOTE The cell voltage levels given correspond to those of common transition metal oxide cathode Li-ion technologies. For others, agreement between supplier and customer is needed.

Compliance is checked by the review of the design and/or the software.“

## **28 Modification to subclause BB.1.1, “Removable (RESS) battery systems (packs) marking”**

*Add at the end of the first paragraph:*

“in BB.1.2, if applicable:“

*Add on the first point:*

“if applicable;“

*Replace the sixth point by:*

“

- rated capacity in Ah, and rated energy in Wh;“

*Replace the sixteenth point by:*

“

- for Li-ion battery systems, text transport under UN-T 38-3,
- symbol BATSO (optional);“

## 29 Modification to Table BB.1, “Graphical symbols”

*Replace Symbol Waste Electrical and Electronic Equipment Directive by (European Community directive 2006/66/EC (“Battery directive”) and BATSO Symbol line as shown in the table below:*

“

**Table BB.1 — Symbols**

	European Community directive 2006/66/EC (“Battery directive”)	European Community directive 2006/66/EC (“Battery directive”) ANNEX II: SYMBOLS FOR BATTERIES, ACCUMULATORS AND BATTERY PACKS FOR SEPARATE COLLECTION
	Graphical symbol ISO 14021:2016	Li or Li-ion battery symbol
	Other official graphical symbols of proven safety organizations, e.g. BATSO	Test marks signals to buyers, retailers, service personnel that the chosen battery, its manual for use and/or installation have been tested by an authorized laboratory, and the production (process) has been inspected.

“

## 30 Modification to subclause BB.2, “Instructions”

*Change the fourth paragraph to:*

“The instructions shall imply the following:“

*Delete item r)*

*Replace item t) by:*

“for Li-Ion battery systems with a capacity of more than 100 Wh a safety instruction is needed.

NOTE 1 See UN-T 3480 for further information.

Such battery systems, if transported separately (not installed in the application) by professionals, shall be considered by them as dangerous goods.

NOTE 2 See UN-T regulations.“

*Replace item ee) by:*

“in case of ingestion of products, seek medical attention immediately.“

*Add item gg):*

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"Products with broken seals shall not be used and shall be immediately forwarded for appropriate recycling."

**31 Modifications to Annex FF, "Transport regulations"**

*Replace Title by:*

**"Transport regulations (Li-ion battery systems)"**

*Add the following paragraph after the title and renumber following clauses in the Annex:*

**"FF.1 General**

The information contained in this Annex is given only to orientate the reader to the relevant regulations. The reader shall verify the applicability of each reference given. The list of reference is not necessarily complete."

**32 Modification of Annex GG, "Test sequences and number of samples"**

*Replace Table GG.1 by the following table:*

"

**Table GG.1 — Number of samples required**

Test category	Clause	Test item	EN 50604 Li-ion
Mechanical	6.101	Vibration	3
	6.102	Mechanical Shock	4
	6.103	Drop test	3
	6.104	Thermoplastic materials exposed to sunlight	1 <sup>a</sup>
Climatic	7.1	Dewing (temperature change)	3
	7.2	Thermal-shock cycling	4
Simulated vehicle accidents	8.101	Crush	2 <sup>b,d</sup>
	8.3	Water immersion	2
	8.4	Exposure to fire	2 <sup>b</sup>
	8.102	Over-temperature condition	3
	8.103	Under-temperature condition	3
Electrical	9.1	Short circuit	3 <sup>c</sup>
System functionality	10.1	Overcharge protection	3 <sup>c</sup>
	10.2	Over-discharge protection	3
	10.3	Loss of thermal control	3
	10.4	Deep discharge protection	1 <sup>b</sup>

<sup>a</sup> This test is performed without cells.  
<sup>b</sup> It is not allowed to use battery samples in further tests.  
<sup>c</sup> It is only allowed to use battery samples in further test for option 2 or option 3.  
<sup>d</sup> Crush test is not applicable for built-in battery systems and removable battery systems fastened to the device by latch and protected by a ridged cover. See Note in 5.103.1

"

### 33 Addition of Annex HH, “Comparison Table for chemistries others than Li-ion”

Add the following annex:

**“Annex HH**  
(informative)

**Comparison table for chemistries other than Li-ion**

#### HH.1 General

This Annex gives a structured list as shown in Table HH.1 of tests that may also be applicable to other battery chemistries for tests that use the same orientation as the tests described in this document.

These options may later be integrated as parts of other appropriate standards. These propositions may not correspond to all situations.

**Table HH.1 — Other chemistries**

Clause	Title	EN 50604-1 Li-ion	Remarks
1	Scope	X	Applicable with additions or changes to the cell chemistry
2	Normative references	X	Applicable with additions to the cell chemistry
3	Terms and definitions	X	Applicable with additions to the cell chemistry
4	Symbols and abbreviated terms	X	Applicable with additions to the cell chemistry
5	General requirements	-	Applicable with additions to the cell chemistry
5.1	General	X	
5.2	Test sequence plan	X	
5.3	Preparation of the DUT for testing	X	
5.4	Pre-conditioning cycles	X	
5.5	General safety requirements	X	
5.101	Battery pack / system requirements	X	
5.102	Void		
5.103	Safety considerations	X	
5.104	Evaluation of protective devices and electronic circuits	X	
5.105	Voltage classes	X	

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<b>Clause</b>	<b>Title</b>	<b>EN 50604-1 Li-ion</b>	<b>Remarks</b>
<b>5.106</b>	Battery management system	X	
<b>5.107</b>	Charging/discharging	X	
<b>5.108</b>	Test result explosion	X	
<b>5.109</b>	Test result fire	X	
<b>5.110</b>	Test result leakage	X	
<b>5.111</b>	Flammability of non-metallic materials	X	
<b>6</b>	Mechanical tests	-	
<b>6.101</b>	Vibration	X	
<b>6.102</b>	Mechanical shock	X	
<b>6.103</b>	Drop Test	X	
<b>6.104</b>	Thermoplastic materials exposed to sunlight	X	
<b>7</b>	Climatic tests	-	
<b>7.1</b>	Dewing (temperature change)	X	
<b>7.2</b>	Thermal shock cycling	X	
<b>8</b>	Simulated vehicle accidents	-	
<b>8.1</b>	Inertial load at vehicle crash	NA	
<b>8.2</b>	Contact force at vehicle crash	NA	
<b>8.101</b>	Crush test	X	
<b>8.3</b>	Water immersion	X	
<b>8.4</b>	Exposure to fire	X	
<b>8.102</b>	Over-temperature condition test	X	
<b>8.103</b>	Under-temperature condition test	X	
<b>9</b>	Electrical tests	-	
<b>9.1</b>	Short circuit	X	
<b>9.101</b>	Leakage current of a battery system while switched-off	X	
<b>10</b>	System functionality tests	-	
<b>10.1</b>	Overcharge protection	X	

Clause	Title	EN 50604-1 Li-ion	Remarks
<b>10.2</b>	Over-discharge protection	X	
<b>10.3</b>	Loss of thermal control/cooling	X	
<b>10.4</b>	Deep discharge protection	X	
<b>AA</b>	Battery Systems and related parts	-	
<b>AA.1</b>	General	X	
<b>AA.2</b>	Battery pack	X	
<b>AA.3</b>	Battery system	X	
<b>AA.3.1</b>	Battery system with integrated BCU/BMS	X	
<b>AA.3.2</b>	Battery system with external BCU/BMS	X	
<b>BB</b>	General marking requirements	-	
<b>BB.1</b>	Marking and instructions	-	
<b>BB.1.1</b>	Removable (RESS) battery systems (packs) marking	X	
<b>BB.1.2</b>	Graphical symbols	X	
<b>BB.2</b>	Instructions	X	
<b>BB.3</b>	Instructions for built-in battery system	X	
<b>BB.4</b>	Language	X	
<b>BB.5</b>	Label test	X	
<b>BB.6</b>	Markings	X	
<b>CC</b>	Test stamp for crush test	X	
<b>DD</b>	Test probe	X	
<b>EE</b>	Packaging and transportation for not tested battery samples	X	
<b>FF</b>	Transport regulations	X	
<b>GG</b>	Test sequences and number of samples	X	

**EN 50604-1:2016/A1:2021 (E)**

**34 Modification to the Bibliography**

*Add the following references:*

"

EN 60745-1:2009, Hand-held motor-operated electric tools - Safety - Part 1: General requirements (IEC 60745-1:2006)

EN 61982-4:2016, *Secondary batteries (except lithium) for the propulsion of electric road vehicles - Part 4: Safety requirements of nickel-metal hydride cells and modules (IEC 61982-4:2015)*

EN 62133-1:2017, *Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications - Part 1: Nickel systems (IEC 62133-1:2017)*

EN 62485-3:2014, *Safety requirements for secondary batteries and battery installations - Part 3: Traction batteries (IEC 62485-3:2014)*

UL 746C:2018, *Polymeric materials - Use in electrical equipment evaluations*

"

## **Why do you have to pay for a standard?**

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