

# INTERNATIONAL STANDARD

## NORME INTERNATIONALE

---

**Safety of primary and secondary lithium cells and batteries during transport**

**Sécurité des piles et des accumulateurs au lithium pendant le transport**





**THIS PUBLICATION IS COPYRIGHT PROTECTED**  
**Copyright © 2016 IEC, Geneva, Switzerland**

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC de votre pays de résidence.

IEC Central Office  
3, rue de Varembe  
CH-1211 Geneva 20  
Switzerland

Tel.: +41 22 919 02 11  
Fax: +41 22 919 03 00  
[info@iec.ch](mailto:info@iec.ch)  
[www.iec.ch](http://www.iec.ch)

#### About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

#### About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

#### IEC Catalogue - [webstore.iec.ch/catalogue](http://webstore.iec.ch/catalogue)

The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

#### IEC publications search - [www.iec.ch/searchpub](http://www.iec.ch/searchpub)

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, replaced and withdrawn publications.

#### IEC Just Published - [webstore.iec.ch/justpublished](http://webstore.iec.ch/justpublished)

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and also once a month by email.

#### Electropedia - [www.electropedia.org](http://www.electropedia.org)

The world's leading online dictionary of electronic and electrical terms containing 20 000 terms and definitions in English and French, with equivalent terms in 15 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

#### IEC Glossary - [std.iec.ch/glossary](http://std.iec.ch/glossary)

65 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

#### IEC Customer Service Centre - [webstore.iec.ch/csc](http://webstore.iec.ch/csc)

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: [csc@iec.ch](mailto:csc@iec.ch).

#### A propos de l'IEC

La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

#### A propos des publications IEC

Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

#### Catalogue IEC - [webstore.iec.ch/catalogue](http://webstore.iec.ch/catalogue)

Application autonome pour consulter tous les renseignements bibliographiques sur les Normes internationales, Spécifications techniques, Rapports techniques et autres documents de l'IEC. Disponible pour PC, Mac OS, tablettes Android et iPad.

#### Recherche de publications IEC - [www.iec.ch/searchpub](http://www.iec.ch/searchpub)

La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études,...). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

#### IEC Just Published - [webstore.iec.ch/justpublished](http://webstore.iec.ch/justpublished)

Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et aussi une fois par mois par email.

#### Electropedia - [www.electropedia.org](http://www.electropedia.org)

Le premier dictionnaire en ligne de termes électroniques et électriques. Il contient 20 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans 15 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

#### Glossaire IEC - [std.iec.ch/glossary](http://std.iec.ch/glossary)

65 000 entrées terminologiques électrotechniques, en anglais et en français, extraites des articles Termes et Définitions des publications IEC parues depuis 2002. Plus certaines entrées antérieures extraites des publications des CE 37, 77, 86 et CISPR de l'IEC.

#### Service Clients - [webstore.iec.ch/csc](http://webstore.iec.ch/csc)

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: [csc@iec.ch](mailto:csc@iec.ch).

# INTERNATIONAL STANDARD

## NORME INTERNATIONALE

---

**Safety of primary and secondary lithium cells and batteries during transport**

**Sécurité des piles et des accumulateurs au lithium pendant le transport**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

COMMISSION  
ELECTROTECHNIQUE  
INTERNATIONALE

---

ICS 29.220.10

ISBN 978-2-8322-3773-1

**Warning! Make sure that you obtained this publication from an authorized distributor.  
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.**

## CONTENTS

FOREWORD.....	4
INTRODUCTION.....	6
1 Scope.....	7
2 Normative references .....	7
3 Terms and definitions .....	7
4 Requirements for safety.....	10
4.1 General considerations .....	10
4.2 Quality plan .....	11
4.3 Packaging.....	11
5 Type testing, sampling and re-testing .....	11
5.1 Type testing.....	11
5.2 Overcharge protection .....	12
5.3 Battery assemblies.....	12
5.3.1 General .....	12
5.3.2 Small battery assemblies .....	12
5.3.3 Large battery assemblies.....	12
5.4 Sampling.....	12
5.5 Re-testing .....	13
6 Test methods and requirements.....	13
6.1 General.....	13
6.1.1 Cautionary notice.....	13
6.1.2 Ambient temperature .....	14
6.1.3 Parameter measurement tolerances .....	14
6.1.4 Pre-discharge and pre-cycling .....	14
6.2 Evaluation of test criteria .....	14
6.2.1 Shifting.....	14
6.2.2 Distortion.....	14
6.2.3 Short-circuit.....	14
6.2.4 Excessive temperature rise.....	14
6.2.5 Leakage.....	14
6.2.6 Venting.....	15
6.2.7 Fire.....	15
6.2.8 Rupture .....	15
6.2.9 Explosion.....	15
6.3 Tests and requirements – Overview .....	15
6.4 Transport tests.....	16
6.4.1 Test T-1: Altitude .....	16
6.4.2 Test T-2: Thermal cycling .....	16
6.4.3 Test T-3: Vibration.....	17
6.4.4 Test T-4: Shock.....	17
6.4.5 Test T-5: External short-circuit.....	18
6.4.6 Test T-6: Impact/crush.....	19
6.5 Misuse tests.....	21
6.5.1 Test T-7: Overcharge.....	21
6.5.2 Test T-8: Forced discharge.....	21
6.6 Packaging test – Test P-1: Drop test.....	21

6.7	Information to be given in the relevant specification .....	22
6.8	Test report .....	22
6.9	Transport certificate .....	23
7	Information for safety .....	23
7.1	Packaging .....	23
7.2	Handling of battery cartons .....	23
7.3	Transport .....	23
7.3.1	General .....	23
7.3.2	Air transport .....	23
7.3.3	Sea transport .....	23
7.3.4	Land transport .....	23
7.3.5	Classification .....	23
7.4	Display and storage .....	24
8	Instructions for packaging and handling during transport – Quarantine .....	24
9	Marking .....	24
9.1	Marking of primary and secondary (rechargeable) cells and batteries .....	24
9.2	Marking of the packaging and shipping documents .....	24
Annex A (informative)	Shock test – adjustment of acceleration for large batteries .....	25
A.1	General .....	25
A.2	Shock energy depends on mass, acceleration, and pulse duration .....	25
A.3	The constant acceleration approach .....	26
A.4	The constant energy approach .....	26
	Bibliography .....	28
	Figure 1 – Example of a test set-up for the impact test .....	20
	Figure A.1 – Half sine shock for batteries (constant peak acceleration) .....	26
	Figure A.2 – Half sine shock for batteries (constant energy) .....	27
	Table 1 – Number of primary test cells and batteries for type testing .....	12
	Table 2 – Number of secondary test cells and batteries for type testing .....	13
	Table 3 – Number of packages with primary or secondary test cells and batteries .....	13
	Table 4 – Mass loss limits .....	15
	Table 5 – Transport and packaging tests and requirements .....	16
	Table 6 – Vibration profile (sinusoidal) .....	17
	Table 7 – Shock parameters .....	18

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**SAFETY OF PRIMARY AND SECONDARY LITHIUM CELLS  
AND BATTERIES DURING TRANSPORT**

## FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of 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, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). 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. 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 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 IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the view in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 62281 has been prepared jointly by IEC technical committee 35: Primary cells and batteries and subcommittee 21A: Secondary cells and batteries containing alkaline or other non-acid electrolytes, of IEC technical committee 21: Secondary cells and batteries.

This third edition cancels and replaces the second edition, published in 2012, and constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) Deletion of the wire mesh screen from the evaluation of test criteria for an explosion;
- b) Extension / modification of the shock test parameters so as to achieve constant energy behaviour for large batteries as well as explanations in a new Annex A;
- c) Modification of the external short-circuit method so as to allow the short-circuit to be applied to large batteries after they have been removed from the temperature chamber;

- d) Change of the cell diameter distinguishing between impact and crush test from 20 mm to 18 mm;
- e) Addition of possible content for a transport certificate.

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

FDIS	Report on voting
35/1370/FDIS	35/1371/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.

## INTRODUCTION

Primary lithium cells and batteries were first introduced in military applications in the 1970s. At that time, little commercial interest and no industrial standards existed. Consequently, the United Nations (UN) Committee of Experts on the Transport of Dangerous Goods, although usually referring to industrial standards for testing and criteria, introduced a sub-section in the Manual of tests and criteria concerning safety tests relevant to transport of primary lithium cells and batteries. Meanwhile, commercial interest in primary and secondary (rechargeable) lithium cells and batteries has grown 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 used as a source of reference in the UN Model Regulations. Therefore this group safety standard has been prepared to harmonize the tests and requirements relevant to transport.

This International Standard applies to primary and secondary (rechargeable) lithium cells and batteries containing lithium in any chemical form: lithium metal, lithium alloy or lithium-ion. Lithium-metal and lithium alloy primary electrochemical systems use metallic lithium and lithium alloy, respectively, as the negative electrode. Lithium-ion secondary electrochemical systems use intercalation compounds (intercalated lithium exists in an ionic, quasi-atomic form within the lattice of the electrode material) in the positive and in the negative electrodes.

This International Standard also applies to lithium polymer cells and batteries, which are considered either as primary lithium-metal cells and batteries or as secondary lithium-ion cells and batteries, depending on the nature of the material used in the negative electrode.

The history of transporting primary and secondary lithium cells and batteries is worth noting. Since the 1970s, over ten billion primary lithium cells and batteries have been transported, and since the early 1990s, over one billion secondary (rechargeable) lithium cells and batteries utilizing a lithium-ion system have been transported. As the number of primary and secondary lithium cells and batteries to be transported is increasing, it is appropriate to also include in this standard the safety testing of packaging used for the transportation of these products.

This International Standard specifically addresses the safety of primary and secondary lithium cells and batteries during transport and also the safety of the packaging used.

The UN Manual of Tests and Criteria [12]<sup>1</sup> distinguishes between lithium metal and lithium alloy cells and batteries on the one hand, and lithium ion and lithium polymer cells and batteries on the other hand. While it defines that lithium metal and lithium alloy cells and batteries can be either primary (non-rechargeable) or rechargeable, it always considers lithium ion cells and batteries as rechargeable. However, test methods in the UN Manual of Tests and Criteria are the same for both secondary lithium metal and lithium alloy cells and batteries and lithium ion and lithium polymer cells and batteries. The concept is only needed to distinguish between small and large battery assemblies. Battery assemblies assembled from (primary or secondary) lithium metal and lithium alloy batteries are distinguished by the aggregate lithium content of all anodes (measured in grams), while battery assemblies assembled from lithium ion or lithium polymer batteries are distinguished by their “nominal” energy (measured in Watt-hours).

---

<sup>1</sup> Numbers in square brackets refer to the Bibliography.

# SAFETY OF PRIMARY AND SECONDARY LITHIUM CELLS AND BATTERIES DURING TRANSPORT

## 1 Scope

This International Standard specifies test methods and requirements for primary and secondary (rechargeable) lithium cells and batteries to ensure their safety during transport other than for recycling or disposal. Requirements specified in this standard do not apply in those cases where special provisions given in the relevant regulations, listed in 7.3, provide exemptions.

NOTE Different standards may apply for lithium-ion traction battery systems used for electrically propelled road vehicles.

## 2 Normative references

There are no normative references in this document.

## 3 Terms and definitions

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

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

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

### 3.1

#### **aggregate lithium content**

total lithium content of the cells comprising a battery

### 3.2

#### **battery**

one or more cells electrically connected and fitted in a case, with terminals, markings and protective devices etc., as necessary for use

Note 1 to entry: This definition is different from the definition used in the UN Manual of Tests and Criteria [12]. The standard was, however, carefully prepared so that the test set-up for each test is harmonized with the UN Manual.

Note 2 to entry: A cell used in equipment where the equipment is providing the functions of a case, terminals, markings and protective devices etc., as necessary for use in the equipment, is, for the purposes of this standard, considered to be a battery.

[SOURCE: IEC 60050-482:2004 [1], 482-01-04, modified – reference to "electrically connected" has been added]

### 3.3

#### **battery assembly**

battery comprising two or more batteries