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Space systems — Lithium ion battery for space vehicles — Design and verification requirements

Systèmes spatiaux — Batteries à ions lithium pour véhicules spatiaux — Exigences de vérification et de conception

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Contents

Page

Foreword ..... **vi**
Introduction ..... **vii**
1 Scope **1**
2 Normative references **1**
3 Terms and definitions **1**
4 Symbols and abbreviated terms **6**
5 Cell **6**
5.1 Performance 6
5.1.1 General 6
5.1.2 Test requirements 7
5.1.3 Test data trending [4] 7
5.1.4 Cell qualification test 8
5.1.5 Leakage (hermetic) test 8
5.1.6 Safety tests 8
5.1.7 Thermal/thermal vacuum test [5] 8
5.1.8 Mechanical environmental test 8
5.1.9 Radiation test 9
5.1.10 Life cycle test 9
5.1.11 Models for analysis 10
5.2 Safety 10
5.2.1 General 10
5.2.2 Hazard description 10
5.2.3 Protective devices as a hazard control 10
5.2.4 Safety testing 11
5.2.5 Important test considerations 12
5.2.6 Optional test 13
5.3 Logistics 13
5.3.1 General 13
5.3.2 Cell manufacturing, storage and testing 14
5.3.3 Safety measure for handling 14
5.3.4 Cell transportation 15
5.4 COTS cells for space use 15
5.4.1 General 15
5.4.2 Safety requirements 15
5.4.3 Lot integrity assessment 15
5.4.4 Mission conformance test 15
5.4.5 Charge and discharge test 15
5.4.6 Thermal vacuum test 16
5.4.7 Mechanical environment test 16
5.4.8 Cycle life test 16
5.4.9 Storage life test 16
6 Battery **16**
6.1 Performance 16
6.1.1 General 16
6.1.2 *C/n* charge or discharge current (c-rate)[4][5][6] 16
6.1.3 Cut-off voltage 16
6.1.4 Cycle 17
6.1.5 Depth of discharge (DOD)[4][5][6][13] 17
6.1.6 End of charge voltage 17
6.1.7 Energy 17
6.1.8 Energy density 17
6.1.9 Energy reserve [4][5] 18
6.1.10 Fully charged [9][13] 18

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6.1.11 Nameplate capacity 18
6.1.12 Nominal capacity 18
6.1.13 Nameplate energy [5][12] 18
6.1.14 Nominal voltage [9] 18
6.1.15 State of charge 18
6.1.16 Standard method for capacity measurement 19
6.1.17 Battery internal resistance (ohmic) 19
6.1.18 Battery impedance 19
6.1.19 Life test demonstration 19
6.1.20 For GEO simulated 20
6.1.21 For LEO simulated 20
6.1.22 For launch vehicle: simulate ground storage and usage at launch phase 20
6.1.23 Battery general requirements [5][11] 20
6.1.24 Electrical design 21
6.1.25 Thermal design 21
6.1.26 Mechanical design 21
6.1.27 Cell-to-cell balancing mechanisms 21
6.1.28 Marking 21
6.1.29 Cell matching 21
6.1.30 Polarization testing (optional) 21
6.1.31 Self-discharge rate test 22
6.1.32 Tailoring screening tests 22
6.1.33 Cell matching criteria 22
6.1.34 Contamination control 23
6.1.35 Test data trending [4] 23
6.1.36 Flight verification acceptance testing [5] 23
6.1.37 Assurance of the life estimation [8] 23
6.1.38 Parameter measurement tolerances 23
6.1.39 Battery testing [5][15] 24
6.1.40 Development testing [4][15] 24
6.1.41 Charge control testing 24
6.1.42 Thermal control testing 24
6.1.43 Mechanical test 25
6.1.44 Qualification test [4] 25
6.1.45 Qualification test levels and duration 25
6.1.46 In-process inspections and tests 25
6.1.47 Data collection and acquisition rates 25
6.2 Safety 26
6.2.1 General 26
6.2.2 Definitions of dangerous phenomenon 27
6.2.3 Technical requirement 27
6.2.4 Fault tolerance 27
6.2.5 Hazard controls [5] 28
6.2.6 Over-current prevention 28
6.2.7 Over-voltage protection 28
6.2.8 Temperature/current management 28
6.2.9 Insulation and wiring 28
6.2.10 Positive protection against accidental shorting 29
6.2.11 Venting 29
6.2.12 Crew touch temperature requirements 29
6.2.13 Terminal contacts 29
6.2.14 Safety testing 29
6.2.15 Important test considerations 30
6.2.16 Thermal runaway propagation 31
6.2.17 Special provision 31
6.2.18 Description for necessary information for system safety review 31
6.3 Logistics 32
6.3.1 General 32
6.3.2 Manufacture/assembly storage and testing 32

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6.3.3 Safety measure for handling 33
6.3.4 Transportation 33
7 Battery onboard space vehicle 33
7.1 Performance 33
7.1.1 General 33
7.1.2 Basic design 34
7.1.3 Electrical ground bonding 34
7.1.4 Temperature reference point of battery module 34
7.1.5 Preparation for handling, transportation 34
7.2 Safety 35
7.2.1 General 35
7.2.2 Definitions of dangerous phenomenon 35
7.2.3 Technical requirement 35
7.3 Logistics 35
7.3.1 General 35
7.3.2 Safety measure for handling 35
7.3.3 Integration to the space vehicle 36
7.3.4 Battery maintenance on the space vehicle 36
7.3.5 Battery transportation equipped in space vehicle 36
8 Launch site 37
8.1 General 37
8.2 Performance 37
8.3 Safety 37
8.4 Logistics 38
8.4.1 General 38
8.4.2 Safety measure for handling 38
8.4.3 Preparation for transportation 38
8.4.4 SOC level for transportation 38
8.4.5 Container for transportation 38
8.4.6 Battery testing (health checking after transportation) 38
8.4.7 Inspection 39
8.4.8 State of health verification 39
8.4.9 Battery storage at launch site 39
8.4.10 Self-discharge rate 39
8.4.11 Protection under integration 40
8.4.12 Handling plate 40
8.4.13 Electrical connection 40
8.4.14 Electrical checkout 40
8.4.15 Battery monitoring 40
8.4.16 Battery monitoring preceding launch 40
9 Mission in orbit and end of life 40
Annex A (informative) **Parameter measurement tolerances 42**
Annex B (informative) **Example of cell qualification test 43**
Annex C (informative) **Hazard identification method 45**
Annex D (normative) **Safety measure for handling 47**
Annex E (informative) **Transportation 49**
Annex F (informative) **Lot assessment of COTS cells 53**
Bibliography 55

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 14, *Space systems and operations*.

This second edition cancels and replaces the first edition (ISO 17546:2016), which has been technically revised.

The main changes are as follows:

— updated 5.4 and Annex F.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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Introduction

This document has been developed for the purpose of establishing the standard to obtain sustainable development and to prevent incidents of lithium-ion battery for space vehicles.

Lithium-ion batteries belong to the category of rechargeable batteries which are based on electrochemical systems. The batteries generally consist of lithium metal oxide for positive electrodes and carbon for negative electrodes. Lithium element exists in an ionic or quasi-atomic form within a lattice structure of each electrode material.

For battery developers and spacecraft system architects, this document leads the way to assessing the whole life cycle from electrolyte filling to the end of the mission in space and to clarify what is considered in the battery design phase and the processes to reach the appropriate verification.

It is important to prevent lithium-ion batteries (LIB) for space vehicles from having performance defects in orbit and incidents through the life cycle. The total life cycle of lithium-ion batteries consists of material manufacturing to deorbit after mission completion as shown in Figure 1.

Since lithium-ion batteries start to deteriorate just after cell activation during cell manufacturing of stage 1, the service life starts at that point. And it continues through cell testing, cell transportation of stage 2, battery manufacturing/testing of stage 3, battery transportation of stage 4. Eventually, the service life is regarded defined as the duration until deorbit which corresponds to the end of life of stage 9.

Clauses in this document address “performance”, “safety” and “logistics” according to each stage of the life cycle, and each requirement belongs to the shelf life of lithium-ion batteries. The shelf life means from cell activation to launch and does not exceed the shelf life limit. A battery whose shelf life exceeds the shelf life limit is judged to be non-conforming even if it is not used because the battery capacity is insufficient for the mission completion. In other words, the shell life is the period until launch while maintaining the battery capacity to complete required missions.

— Performance

Since LIB starts to degrade from activation, it is necessary to consider meeting the power requirement through the mission life; that is, to be unaffected from handling conditions (temperature) and usage conditions in orbit (temperature, cycle, current or power and depth of discharge). Also, the risk in orbit can be mitigated based on the life estimation; and with care unexpected degradation can be avoided throughout the whole life cycle.

— Safety

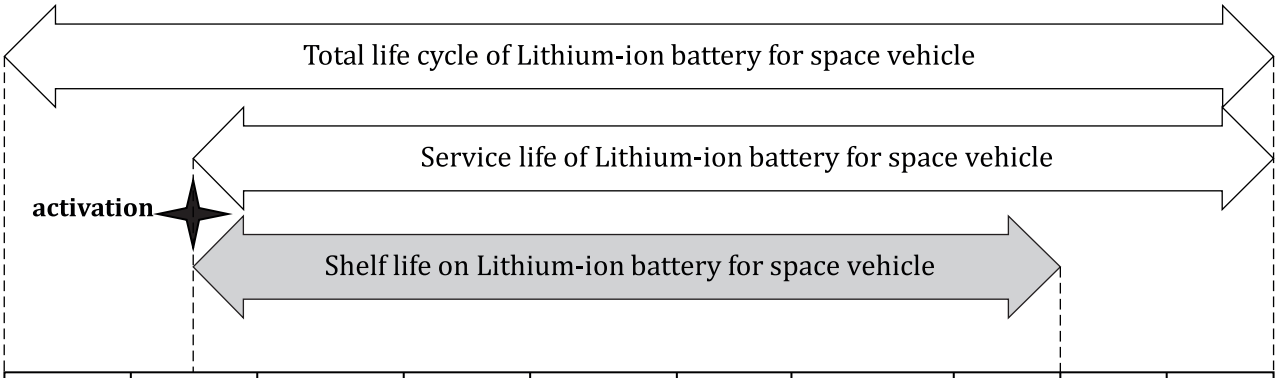
A complex risk assessment process that is easy to understand is established. The method was agreed internationally at ISO/IEC and is a traditional method for space use. LIB keeps some amount of the SOC to avoid significant capacity degradation, so that the specific consideration and care for handling are required because of potential hazard source. It is well known that LIB has specific risks with higher voltage when compared to other power sources and no saturation characteristic for over-charge. The important thing is that the process, which can result in a hazardous situation, does not always immediately result in an incident. Because of these risks, LIB is considered hazardous at all times. The risk assessment becomes very important to cover a variety of environments during the handling or use and history of stress.

— Logistics

The most important aspect of assuring battery safety and space quality in transportation is to perform a life cycle assessment of performance and safety from a broad perspective.

Critical damage includes, for example, the temperature history (especially high uncontrolled temperature outdoors), shock/vibration, and electrical shorts. Also, to reflect the results of handling or usage, the measurement should be done. All the personnel with responsibilities for the development, design, and handling should survey and estimate the influence of their assessment spontaneously to improve the sustainable development of the space component.

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Stage 0	Stage 1 Clause 5	Stage 2 Clause 5	Stage 3 Clause 6	Stage 4 Clause 6	Stage 5 Clause 7	Stage 6 Clause 7	Stage 7 Clause 8	Stage 8	Stage 9
Material Manufacture / Inspection	Cell Manufacture / Testing	Cell Transportation	Battery Manufacture / Testing	Battery Transportation	Space vehicle Integration / Testing	Space vehicle Transportation equipped battery	Launch site - Launch	Mission in orbit	End of life - Deorbit

Figure 1 — Definition of life cycle stages of lithium-ion battery for space vehicle

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Space systems — Lithium ion battery for space vehicles — Design and verification requirements

1 Scope

This document specifies design and minimum verification requirements for lithium-ion batteries from the perspectives of performance, safety and logistics.

This document is applicable to battery assemblies for space vehicles and component cells of batteries, which are critical devices to be harmonized with standards and regulations for other industries. In addition, this document is applicable to component cells which are not designed for space vehicles but can be used in space.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 24113, *Space systems — Space debris mitigation requirements*

MIL-STD-1686, *ELECTROSTATIC DISCHARGE CONTROL PROGRAM FOR PROTECTION OF ELECTRICAL AND ELECTRONIC PARTS, ASSEMBLIES AND EQUIPMENT (EXCLUDING ELECTRICALLY INITIATED EXPLOSIVE DEVICES)*

3 Terms and definitions

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

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

— IEC Electropedia: available at https://www.electropedia.org/

— ISO Online browsing platform: available at https://www.iso.org/obp

3.1
activation
process of making an assembled *cell* (3.4) functional, by introducing an electrolyte at the manufacturing facility during cell production, which is used to define the start of *battery* (3.3) shelf *life* (3.19)

Note 1 to entry: See References [4], [5], [6] and [11].

3.2
aging
permanent loss of capacity due to repeated cycling or passage of time from *activation* (3.1)

Note 1 to entry: See Reference [6].

3.3
battery
two or more *cells* (3.4) which are electrically connected together, fitted with devices necessary for use, for example, case, terminals, marking and *protective devices* (3.26)

Note 1 to entry: A single cell battery is considered a “cell”[9].

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