

**Secondary cells and batteries containing
alkaline or other non-acid electrolytes — Safety
requirements for secondary lithium batteries
for use in road vehicles not for the propulsion**

National foreword

This British Standard is the UK implementation of IEC 63057:2020.

The UK participation in its preparation was entrusted to Technical Committee PEL/21/1, Secondary cells and batteries containing alkaline and other non-acidic electrolytes.

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

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Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for secondary lithium batteries for use in road vehicles not for the propulsion

Accumulateurs alcalins et autres accumulateurs à électrolyte non acide – Exigences de sécurité pour les batteries d'accumulateurs au lithium destinées à être utilisées dans les véhicules routiers, mais non destinées à la propulsion

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**SECONDARY CELLS AND BATTERIES CONTAINING ALKALINE
OR OTHER NON-ACID ELECTROLYTES –
SAFETY REQUIREMENTS FOR SECONDARY LITHIUM
BATTERIES FOR USE IN ROAD VEHICLES
NOT FOR THE PROPULSION**

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International Standard IEC 63057 has been prepared by subcommittee 21A: Secondary cells and batteries containing alkaline or other non-acid electrolytes, of IEC technical committee 21: Secondary cells and batteries.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
21A/715/FDIS	21A/719/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

SECONDARY CELLS AND BATTERIES CONTAINING ALKALINE OR OTHER NON-ACID ELECTROLYTES – SAFETY REQUIREMENTS FOR SECONDARY LITHIUM BATTERIES FOR USE IN ROAD VEHICLES NOT FOR THE PROPULSION

1 Scope

This document specifies safety tests and requirements for secondary lithium batteries permanently installed in road vehicles not for the propulsion. Replacement secondary batteries permanently installed in road vehicles not for propulsion are covered by this document.

The following are typical applications that utilize the batteries under the scope of this document: a power source for the starting of internal combustion engines, lighting, on-board auxiliary equipment, and energy absorption for regeneration from braking.

This document applies to batteries with a maximum voltage less than or equal to 60 V DC.

The batteries primarily used for propulsion of electric vehicles (EVs), including battery electric vehicles (BEVs), hybrid electric vehicles (HEVs), and plug-in hybrid electric vehicles (PHEVs) are not covered by this document.

NOTE Testing on cell level is specified in IEC 62619.

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.

IEC 60050-482, *International Electrotechnical Vocabulary (IEV) – Part 482: Primary and secondary cells and batteries* (available at <http://www.electropedia.org/>)

IEC 62619:2017, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for secondary lithium cells and batteries, for use in industrial applications*

ISO/IEC Guide 51, *Safety aspects – Guidelines for their inclusion in standards*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-482, ISO/IEC Guide 51 and the following apply.

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

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1**battery**

unit comprising one or more cells, modules and a battery management system

3.2**battery management system****BMS**

set of protection functions associated with a battery to prevent overcharge, overcurrent, over temperature, under temperature and if applicable overdischarge

Note 1 to entry: The function of the BMS can be assigned to the battery or to the vehicle that uses the battery. See Figure 1.

Note 2 to entry: The BMS can be divided and it can be found partially in the battery and partially on the equipment that uses the battery. See Figure 1.

Note 3 to entry: The BMS is sometimes also referred to as a BMU (battery management unit).

Note 4 to entry: This term applies to the French language only.

3.3**cell**

secondary cell where electrical energy is derived from the insertion or extraction reactions of lithium ions or oxidation/reduction reaction of lithium between the negative electrode and the positive electrode

Note 1 to entry: The cell typically has an electrolyte that consists of a lithium salt and organic solvent compound in liquid, gel or solid form and has a metal or a laminate film casing. It is not ready for use in an application because it is not yet fitted with its final housing, terminal arrangement and electronic control device.

3.4**cell block**

group of cells connected together in parallel configuration with or without protective devices (e.g. fuse or positive temperature coefficient device) and monitoring circuitry

Note 1 to entry: It is not ready for use in an application because it is not yet fitted with its final housing, terminal arrangement and electronic control device.

3.5**explosion**

failure that occurs when a battery case opens violently, and solid components are forcibly expelled

Note 1 to entry: Liquid, gas, and smoke can be erupted.

3.6**final voltage**

specified closed circuit voltage at which the discharge of a battery is terminated

Note 1 to entry: The final voltage should be declared by the battery manufacturer.

3.7**fire**

emission of flames from a battery

3.8**harm**

physical injury or damage to the health of people or damage to property or to the environment

3.9**hazard**

potential source of harm

3.10**intended use**

use of a product, process or service in accordance with specifications, instructions and information provided by the battery manufacturer

3.11**leakage**

visible escape of liquid electrolyte

3.12**module**

group of cells connected together in a series and/or parallel configuration with or without protective devices (e.g. fuse or positive temperature coefficient device) and monitoring circuitry

3.13**rated capacity**

capacity value of a battery determined under specified conditions and declared by the battery manufacturer

Note 1 to entry: The rated capacity is the quantity of electricity C_n Ah (ampere-hours) declared by the battery manufacturer which a battery can deliver during an n h period when charging, storing and discharging under the conditions specified in IEC 62620:2014, 6.3.1.

3.14**reasonably foreseeable misuse**

use of a product, process or service in a way which is not intended by the battery manufacturer, but which can result from readily predictable human behaviour

3.15**risk**

combination of the probability of occurrence of harm and the severity of that harm

3.16**rupture**

mechanical failure of a cell container or battery case induced by an internal or external cause, resulting in exposure or spillage but not ejection of materials

3.17**safety**

freedom from unacceptable risk

3.18**venting**

release of excessive internal pressure from a cell, module, or battery in a manner intended by design to preclude rupture or explosion

4 Parameter measurement tolerances

The overall accuracy of controlled or measured values, relative to the specified or actual values, shall be within the following tolerances unless otherwise noted in the individual test procedure:

- a) $\pm 0,5$ % for voltage;
- b) ± 1 % for current;
- c) ± 2 °C for temperature;
- d) $\pm 0,1$ % for time;

- e) ± 1 % for dimensions
- f) ± 1 % for mass.

These tolerances comprise the combined accuracy of the measuring instruments, the measurement techniques used, and all other sources of error in the test procedure.

The details of the instrumentation used shall be provided in any report of results.

5 General safety considerations

5.1 General

The safety of lithium secondary batteries requires the consideration of two sets of applied conditions:

- 1) intended use;
- 2) reasonably foreseeable misuse.

Batteries shall be so designed and constructed that they are safe under conditions of both intended use and reasonably foreseeable misuse.

It is expected that batteries subjected to misuse can fail to function. However, even if such a situation occurs, they shall not present any significant hazards.

Potential hazards which are the subject of this document are:

- a) fire,
- b) explosion.

Conformity with 5.1 to 5.7 is checked by the tests of Clauses 6 and 7, and in accordance with the appropriate standard.

5.2 Insulation and wiring

Wiring and its insulation shall be sufficient to withstand the maximum anticipated voltage, current, and temperature requirements. The design of wiring shall be such that adequate clearances and creepage distances are maintained between conductors. The mechanical integrity of the battery and its connections shall be sufficient to accommodate conditions of reasonably foreseeable misuse.

5.3 Venting

The casing of the battery shall incorporate a pressure relief function that will preclude rupture or explosion. If encapsulation is used to support cells within an outer case, the type of encapsulant and the method of encapsulation shall neither cause the battery to overheat during normal operation nor inhibit pressure relief.

5.4 Temperature/voltage/current

The design of batteries shall be such that abnormal temperature-rise conditions are prevented. The battery shall be designed within voltage, current, and temperature limitations specified by the cell manufacturer. The battery shall be provided with specifications and charge instructions for vehicle manufacturer or battery-charger manufacturer so that associated chargers are designed to maintain charging within the voltage, current and temperature limits specified.

NOTE Where necessary, means can be provided to limit current or voltage to safe levels during charging and discharging.

5.5 Terminal contacts of the battery

Terminals shall have clear polarity marking(s) on the external surface of the battery, and the polarity marking(s) should be located near the terminal in order to be understood easily.

The size and shape of the terminal contacts shall ensure that they can carry the maximum anticipated current. External terminal contact surfaces shall be formed from conductive materials with good mechanical strength and corrosion resistance. Terminal contacts shall be arranged so as to minimize the risk of short-circuits (caused by metal tools, for example).

5.6 Assembly of battery

5.6.1 General

- The battery should have an independent control and protection method.
- The cell manufacturer shall provide recommendations about current, voltage and temperature limits so that the battery manufacturer or designer can ensure proper design and assembly.
- Protective circuit components should be added as appropriate, and consideration given to the vehicle.

5.6.2 Battery design

The voltage control function of the battery design shall ensure that the voltage of each cell or cell block shall not exceed the upper limit of the charging voltage specified by the cell manufacturer, except in the case where the vehicle system provides an equivalent voltage control function.

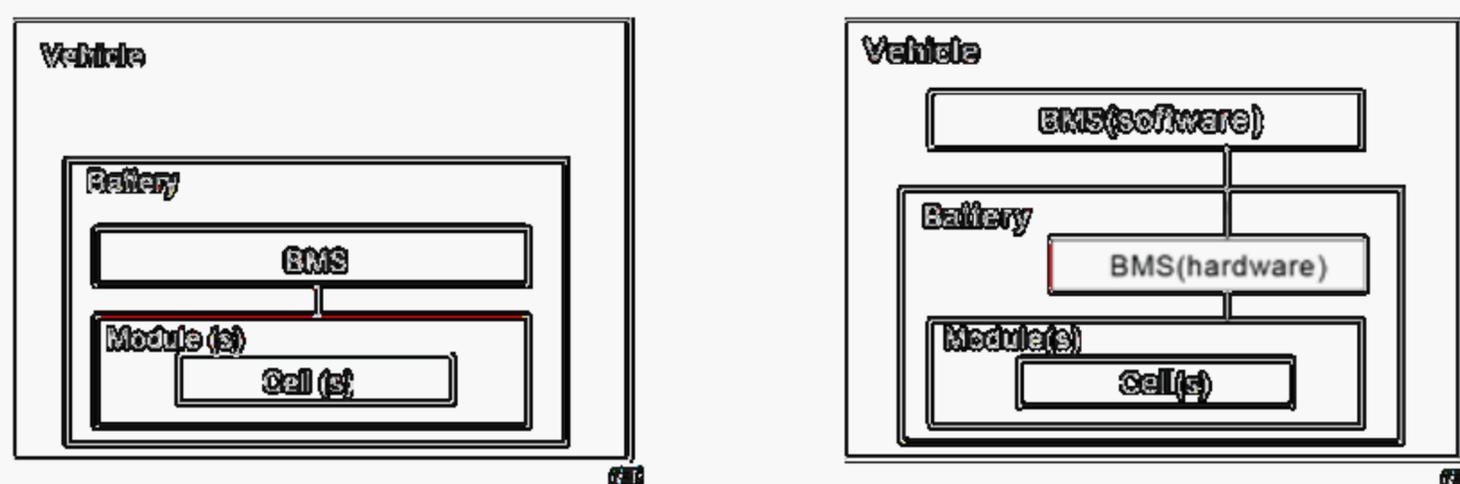
The following should be considered at battery level and by the battery manufacturer:

For a battery that has several series-connected cells or modules, it is recommended that the voltages of any one of the single cells or cell blocks do not exceed the upper limit of the charging voltage, specified by the cell manufacturer, by monitoring the voltage of every single cell or cell block.

5.7 Requirements for the BMS

The BMS evaluates the condition of cells and batteries, and it maintains cells and batteries within the specified cell operating region. Key factors of the cell operating region are voltage, temperature and current for charging and discharging.

The functions of the BMS can be incorporated into the battery or into the vehicle that uses the battery. The BMS can also be divided so that it can be found partially in the battery and partially in the vehicle that uses the battery (see Figure 1).



a) All functions of BMS are in the battery

b) BMS functions are divided between battery and vehicle side

Figure 1 – Examples of BMS locations and battery configurations

A hazard analysis and risk assessment in accordance with Clause 8 of IEC 62619:2017 shall be conducted on the battery and BMS combination.

5.8 Operating region of lithium cells and battery for safe use

Cells shall comply with the cell criteria outlined in IEC 62619:2017. The cell manufacturer shall specify the cell's operating region. The battery manufacturer shall design the battery to comply with the cell's operating region. Determination of the cell's operating region is explained in Annex A of IEC 62619:2017.

5.9 Quality plan

The battery manufacturer shall prepare and implement a quality plan that defines procedures for the inspection of materials, components, cells, modules, and batteries and which covers the whole process of producing each type of cell, module, and battery (e.g. ISO 9001). The battery manufacturer should understand their process capabilities and should institute the necessary process controls as they relate to product safety.

6 Type test conditions

6.1 General

A battery that is used outside of its operating region can exhibit hazards resulting from that battery. Such risks have to be taken into consideration in order to prepare a safe test plan.

The test facility should have a sufficient structural integrity and a fire suppression system to sustain the conditions of overpressure, fire and electrolyte leakage that can occur as a result of testing. The facility should have a ventilation system to remove and capture gas that might be produced during the tests. Consideration should be given to high-voltage hazards when applicable.

Warning: THESE TESTS USE PROCEDURES THAT MAY RESULT IN HARM IF ADEQUATE PRECAUTIONS ARE NOT TAKEN. TESTS SHOULD ONLY BE PERFORMED BY QUALIFIED AND EXPERIENCED TECHNICIANS USING ADEQUATE PROTECTION. TO PREVENT BURNS, CAUTION SHOULD BE TAKEN FOR THOSE BATTERIES WHOSE CASINGS MAY EXCEED 75 °C AS A RESULT OF TESTING.

6.2 Test items

Tests are made with the number of batteries specified in Table 1, using batteries that are not more than six months old. Batteries charged by the method specified in 7.1 shall deliver the rated capacity or more when they are discharged at $25\text{ °C} \pm 5\text{ °C}$ down to a specified final voltage at a constant current of $0,2 I_t$ A. This capacity confirmation may be done by the battery manufacturer. The battery capacity may be calculated on the basis of the cell capacity measurement.

Unless otherwise specified, tests are carried out in an ambient temperature of $25\text{ °C} \pm 5\text{ °C}$.

Table 1 – Type tests

Test	Automotive application		Moped and motorcycle application	
	Subclause	Battery	Subclause	Battery
Mechanical shock	7.1.3	Y	7.2.3	Y
Vibration	7.1.4	Y	7.2.4	Y
Thermal cycling	7.1.5	Y	7.2.5	Y
Overcharge	7.1.6	Y	7.2.6	Y
Overdischarge	7.1.7	Y	7.2.7	Y
External short-circuit	7.1.8	Y	7.2.8	Y
Drop	7.1.9	Y	7.2.9	Y
Thermal abuse	7.1.10	Y	7.2.10	Y
Crush	7.1.11	Y	–	–

NOTE "Y" indicates that the test is required: the sample number is at least one.

7 Specific requirements and tests

7.1 Specific requirements and tests for automotive battery

7.1.1 General

Subclause 7.1 specifies the test procedure and requirements for an automotive battery.

7.1.2 Charging procedure for test purposes

Prior to charging, the battery shall be discharged at $25\text{ °C} \pm 5\text{ °C}$ at a constant current of $0,2 I_t$ A, down to the final voltage specified by the battery manufacturer.

Unless otherwise stated in this document, batteries shall be charged, in an ambient temperature of $25\text{ °C} \pm 5\text{ °C}$, using the method declared by the battery manufacturer.

7.1.3 Mechanical shock [intended use]

a) Requirements

An impact to the battery as specified in Table 2 shall not cause a fire or an explosion.

b) Test

Step 1 – The battery shall be fully charged in accordance with 7.1.2.

Step 2 – The battery shall be subjected to the mechanical shock parameters shown in Table 2. Acceleration from the shock in the test shall be applied in the same direction as the acceleration of the shock that occurs in the vehicle. If the direction of the effect is not known, the battery shall be tested in all six spatial directions.

The test shall end with an observation period of 1 h at the ambient temperature conditions of the test environment.

Table 2 – Mechanical shock test – parameters

Parameter	Value
Pulse shape	half-sinusoidal
Acceleration	500 m/s ²
Duration	6 ms
Number of shocks	10 per test direction

If more severe test parameters are requested by the vehicle manufacturer, such test conditions can be applied.

c) Acceptance criteria

No fire, no explosion.

7.1.4 Vibration [intended use]

a) Requirements

Vibration to the battery as specified in Table 3 shall not cause a fire or an explosion.

b) Test

Step 1 – The battery shall be fully charged in accordance with 7.1.2.

Step 2 – The battery shall be subjected to a vibration having a sinusoidal waveform with a logarithmic sweep between 7 Hz and 50 Hz and back to 7 Hz traversed in 15 min. This cycle shall be repeated 12 times for a total of 3 h in the same direction as the acceleration of the shock that occurs in the vehicle. If the direction of the effect is not known, the battery shall be tested in X, Y and Z directions. The correlation between frequency and acceleration shall be as shown in Table 3.

The test shall end with an observation period of 1 h at the ambient temperature conditions of the test environment.

Table 3 – Frequency and acceleration

Frequency, <i>f</i> Hz	Acceleration
$7 \leq f < 18$	10 m/s ²
$18 \leq f < 30$	Gradually reduced from 10 to 2 m/s ²
$30 \leq f < 50$	2 m/s ²

At the request of the vehicle manufacturer, a higher acceleration level as well as a higher maximum frequency can be used.

c) Acceptance criteria

No fire, no explosion.

7.1.5 Thermal cycling [intended use]

a) Requirements

Rapid temperature changes shall not cause a fire or an explosion.

b) Test

Step 1 – The battery shall be fully charged in accordance with 7.1.2.

Step 2 – The battery shall be stored for at least 6 h at a test temperature equal to $60\text{ °C} \pm 2\text{ °C}$ or higher if requested by the vehicle manufacturer, followed by storage for at least 6 h at a test temperature equal to $-40\text{ °C} \pm 2\text{ °C}$ or lower if requested by the vehicle manufacturer. The maximum time interval between test temperature extremes shall be 30 min. This procedure shall be repeated until a minimum of five total cycles are completed, after which the battery shall be stored for 24 h at an ambient temperature of $25\text{ °C} \pm 5\text{ °C}$.

The test shall end with an observation period of 1 h at the ambient temperature conditions of the test environment.

c) Acceptance criteria

No fire, no explosion.

7.1.6 Overcharge [reasonably foreseeable misuse]

a) Requirements

Overcharging the battery shall not cause a fire or an explosion.

b) Test

Step 1 – The battery shall be fully charged in accordance with 7.1.2.

Step 2 – The battery shall be charged with charge current of at least $1/3 I_t$ A but not exceeding the maximum charging current within the normal operating range as specified by the battery manufacturer. The charging shall be continued until the operation of the protection function of the battery interrupts or limits the charging. If there is no such function, the charging shall be continued until the voltage of the tested device reaches 200 % of the maximum voltage specified by the battery manufacturer.

The test shall end with an observation period of 1 h at the ambient temperature conditions of the test environment.

c) Acceptance criteria

No fire, no explosion.

7.1.7 Overdischarge [reasonably foreseeable misuse]

a) Requirements

Overdischarging and the subsequent recharging of the battery shall not cause a fire or an explosion.

b) Test

Step 1 – The battery shall be fully charged in accordance with 7.1.2.

Step 2 – The battery shall then be discharged in the same ambient temperature at $1 I_t$ A to the final voltage specified by the battery manufacturer.

Step 3 – The battery shall then be discharged with constant current of $1 I_t$ A. The discharging shall be continued until the operation of the protection function of the battery interrupts or limits the discharging. If there is no such function, the discharging shall be continued for 90 min. If the voltage in discharge reaches the target voltage shown below within the test period, the voltage shall be kept at the target voltage by reducing the current for the remaining test period. The target voltage is determined as follows:

$$U_t = -U_{lim}$$

where

U_t is the target voltage;

U_{lim} is the upper limit charging voltage specified by the battery manufacturer.

Step 4 – The battery shall then be recharged using the method declared by the battery manufacturer if the protective function of battery cannot prevent recharging. The charging

shall be continued until the voltage of the test device reaches the maximum voltage specified by the battery manufacturer. The maximum charging time is 3 h.

The test shall end with an observation period of 1 h at the ambient temperature conditions of the test environment.

c) Acceptance criteria

No fire, no explosion.

7.1.8 External short-circuit [reasonably foreseeable misuse]

a) Requirements

Short-circuit between the positive and negative terminals shall not cause a fire or an explosion.

b) Test

Step 1 – The battery shall be fully charged in accordance with 7.1.2.

Step 2 – The positive and negative terminals of the tested-device shall be connected to each other to produce a short-circuit. The connection used for this purpose shall have a resistance not exceeding 5 mΩ. The short-circuit condition shall be continued until the operation of the protection function of battery to interrupt or limit the short-circuit current is confirmed, or for at least 1 h after the temperature measured on the battery surface has stabilized, such that the temperature gradient varies by less than 4 °C during this 1 h.

c) Acceptance criteria

No fire, no explosion.

7.1.9 Drop [reasonably foreseeable misuse]

a) Requirements

Dropping the battery shall not cause a fire or an explosion.

b) Test

Step 1 – The battery shall be fully charged in accordance with 7.1.2.

Step 2 – The battery shall be dropped three times from a height of 100,0 cm ± 5,0 cm onto a flat concrete or metal floor. In the case of a metal floor, external short-circuits of the battery with the floor should be avoided by appropriate measures. The battery is dropped so as to obtain impacts in random orientations.

Step 3 – After the test, the test units shall be put on rest for a minimum of 1 h and then a visual inspection shall be performed.

c) Acceptance criteria

No fire, no explosion.

7.1.10 Thermal abuse [reasonably foreseeable misuse]

a) Requirements

An elevated temperature exposure shall not cause a fire or an explosion.

b) Test

Step 1 – The battery shall be fully charged in accordance with 7.1.2.

Step 2 – The battery shall be placed in an oven. The oven temperature shall be raised at a rate of 5 °C/min ± 2 °C/min to a temperature of 85 °C ± 5 °C.

Step 3 – The battery shall remain at this temperature for 3 h before removal from the heat.

The test shall end with an observation period of 1 h at the ambient temperature conditions of the test environment.

c) Acceptance criteria

No fire, no explosion.

7.1.11 Crush [reasonably foreseeable misuse]

a) Requirements

Contact force to the battery as mentioned below shall not cause a fire or an explosion.

b) Test

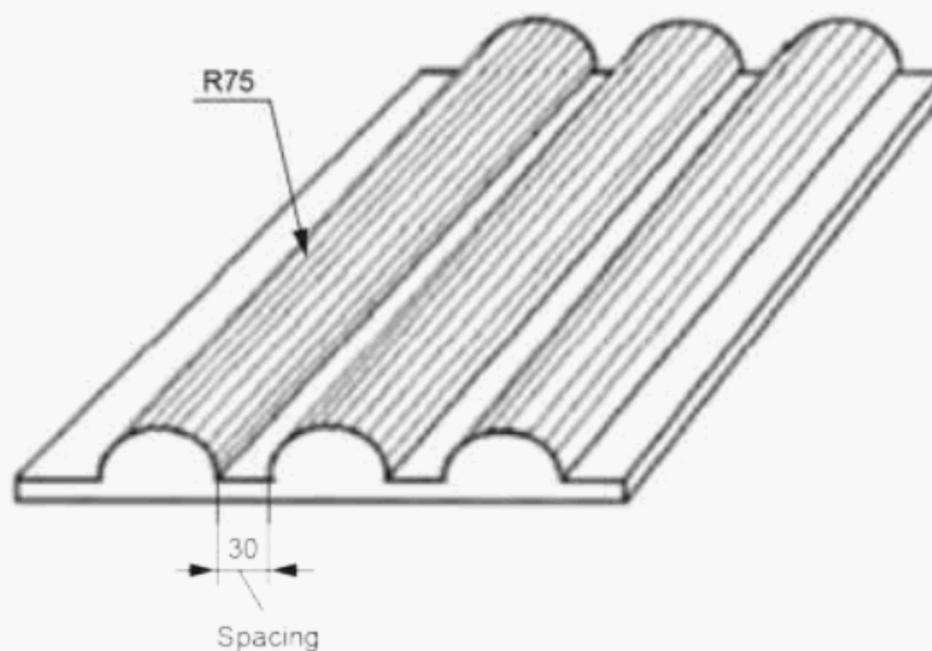
If vehicle structures surrounding the battery are specified by the vehicle manufacturer, the vehicle structures may be included in the test.

Step 1 – The battery shall be fully charged in accordance with 7.1.2.

Step 2 – The battery shall be crushed between a resistance and a crush plate as described in Figure 2 with a force of at least 100 kN, but not exceeding 105 kN, with an onset time of less than 3 min and a hold time of at least 100 ms but not exceeding 10 s. The force for the crushing shall be applied in the same direction as the acceleration of the shock that occurs in the vehicle. If the direction of the effect is not known, the battery shall be tested in all six spatial directions. A higher crush force, a longer onset time, a longer hold time, or a combination of these, may be applied at the request of the vehicle manufacturer.

The test shall end with an observation period of 1 h at the ambient temperature conditions of the test environment.

Dimensions in millimetres



Dimensions of the crush plate: 600 mm × 600 mm area of the battery under test.

Figure 2 – Dimensions of the crush plate

c) Acceptance criteria

No fire, no explosion.

7.2 Specific requirements and tests for moped and motorcycle battery

7.2.1 General

Subclause 7.2 specifies the test procedure and requirements for a moped and motorcycle battery.

7.2.2 Charging procedure for test purposes

Prior to charging, the battery shall be discharged at $25\text{ °C} \pm 5\text{ °C}$ at a constant current of $0,2 I_t$ A, down to the final voltage specified by the battery manufacturer.

Unless otherwise stated in this document, batteries shall be charged, in an ambient temperature of $25\text{ °C} \pm 5\text{ °C}$, using the method declared by the battery manufacturer.

7.2.3 Mechanical shock [intended use]

a) Requirements

An impact to the battery as specified in Table 4 and Table 5 shall not cause a fire or an explosion.

b) Test

Step 1 – The battery shall be fully charged in accordance with 7.2.2.

Step 2 – The battery shall be subjected to the mechanical shock parameters shown in Table 4 or Table 5. Acceleration from the shock in the test shall be applied in the same direction as the acceleration of the shock that occurs in the vehicle. If the direction of the effect is not known, the battery shall be tested in all six spatial directions.

The test shall end with an observation period of 1 h at the ambient temperature conditions of the test environment.

**Table 4 – Mechanical shock test – parameters
(gross mass of the battery less than 12 kg)**

Parameter	Value
Pulse shape	half-sinusoidal
Acceleration	1500 m/s ²
Duration	6 ms
Number of shocks	3 per test direction

**Table 5 – Mechanical shock test – parameters
(gross mass of the battery of 12 kg or more)**

Parameter	Value
Pulse shape	half-sinusoidal
Acceleration	500 m/s ²
Duration	11 ms
Number of shocks	3 per test direction

If more severe test parameters are requested by the vehicle manufacturer, such test conditions may be applied.

c) Acceptance criteria

No fire, no explosion.

7.2.4 Vibration [intended use]

a) Requirements

Vibration to the battery as specified in Table 6 shall not cause a fire or an explosion.

b) Test

Step 1 – The battery shall be fully charged in accordance with 7.2.2.

Step 2 – The battery shall be subjected to a vibration having a sinusoidal waveform with a logarithmic sweep between 7 Hz 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 in the same direction as the acceleration of the shock that occurs in the vehicle. If the direction of the effect is not known, the battery shall be tested in X, Y and Z directions. The correlation between frequency and acceleration shall be as shown in Table 6 or Table 7.

The test shall end with an observation period of 1 h at the ambient temperature conditions of the test environment.

**Table 6 – Frequency and acceleration
(gross mass of the battery less than 12 kg)**

Frequency, f Hz	Acceleration
$7 \leq f < 18$	10 m/s ²
18 Hz to approximately 50 Hz ^a	Gradually increased from 10 m/s ² to 80 m/s ²
$50 \leq f < 200$	80 m/s ²
^a The amplitude is then maintained at 0,8 mm (1,6 mm total excursion) and the frequency is increased until the maximum acceleration as described in Table 6 occurs.	

**Table 7 – Frequency and acceleration
(gross mass of the battery of 12 kg or more)**

Frequency, f Hz	Acceleration
$7 \leq f < 18$	10 m/s ²
18 Hz to approximately 25 Hz ^a	Gradually increased from 10 m/s ² to 20 m/s ²
$25 \leq f < 200$	20 m/s ²
^a The amplitude is then maintained at 0,8 mm (1,6 mm total excursion) and the frequency is increased until the maximum acceleration as described in Table 7 occurs.	

At the request of the vehicle manufacturer, a higher acceleration level as well as a higher maximum frequency may be used.

c) Acceptance criteria

No fire, no explosion.

7.2.5 Thermal cycling [intended use]

a) Requirements

Rapid temperature changes shall not cause a fire or an explosion.

b) Test

Step 1 – The battery shall be fully charged in accordance with 7.2.2.

Step 2 – The battery shall be stored for at least 6 h at a test temperature equal to 60 °C ± 2 °C or higher if requested by the vehicle manufacturer, followed by storage for at least 6 h at a test temperature equal to –40 °C ± 2 °C or lower if requested by the vehicle manufacturer. The maximum time interval between test temperature extremes shall be 30 min. This procedure shall be repeated until a minimum of five total cycles are completed, after which the battery shall be stored for 24 h at an ambient temperature of 25 °C ± 5 °C.

The test shall end with an observation period of 1 h at the ambient temperature conditions of the test environment.

c) Acceptance criteria

No fire, no explosion.

7.2.6 Overcharge [reasonably foreseeable misuse]

a) Requirements

Overcharging the battery shall not cause a fire or an explosion.

b) Test

Step 1 – The battery shall be fully charged in accordance with 7.2.2.

Step 2 – The battery shall be charged with charge current of at least $1/3 I_t$ A but not exceeding the maximum charging current within the normal operating range as specified by the battery manufacturer. The charging shall be continued until the operation of the protection function of the battery interrupts or limits the charging. If there is no such function, the charging shall be continued until the voltage of the tested device reaches 200 % of the maximum voltage specified by the battery manufacturer.

The test shall end with an observation period of 1 h at the ambient temperature conditions of the test environment.

c) Acceptance criteria

No fire, no explosion.

7.2.7 Overdischarge [reasonably foreseeable misuse]

a) Requirements

Overdischarging and the subsequent recharging of the battery shall not cause a fire or an explosion.

b) Test

Step 1 – The battery shall be fully charged in accordance with 7.2.2.

Step 2 – The battery shall then be discharged in the same ambient temperature at $1 I_t$ A to the final voltage specified by the battery manufacturer.

Step 3 – The battery shall then be discharged with constant current of $1 I_t$ A. The discharging shall be continued until the operation of the protection function of the battery interrupts or limits the discharging. If there is no such function, the discharging shall be continued for 90 min. If the voltage in discharge reaches the target voltage shown below within the test period, the voltage shall be kept at the target voltage by reducing the current for the remaining test period. The target voltage is determined as follows:

$$U_t = -U_{lim}$$

where

U_t is the target voltage;

U_{lim} is the upper limit charging voltage specified by the battery manufacturer.

Step 4 – The battery shall then be recharged using the method declared by the battery manufacturer if the protective function of battery cannot prevent recharging. The charging shall be continued until the voltage of the test device reaches the maximum voltage specified by the battery manufacturer. The maximum charging time is 3 h. The test shall end with an observation period of 1 h at the ambient temperature conditions of the test environment.

c) Acceptance criteria

No fire, no explosion.

7.2.8 External short-circuit [reasonably foreseeable misuse]

a) Requirements

Short-circuit between the positive and negative terminals shall not cause a fire or an explosion.

b) Test

Step 1 – The battery shall be fully charged in accordance with 7.2.2.

Step 2 – The positive and negative terminals of the tested device shall be connected to each other to produce a short-circuit. The connection used for this purpose shall have a resistance not exceeding 5 mΩ. The short-circuit condition shall be continued until the operation of the protection function of the battery to interrupt or limit the short-circuit current is confirmed, or for at least 1 h after the temperature measured on the battery surface has stabilized, such that the temperature gradient varies by less than 4 °C during this 1 h.

- c) Acceptance criteria
No fire, no explosion.

7.2.9 Drop [reasonably foreseeable misuse]

- a) Requirements

Dropping the battery shall not cause a fire or an explosion.

- b) Test

Step 1 – The battery shall be fully charged in accordance with 7.2.2.

Step 2 – The battery shall be dropped three times from a height of 100,0 cm \pm 5,0 cm onto a flat concrete or metal floor. In the case of a metal floor, an external short-circuit of the battery with the floor should be avoided by appropriate measures. The battery is dropped so as to obtain impacts in random orientations.

Step 3 – After the test, the test units shall be put on rest for a minimum of 1 h and then a visual inspection shall be performed.

- c) Acceptance criteria
No fire, no explosion.

7.2.10 Thermal abuse [reasonably foreseeable misuse]

- a) Requirements

An elevated temperature exposure shall not cause a fire or an explosion.

- b) Test

Step 1 – The battery shall be fully charged in accordance with 7.2.2.

Step 2 – The battery shall be placed in an oven. The oven temperature shall be raised at a rate of 5 °C/min \pm 2 °C/min to a temperature of 85 °C \pm 5 °C.

Step 3 – The battery shall remain at this temperature for 3 h before removal from the heat.

The test shall end with an observation period of 1 h at the ambient temperature conditions of the test environment.

- c) Acceptance criteria
No fire, no explosion.

8 Information for safety

The use, and particularly abuse, of secondary lithium batteries can result in the creation of hazards and can cause harm. The battery manufacturer shall provide information about current, voltage and temperature limits of their products. The battery manufacturer shall provide information to mitigate hazards to equipment manufacturers and, in the case of direct sales, to end-users. It is the equipment manufacturer's responsibility to inform end-users of the potential hazards arising from the use of equipment containing secondary lithium batteries.

Information shall be provided for proper installation in the end-use application, charging instructions, and instructions for safe removal and disposal of these batteries. The instructions' wording and details provided shall consider the end-use handling of the battery, whether it is for installation by technicians in the end-use equipment or whether it is for direct sale for installation by the end user.

Bibliography

IEC 62281, *Safety of primary and secondary lithium cells and batteries during transport*

IEC 62620:2014, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Secondary lithium cells and batteries for use in industrial applications*

IEC 63118, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Performance of secondary lithium batteries for use in road vehicles not for the propulsion*¹

ISO 9001, *Quality management systems – Requirements*

United Nations: *Recommendations on the Transport of Dangerous Goods, Manual of Tests and Criteria, Section 38.3: Lithium Batteries*

¹ Under preparation. Stage at the time of publication: IEC CD 63118:2018.

