



NEW WORK ITEM PROPOSAL

Proposer Germany	Date of proposal 2000-06
TC/SC 35	Secretariat Japan
Date of circulation 2000-07-07	Closing date for voting 2000-10-16

A proposal for a new work item within the scope of an existing technical committee or subcommittee shall be submitted to the Central Office. The proposal will be circulated to the P-members of the technical committee or subcommittee for voting, and to the O-members for information. The proposer may be a National Committee of the IEC, the secretariat itself, another technical committee or subcommittee, an organization in liaison, the Committee of Action or one of the advisory committees, or the General Secretary. Guidelines for proposing and justifying a new work item are given in ISO/IEC Directives, Part 1, Annex C (see extract overleaf). **This form is not to be used for amendments or revisions to existing publications.**

The proposal (to be completed by the proposer)

Title of proposal		
SAFETY OF LITHIUM BATTERIES DURING TRANSPORT		
<input checked="" type="checkbox"/> Standard	<input type="checkbox"/> Technical Report	
Scope (as defined in ISO/IEC Directives, Part 3, 6.2.1)		
This International Standard specifies test methods and requirements for primary and secondary lithium batteries to ensure their safety during transport.		
Purpose and justification , including the market relevance and relationship to Safety (Guide 104), EMC (Guide 107), Environmental aspects (Guide 109) and Quality assurance (Guide 102) . (attach a separate page as annex, if necessary) Lithium batteries were first introduced in military applications in the 1970's. At that time, little commercial interest and no industrial standards existed. Consequently, the United Nations (UN), although having a tendency to refer to industrial standards for testing and criteria, introduced a sub-section in the Manual of tests and criteria, dealing with safety tests of lithium batteries relevant to transport. Meanwhile, commercial interest in lithium batteries is large and several industrial standards exist. However, the existing IEC standards are manifold, not completely harmonized, and not necessarily relevant to transport. They are not suitable to be referred to in the UN Model Regulations. It is therefore proposed to create a new group safety standard, harmonizing the tests and requirements relevant to transport.		
Target date	for first CD 2000	for IS 2002
Estimated number of meetings 4-8	Frequency of meetings 2-4 per year	Date and place of first meeting:
Proposed working methods	<input checked="" type="checkbox"/> E-mail	<input type="checkbox"/> ftp
Relevant documents to be considered		
1) UN Recommendations on the Transport of Dangerous Goods, Manual of Tests and Criteria, 3 rd revised edition 2) UN INF paper 7, Lithium Batteries, www.unece.org/trans/danger/meetings/ecosoc/1999_12/infpape.htm 3) IEC 60086-4, Ed. 2, PRIMARY BATTERIES – Part 4: Safety of lithium batteries 4) IEC 61960-1, – Part 1: Secondary lithium cells (to be published) 5) IEC 61960-2, – Part 2: Secondary lithium batteries (to be published)		
Relationship of project to activities of other international bodies		
The subject of the proposed new standard is basically contained in sub-section 38.3 of the UN Manual of Tests and Criteria. However, it seems that the UN subcommittee of experts supports an IEC standard to replace it.		
Liaison organizations	Need for coordination within ISO or IEC	
United Nations subcommittee of experts on the transport of dangerous goods	JWG21/21A (Aircraft Batteries) and JWG21A/69 (Batteries for Electric Vehicles)	
Preparatory work		
Check one of the two following boxes <input checked="" type="checkbox"/> A draft is attached for vote and comment <input type="checkbox"/> An outline is attached We nominate a project leader as follows in accordance with ISO/IEC Directives, Part 1, 2.3.4 (name, address, fax and e-mail): Thomas Dittrich, Sonnenschein Lithium GmbH, Industriestr. 22, D-63654 Büdingen, Germany, Tel.: +49(6042)81-469, Fax: +49(6042)81-483, E-mail: dittrich@sonnenschein-lithium.de		
Concerns known patented items (see ISO/IEC Directives, Part 2)	Name and/or signature of the proposer	
<input type="checkbox"/> yes <input checked="" type="checkbox"/> no If yes, provide full information as an annex	German National Committee	

Comments and recommendations from the TC/SC officers

Comments with respect to the proposal in general, and recommendations thereon
1) Work allocation <input type="checkbox"/> Project team <input checked="" type="checkbox"/> New working group <input type="checkbox"/> Existing working group no:
2) Draft suitable for direct submission as <input type="checkbox"/> CD <input type="checkbox"/> CDV
3) General quality of the draft (conformance with ISO/IEC Directives, Part 3) <input type="checkbox"/> Little redrafting needed <input type="checkbox"/> Substantial redrafting needed <input type="checkbox"/> no draft (outline only)
4) Relationship with other activities In IEC National Committees are requested to nominate experts from both TC 35 and SC 21A In other organizations
Other remarks
Remarks from the TC/SC officers The officers of TC35 strongly support this proposed new work. In the current climate, the safe transportation of lithium batteries, both primary and secondary, has received a tremendous amount of attention in such important organizations as the United Nations and the United States Department of Transportation. The proposed new work is the most ambitious attempt to date to unify and harmonize lithium transportation safety testing and information for all portable lithium batteries into a comprehensive standard. When complete, it could easily be the most definitive work of its kind and, hopefully, should become the global standard of choice.
Remarks from the Sector Board

Elements to be clarified when proposing a new work item**Title**

Indicate the subject matter of the proposed new standard.

Indicate whether it is intended to prepare a standard, a technical report or an amendment to an existing standard.

Scope

Give a clear indication of the coverage of the proposed new work item and, if necessary for clarity, exclusions.

Indicate whether the subject proposed relates to one or more of the fields of safety, EMC, the environment or quality assurance.

Purpose and justification

Give details based on a critical study of the following elements wherever practicable.

- a) The specific aims and reason for the standardization activity, with particular emphasis on the aspects of standardization to be covered, the problems it is expected to solve or the difficulties it is intended to overcome.
- b) The main interests that might benefit from or be affected by the activity, such as industry, consumers, trade, governments, distributors.
- c) Feasibility of the activity: Are there factors that could hinder the successful establishment or general application of the standard?
- d) Timeliness of the standard to be produced: Is the technology reasonably stabilized? If not, how much time is likely to be available before advances in technology may render the proposed standard outdated? Is the proposed standard required as a basis for the future development of the technology in question?
- e) Urgency of the activity, considering the needs of the market (industry, consumers, trade, governments etc.) as well as other fields or organizations. Indicate target date and, when a series of standards is proposed, suggest priorities.
- f) The benefits to be gained by the implementation of the proposed standard; alternatively, the loss or disadvantage(s) if no standard is established within a reasonable time. Data such as product volume or value of trade should be included and quantified.
- g) If the standardization activity is, or is likely to be, the subject of regulations or to require the harmonization of existing regulations, this should be indicated.

If a series of new work items is proposed, the purpose and justification of which is common, a common proposal may be drafted including all elements to be clarified and enumerating the titles and scopes of each individual item.

Relevant documents

List any known relevant documents (such as standards and regulations), regardless of their source. When the proposer considers that an existing well-established document may be acceptable as a standard (with or without amendments), indicate this with appropriate justification and attach a copy to the proposal.

Cooperation and liaison

List relevant organizations or bodies with which cooperation and liaison should exist.

Preparatory work

Indicate the name of the project leader nominated by the proposer.

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

SAFETY OF LITHIUM BATTERIES DURING TRANSPORT

FOREWORD

- 1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of the IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested National Committees.
- 3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical specifications, technical reports or guides and they are accepted by the National Committees in that sense.
- 4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.
- 5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.
- 6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC XXX has been prepared by subcommittee XX, of IEC technical committee XX:

The text of this standard is based on the following documents:

FDIS	Report on voting
XX/XX/FDIS	XX/XX/RVD

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 3.

The committee has decided that the contents of this publication will remain unchanged until _____. At this date, the publication will be

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

INTRODUCTION

Lithium batteries were first introduced in military applications in the 1970's. At that time, little commercial interest and no industrial standards existed. Consequently, the United Nations (UN), although having a tendency to refer to industrial standards for testing and criteria, introduced a sub-section in the Manual of tests and criteria, dealing with safety tests of lithium batteries relevant to transport. Meanwhile, commercial interest in lithium batteries is large and several industrial standards exist. However, the existing IEC standards are manifold, not completely harmonized, and not necessarily relevant to transport. They are not suitable to be referred to in the UN Model Regulations. It is therefore proposed to create a new group safety standard, harmonizing the tests and requirements relevant to transport.

This International Standard applies to cells and batteries containing lithium in any form, including lithium metal and lithium alloy chemistries and lithium-ion chemistries. Lithium metal and lithium alloy chemistries use metallic lithium and lithium alloy, respectively, as the negative electrode. Lithium-ion chemistries use intercalation compounds (intercalated lithium exists in an ionic or quasi-atomic form within the lattice of the electrode material) in the positive and negative electrodes. This International Standard also applies to lithium polymer cells and batteries, which are considered either as lithium metal or as lithium-ion cells and batteries, depending on the nature of the material used in the negative electrode.

The history of transporting lithium cells and batteries is worth noting. Since the 1970's, over ten billion primary lithium cells/batteries have been transported, and since the early 1990's, over one billion rechargeable lithium cells/batteries utilizing lithium-ion chemistries have been transported.

As the numbers of lithium batteries being transported are increasing, it is appropriate to include the safety testing of packaging for transport.

1 Scope

This International Standard specifies test methods and requirements for primary and secondary lithium cells and batteries as well as their packaging to ensure their safety during transport.

2 Normative References

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60086-4:2000, *Primary batteries – Part 4: Safety of lithium batteries*

IEC 61960-1, *Secondary cells and batteries containing alkaline or other non-acid electrolytes, secondary lithium cells and batteries for portable applications – Part 1: Secondary lithium cells* (to be published)

IEC 61960-2, *Secondary cells and batteries containing alkaline or other non-acid electrolytes, secondary lithium cells and batteries for portable applications – Part 2: Secondary lithium batteries* (to be published)

3 Definitions

3.1

battery

unit comprising one or more cells including case, terminals, marking and protective devices as necessary for use

NOTE, referring to the English version:

This definition reflects the use of the term battery in a majority of countries. However, “battery” comes from the French word “*batterie*” designating a set of objects. Consequently, the French term “*batterie*” applies only to batteries comprising two or more cells. When referring to a battery with only one cell, the French terms “*pile*” for a primary battery or “*accumulateur*” for a secondary battery are used.

3.2

battery, button (button battery)

small round battery, where the overall height is less than the diameter

[adapted from IEC 60086-4:2000]

3.3

battery, round (round battery)

battery with round geometry where the overall height is equal to or greater than the diameter

[adapted from IEC 60086-4:2000]

3.4

battery, prismatic (prismatic battery)

battery with non-round geometry.

[adapted from IEC 60086-4:2000]

3.5

capacity, rated (rated capacity)

capacity of a battery determined under conditions specified in the relevant standard (if applicable) and declared by the manufacturer or supplier. Also sometimes referred to as Nominal capacity.

[IEC 60086-4:2000]

3.6

cell

a single encased electrochemical unit designed to serve as a source of electrical energy in a battery

3.7

deep cycle

one sequence of fully charging and fully discharging a secondary cell or battery.

[adapted from UNSCETDG/17/INF7]

3.8

depth of discharge (DOD)

percentage of rated capacity discharged from a battery.

[IEC 60086-4:2000]

3.9

first cycle

the initial cycle of a secondary cell or battery following completion of all manufacturing processes.

[UNSCETDG/17/INF7]

3.10

fully charged

state of charge of a secondary cell or battery corresponding to 0 % depth of discharge

3.11

fully discharged

state of charge of a cell or battery corresponding to 100 % depth of discharge

3.12

primary cell or battery

a cell or battery which is not designed to be electrically recharged. Also referred to as non-rechargeable cell or battery

[adapted from UNSCETDG/17/INF7]

3.13

protective devices

devices such as fuses, diodes or other electric or electronic current limiters designed to interrupt the current flow, block the current flow in one direction or limit the current flow in an electrical circuit

[adapted from UNSCETDG/17/INF7]

3.14

secondary cell or battery

a cell or battery which is designed to be electrically recharged. Also referred to as rechargeable cell or battery

[UNSCETDG/17/INF7]

3.15

recommended charge current

specified current, recommended by the manufacturer, to which a cell can be subjected, during constant current charge for optimum performance and safety.

[IEC 61960, to be published]

3.16 undischarged

state of charge of a primary battery corresponding to 0 % depth of discharge

3.17 voltage, open circuit (open circuit voltage, OCV)

voltage across the terminals of a cell or battery when no external current is flowing.

[IEC 60086-4:2000]

4 Requirements for Safety

4.1 Battery design

Lithium batteries are categorized by their chemical composition (anode, cathode, electrolyte), internal construction (bobbin, spiral) and are available in round, button/coin, and prismatic configuration. It is necessary to consider all relevant safety aspects at the battery design stage, recognizing the fact that they may differ considerably, depending on the specific lithium system, power output and battery configuration.

The following design concepts for safety are common to all lithium batteries:

- a) Abnormal temperature rise above the critical value defined by the manufacturer shall be prevented by design.
- b) Temperature increases in the battery shall be controlled by a design which limits current flow.
- c) Lithium cells and batteries shall be designed to relieve excessive internal pressure or to preclude a violent rupture under conditions of transport.
- d) Lithium cells and batteries shall be designed so as to prevent a short circuit under conditions of transport and intended use.
- e) Lithium cells and batteries containing a liquid cathode shall be hermetically sealed.
- f) Lithium batteries containing cells or strings of cells connected in parallel shall be equipped with effective means, in so far as it is necessary, to prevent dangerous reverse current flow (e. g., diodes, fuses, etc.).

4.2 Lithium batteries in equipment

Lithium batteries offered for transport in equipment that is likely to be used during transport shall be subjected to the appropriate tests:

Primary lithium batteries shall be subjected to the applicable overdischarge tests described in IEC 60086-4;

Secondary lithium batteries shall be subjected to the overdischarge / overcharge test described in IEC 61960-2.

Equipment that contains lithium batteries and is likely to be used during transport should comply with the recommendations for the design of equipment given in IEC 60086-4 and IEC 61960-2.

4.3 Packaging

- a) Lithium cells and batteries shall be packaged so as to prevent an external short circuit or crushing under conditions of transport.
- b) The packaging shall provide for separation between individual cells or batteries as necessary to prevent short circuits.
- c) The packaging shall be chosen so as to prevent corrosion of the terminals.

5 Sampling and occasions for testing

5.1 Sampling

Samples shall be taken randomly from production lots in accordance with accepted quality control procedures. The number of samples is given Table 1 below.

Table 1 – Number of test cells and batteries

Primary cells and batteries						
Number of samples for tests T-1 to T-5	Cells		Batteries			
	undischarged	fully discharged	undischarged		fully discharged	
	10 cells	10 cells	4 batteries ^a		4 batteries ^a	
Number of samples for test T-6	Cells		Batteries built from round and button component cells		Batteries built from prismatic component cells	
	undischarged	fully discharged	undischarged	fully discharged	undischarged	fully discharged
	5 cells	5 cells	5 component cells	5 component cells	10 component cells	10 component cells
Secondary cells and batteries						
Number of samples for tests T-1 to T-5	Cells		Batteries			
	first cycle, fully charged	first cycle, fully discharged	first cycle, fully charged	first cycle, fully discharged	after 50 deep cycles, fully charged	after 50 deep cycles, fully discharged
	10 cells	10 cells	4 batteries ^a	4 batteries ^a	4 batteries ^a	4 batteries ^a
Number of samples for test T-6	Cells		Batteries built from round and button component cells		Batteries built from prismatic component cells	
	first cycle, transport state of charge ^b	after 50 deep cycles, fully discharged	first cycle, transport state of charge ^b	after 50 deep cycles, fully discharged	first cycle, transport state of charge ^b	after 50 deep cycles, fully discharged
	5 cells	5 cells	5 component cells	5 component cells	10 component cells	10 component cells
^a When testing batteries, the number of test batteries shall at least be such that the number of component cells contained in the test batteries equals the number of test cells required for that test.						
^b State of charge, when the cells or batteries are transported, usually 50 % DOD.						

5.2 Test repetition

5.2.1 New type

Lithium cells or batteries which differ from a tested type by:

- d) a change of more than 20% by mass to the cathode, to the anode, or to the electrolyte, or
- e) a change that would materially affect the test results

shall be considered a new type and shall be subject to the required tests.

5.2.2 Re-testing

In the event that a lithium cell or battery type does not meet the test requirements, steps shall be taken to correct the deficiency or deficiencies that caused the failure before such a cell or battery is re-tested.

6 Testing and requirements

6.1 General

6.1.1 Safety notice

WARNING:

These tests call for the use of procedures which may result in injury if adequate precautions are not taken.

It has been assumed in the drafting of these tests that their execution is undertaken by appropriately qualified and experienced technicians using adequate protection.

6.1.2 Ambient temperature

Unless otherwise specified the tests shall be carried out at (20 ± 5) °C.

6.1.3 Predischarge and precycling

Where it is required to discharge test cells or batteries prior to a test, they shall be discharged to the respective depth of discharge with a resistive load with which the rated capacity is obtained or with a current specified by the manufacturer.

Where it is required to cycle secondary test cells or batteries prior to a test, they shall be cycled using the charge and discharge current recommended by the manufacturer, to which the cells and batteries can be subjected during constant current charge and discharge for optimum performance and safety.

6.2 Evaluation of test criteria

6.2.1 Shifting

Shifting is considered to have occurred during a test if one or more test cells or batteries are released from the packaging, do not retain their original orientation, or are affected in such a way that the occurrence of an external short circuit or crushing cannot be excluded.

6.2.2 Distortion

Distortion is considered to have occurred if during a test a physical dimension changes by more than 10 %.

6.2.3 Short circuit

A short circuit is considered to have occurred during a test if the open circuit voltage of the cell or battery after the test is less than 90% of its voltage immediately prior to the test. This criterion is not applicable to test cells and batteries at fully discharged states.

6.2.4 Excessive temperature rise

An excessive temperature rise is considered to have occurred during a test if the wall temperature of the test cell or battery rises above 170 °C.

NOTE: Aircraft fire suppression systems employing Halon are designed to keep cargo environments below 204 °C. At higher temperatures, items such as packaging materials may begin to thermally decompose and further contribute to the incident.

6.2.5 Leakage

Leakage is considered to have occurred during a test if electrolyte, gas or other material escapes from the test cell or battery in a manner not intended by design.

6.2.6 Mass loss

In order to quantify mass loss $\Delta m / m$, the following equation is provided.

$$\Delta m / m = \frac{m_1 - m_2}{m_1} \times 100 \%$$

where

m_1 is the mass before the first test in a series

m_2 is the mass after the last test in a series

Mass loss is considered to have occurred if during a series of consecutive tests, all of which are required to result in "No mass loss", the maximum values given in Table 2 below are exceeded.

Table 2 – Maximum mass loss

Mass m of battery	Maximum mass loss $\Delta m / m$ %
$m \leq 1$ g	0,5
1 g $< m \leq 5$ g	0,2
$m > 5$ g	0,1

6.2.7 Venting

Venting is considered to have occurred during a test if excessive internal pressure is released from the test cell or battery in a manner intended by design to preclude explosion.

6.2.8 Fire

A fire is considered to have occurred if, during a test, flames are emitted from the test cell or battery.

6.2.9 Explosion

An explosion is considered to have occurred if, during a test, solid matter from any part of the cell or battery is propelled to a distance greater than 0,25 m away from the cell or battery.

6.3 Test plan

Table 3 contains the requirements for transport and packaging tests.

Table 3 – Transport and packaging tests and requirements

Test	Transport	Requirements	
Transport tests	T-1	Vibration	NM, NL, NV, NC, NE, NF
	T-2	Shock	NM, NL, NV, NC, NE, NF
	T-3	Thermal shock	NM, NL, NV, NC, NE, NF
	T-4	Altitude Simulation	NM, NL, NV, NC, NE, NF
	T-5	External short circuit	NM, NL, NV, NT, NE, NF
	T-6	Crush	NE, NF
Packaging tests	P-1	Drop	NS, ND, NM, NL, NV, NC, NE, NF
Tests T-1 through T-5 shall be conducted in sequence on the same cell or battery.			
Key: NC: No short circuit ND: No distortion NE: No explosion NF: No fire NL: No leakage NM: No mass loss (cumulative) NS: No shifting NT: No excessive temperature rise NV: No venting See 6.2 for a detailed description of the test criteria.			

6.4 Transport tests

6.4.1 Test T-1: Vibration

f) Purpose

This test simulates vibration during transport.

g) Test procedure

Test cells and batteries shall be subjected to simple harmonic motion with an amplitude of 0.8 mm (1.6 mm total maximum excursion). The frequency shall be varied at a rate of 1 Hz/minute between 10 Hz and 55 Hz, and return in no less than 90 minutes and no more than 100 minutes. Each test cell and battery shall be tested in three mutually perpendicular directions.

h) Requirements

See Table 3.

6.4.2 Test T-2: Shock

i) Purpose

This test simulates rough handling during transport.

j) Test procedure

Test cells and batteries shall be secured to the testing machine by means of a rigid mount which will support all mounting surfaces of each test battery. Each test cell and battery shall be subjected to a total of three shocks of equal magnitude. The shocks shall be applied in each of three mutually perpendicular axes. Each shock shall be applied in a direction normal to a face of the test battery. For each shock, the following parameters apply:

When testing cells and batteries up to 0,75 kg, the test cell and battery shall be accelerated in such a manner that during the first 3 ms the minimum average acceleration is $75 g_n$. The peak acceleration shall be between $125 g_n$ and $175 g_n$.

When testing cells and batteries over 0,75 kg, the test cell and battery shall be accelerated in such a manner that the peak acceleration is not less than $50 g_n$ and is attained within 11 ms.

The test shall be conducted using the test cells and batteries previously subjected to the vibration test.

k) Requirements

See Table 3.

6.4.3 Test T-3: Thermal shock

l) Purpose

This test assesses cell and battery seal integrity, and internal electrical connections. The test is conducted using rapid and extreme temperature changes.

m) Test procedure

Test cells and batteries shall be stored for 6 h at a temperature of $(75 \pm 2) ^\circ\text{C}$, followed by storage for 6 h at a temperature of $(-20 \pm 2) ^\circ\text{C}$. The maximum time for transfer to each temperature shall be 5 min when testing cells and batteries up to 0,75 kg and 120 min when testing cells and batteries over 0,75 kg. Each test cell and battery shall undergo this procedure 5 times. This is then followed by storage for at least 24 h at ambient temperature.

The test shall be conducted using the test cells and batteries previously subjected to the shock test.

n) Requirements

See Table 3.

6.4.4 Test T-4: Altitude simulation

o) Purpose

This test simulates air transport under low pressure conditions.

p) Test procedure

Test cells and batteries shall be stored at a pressure of 11,6 kPa or less for at least 6 h at ambient temperature.

The test shall be conducted using the test cells and batteries previously subjected to the thermal shock test.

q) Requirements

See Table 3.

6.4.5 Test T-5: External short circuit

r) Purpose

This test simulates conditions resulting in an external short circuit.

s) Test procedure

The cell or battery to be tested shall be stabilized at (55 ± 2) °C and then subjected to a short circuit condition with a total external resistance of less than $0,1 \Omega$ at (55 ± 2) °C. This short-circuit condition is continued for at least 1 h after the cell or battery case temperature has returned to (55 ± 2) °C.

The test shall be conducted using the test cells and batteries previously subjected to the altitude simulation test.

t) Requirements

See Table 3.

6.4.6 Test T-6: Crush

u) Purpose

This test simulates an internal short circuit.

v) Test procedure

The cell or component cell to be tested shall be crushed between two flat surfaces. The force shall be applied by a vice or by a hydraulic ram with a 32 mm diameter piston. The crushing shall be continued until

- (1) the cell or component cell voltage drops abruptly or is reduced to at least one third, or
- (2) a pressure reading of either 17 MPa (an applied force of approximately 13 kN) or a maximum force of 1000 times the weight of the cell is attained, whichever is greater.

Once the voltage drops abruptly or is reduced to at least one third, or the maximum pressure has been attained, the pressure shall be released.

A round cell or component cell shall be crushed with its longitudinal axis parallel to the flat surfaces of the crushing apparatus. A prismatic cell or component cell shall be crushed by applying the force in the direction of one of the two axes perpendicular to its longitudinal axis, and, separately, with another test cell or component cell, by applying the force in the direction of the other one of these two axes. A button/coin cell shall be crushed by applying force on its flat surfaces.

Each cell or component cell used in the test shall only be crushed once.

The test shall be conducted using test cells or component cells that have not been previously subjected to other transport tests.

w) Requirements

See Table 3.

6.5 Packaging tests

6.5.1 Drop test

x) Purpose

This test assesses the ability of the packaging to prevent damage during rough handling.

y) Test procedure

A package filled with cells or batteries as offered for transport shall be dropped from a height of 1,2 m onto a concrete surface in such a manner that any of its corners first touches the ground.

The test shall be conducted using test cells or batteries that have not been previously subjected to a transport test.

z) Requirements

See Table 3.

6.6 Information to be given in the relevant specification

When this test is included in a relevant specification, the following parameters shall be given in so far as they are applicable, paying particular attention to the items marked with an asterisk (*) as this information is always required.

	Clause and/or subclause
aa) * Charge and discharge current for predischARGE and precycling	6.1.3
bb) * End-of-charge voltage for precycling of secondary batteries	6.1.3
cc) * End-of-discharge voltage for precycling of secondary batteries	6.1.3
dd) Maximum discharge current specified by the manufacturer	4.2
NOTE: This value is needed for the Electrical test D-5 – Overdischarge 1 described in IEC 60086-4:2000.	
ee) Charging method as declared by the manufacturer	4.2

NOTE: This declaration is needed for the Overdischarge /Overcharge test described in IEC 61960-2:(to be published).

6.7 Evaluation and report

A cell or battery type is qualified for transport if it meets all requirements of the relevant tests and a report has been issued.

The report shall contain:

the details of the test cells or batteries according to 4.1 and 4.2;

the actual test program;

the parameters according to 6.6;

the results of each test, and

the conclusions.

7 Information for safety

7.1 Packaging

It is the purpose of the packaging to avoid mechanical damage during transport, handling and stacking. It is particularly important that the packaging prevents crushing of the cells or batteries during rough handling as well as the development of unintentional electrical short circuit and corrosion of the terminals. Crushing or external short circuit can result in leakage, venting, fire, or explosion.

Whenever lithium cells or batteries are sent or re-sent, it is recommended for safety reasons to use the original packaging or packaging that complies with the requirements listed in 4.3.

7.2 Handling of battery cartons

Battery cartons should be handled with care. Rough handling may result in batteries being short circuited or damaged. This may cause leakage, explosion, or fire.

7.3 Transport

7.3.1 General

Regulations concerning international transport of lithium batteries are based on the recommendations of the United Nations Committee of Experts on the transport of dangerous goods, see UN Model Regulations.

Regulations for transport are subject to change. For the transport of lithium batteries, the latest editions of the following regulations must be consulted.

7.3.2 Air transport

Regulations concerning air transport of lithium batteries are specified in Technical Instruction of ICAO (International Civil Aviation Organization). DGR (Dangerous Goods Regulation) is specified by the regulations of ICAO. The International Air Transport Association (IATA) annually publishes Dangerous Goods Regulations.

7.3.3 Sea transport

Regulations concerning sea transport of lithium batteries are specified in IMDG (International Maritime Dangerous Goods) code in IMO (International Maritime Organization).

7.3.4 Inland transport

There are no world-wide international regulations concerning inland transport of lithium batteries. Specific regulations may be defined locally.

7.4 Display and storage

a) *Store batteries in well ventilated, dry and cool conditions*

High temperature or high humidity may cause deterioration of the battery performance and/or surface corrosion.

b) *Do not stack battery cartons on top of each other exceeding a specified height.*

If too many battery cartons are stacked, batteries in the lowest cartons may be deformed and electrolyte leakage may occur.

c) *Avoid storing or displaying batteries in direct sun or in places where they get exposed to rain.*

When batteries get wet, their insulation resistance may be impaired and self-discharge and corrosion may occur. Heat may cause deterioration.

d) *Store and display batteries in their original packing.*

When batteries are unpacked and mixed they may be short circuited or damaged.

8 Instructions for packaging and handling during transport

8.1 Quarantine

Cells or batteries shall not be transported within 7 days of an event which may have damaged the cell or battery or the function of its protective devices unless the cell or battery is visually inspected and its voltage is verified as not having changed due to the event.

9 Marking

9.1 Marking of batteries

The marking of primary lithium cells and batteries should comply with IEC 60086-4. The marking of secondary lithium cells should comply with IEC 61960-1. The marking of secondary lithium batteries should comply with IEC 61960-2.

9.2 Marking of the packaging

A consignment of lithium cells or batteries which exceeds 500 kg and is to be delivered to one destination shall be marked such that the shipping pallet containing the consignment is marked on all four sides with a label that contains the words "Lithium Batteries" and appropriate safety warnings in English as well as the languages of the sender's and receiver's countries. The typeface of each word in the label shall be 3-5 cm in height. (Better create a good UN-compatible pictogram)

Bibliography

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- IEC 60068-2-6:1995, *Environmental testing – Part 2: Tests – Test Fe: Vibration (sinusoidal)*
- IEC 60068-2-27:1987, *Basic environmental testing procedures – Part 2: Tests – Test Ea and guidance: Shock*
- (IEC 61809: check doc #), *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety standard for portable sealed alkaline secondary cells and batteries (in preparation)*
- IMO, *International Maritime Dangerous Goods Code (IMDG)*
- ISO/IEC GUIDE 51, *Guidelines for the inclusion of safety aspects in standards*
- UL 1642, Underwriters Laboratories, *Standard for Lithium Batteries*
- UN Model Regulations, United Nations UN/ST/SG/AC.10/11, *Recommendations on the Transport of Dangerous Goods, Model Regulations (revised biennially)*
- UNSCETDG/17/INF.7, United Nations Sub-Committee of Experts on the Transport of Dangerous Goods, (Seventeenth session, Geneva, 6-17 December 1999, agenda item 5 (c)), *Miscellaneous draft amendments to the model regulations on the transport of dangerous goods, lithium batteries, transmitted by the experts from Canada and Japan*