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Vesoljska tehnika - Priročnik za testiranje Li-ionske baterije

Space engineering - Li-ion battery testing handbook

Raumfahrttechnik - Handbuch zum Testen von Li-Ionen-Akkus

Ingénierie spatiale - Manuel de tests des batteries li-ion

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Space engineering - Li-ion battery testing handbook

Ingénierie spatiale - Manuel de tests des batteries li-ion

Raumfahrttechnik - Handbuch zum Testen von Li-Ionen-Akkus

This draft Technical Report is submitted to CEN members for Vote. It has been drawn up by the Technical Committee CEN/CLC/JTC 5.

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European Foreword

This document (FprCEN/CLC/TR 17603-20-02:2020) has been prepared by Technical Committee CEN/CLC/JTC 5 “Space”, the secretariat of which is held by DIN.

This document is currently submitted to the Vote on TR.

It is highlighted that this technical report does not contain any requirement but only collection of data or descriptions and guidelines about how to organize and perform the work in support of EN 16603-20.

This Technical report (FprCEN/CLC/TR 17603-20-02:2020) originates from ECSS-E-HB-20-02A.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

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

This document has been developed to cover specifically space systems and has therefore precedence over any TR covering the same scope but with a wider domain of applicability (e.g.: aerospace).

This document is currently submitted to the CEN CONSULTATION.

Introduction

Energy storage is required aboard almost all spacecraft. Batteries are the most common energy storage device. Batteries provide electrical power when power from solar arrays is temporarily unavailable or insufficient due to eclipses, payload peak loads, before solar panels are deployed or in case of emergencies or special manoeuvres. Batteries are tested in order to assess their performance and their suitability to meet mission requirements. This issue of the document does not include the battery management subsystem testing.

In order for a new cell or battery system to be accepted for a spacecraft mission, it is essential not only to have hardware which is qualified for a good beginning of life performance but also to have hardware whose performance changes with cycle life are well understood and predictable by appropriate models. For this reason the availability of comprehensive test data is very important.

The present handbook aims at providing practical and helpful guidelines for Li-ion cell and battery testing (testing conditions, required information, reporting) during the development and qualification of space equipment and systems. This document has been derived from requirements from ECSS-E-ST-20C and its purpose is to support the use of ECSS-E-ST-20C.

This Handbook gathers battery testing experience, know-how and lessons-learnt from the European Space Community.

1 Scope

This Handbook establishes support the testing of Li-ion battery and associated generation of test related documentation.

This handbook sets out to:

- summarize most relevant characterisation tests
- provide guidelines for Li-ion battery testing
- provide guidelines for documentation associated with Li-ion cell or battery testing
- give an overview of appropriate test methods
- provide best practices

2 References

EN Reference	Reference in text	Title
EN 16601-00-01	ECSS-S-ST-00-01	ECSS System - Glossary of terms
EN 16603-10-02	ECSS-E-ST-10-03	Space engineering - Testing
EN 16603-10-04	ECSS-E-ST-10-04	Space engineering - Space environment
EN 16603-20	ECSS-E-ST-20	Space engineering - Electrical and electronic
EN 16602-20-08	ECSS-Q-ST-20-08	Space product assurance - Storage, handling and transportation of space hardware
EN 16602-70-02	ECSS-Q-ST-70-02	Space product assurance - Thermal vacuum outgassing test for the screening of space materials
-	IEC 62281 2013-08	Safety of primary and secondary lithium cells and batteries during transport
-	ST/SG/AC.10/11/rev5	United Nations Transport of Dangerous Goods UN manual of Tests and Criteria, Part III, subsection 38.3
-	JSC-20793 Rev.B April 2006	Crewed Space Vehicle Battery Safety Requirements

3 Terms, definitions and abbreviated terms

3.1 Terms from other documents

For the purpose of this document, the terms and definitions from ECSS-S-ST-00-01 apply, in particular for the following terms:

acceptance
applicable document
assembly
bakeout
calibration
catastrophic
environment
failure
handbook
hazard
inspection
lot
model
nonconformance
outgassing
procedure
process
product assurance
project
qualification
quality
quality assurance
quality control
reliability
requirement
review
safety
specification
standard
supplier
traceability
validation
verification

3.2 Terms specific to the present document

3.2.1 accelerated test

test designed to shorten cycle life test to estimate the average cell or battery lifetime at normal operating conditions

NOTE Temperature, SoC, cycle profile are sources of test acceleration.

3.2.2 activation

introduction of electrolyte in an assembled cell at the manufacturing facility during production

NOTE This is used to define the start of the cell shelf-life. The formation process is also part of the activation.

3.2.3 aging

permanent change in characteristics and performance due to repeated use or the passage of time

NOTE Permanent changes include loss of capacity and energy, increase in resistance.

3.2.4 battery

one or more cells (or modules) electrically connected to provide the required operating voltage, current and energy storage levels

3.2.5 battery management subsystem

electronics circuitry preventing cell or battery operation outside of specified voltage, current and temperature ranges, and managing cell-to-cell unbalance

NOTE It also includes cell or module of cells bypass circuits when deemed necessary by FMECA outcomes.

3.2.6 calendar loss

permanent degradation of electrical performance due to time after activation

NOTE Reversible effects such as self-discharge are not included in the calendar loss.

3.2.7 capacity

amount of charge available expressed in ampere-hours (Ah)

NOTE 1 Cell or battery (Ah) = $\int I_d.dt$. It is the integral of the discharge current, between start of discharge and cut-off voltage or other specified voltage or specified duration.

NOTE 2 The capacity of a cell or battery is determined by a number of factors, including the cut-off voltage, discharge rate, temperature, method of charge (i.e. current, end-of-charge voltage) and the age and life history of the cell or battery.

3.2.8 capacity retention

fraction of the rated capacity available from a cell or battery under specified conditions of discharge after it has been stored for a certain time period at a specified temperature and state of charge in open circuit

3.2.9 cell can

cell packaging

3.2.10 cell building block or brick

sub-assembly unit, which consists of identical electrically connected cells

NOTE Building blocks (or bricks) are connected together to form a module or battery.

3.2.11 cell electromotive force

difference of potentials which exists between the two electrodes of opposite polarity in an electrochemical cell under open circuit steady state conditions

3.2.12 cell reversal

reverse polarity of a cell during discharge

3.2.13 cell terminal

electrical contacts to connect the cell

3.2.14 cell type

cell chemistry, cell size and cell can geometry

3.2.15 charge rate

amount of current applied to a cell or battery during the charge

NOTE This rate is commonly expressed as a fraction of the nameplate capacity of the battery. For example, C/2 or C/5.

3.2.16 cycle life

<CONTEXT: cell or battery> number of cycles under specified conditions, that a cell or battery can undergo before failing to meet its specified performance criteria

3.2.17 cycle loss

gradual and irreversible degradation of electrical performance due to electrical cycling

3.2.18 deperm

demagnetisation of battery

3.2.19 depth of discharge (DoD)

ampere–hour removed from a battery expressed as a percentage of the nameplate capacity whatever the initial state of charge

3.2.20 depth of discharged energy (DoDE)

Watt-hours removed from a cell or battery, expressed as a percentage of nameplate energy, whatever the initial state of charge

3.2.21 discharge rate

amount of current delivered by a cell or battery during the discharge

NOTE This rate is commonly expressed as a fraction of the nameplate capacity of the battery. For example, C/2 or C/5.

3.2.22 energy

watt-hours available when the battery that has been discharged from a specified end-of-charge voltage to a selected cut-off voltage, under specified conditions

NOTE 1 Cell or battery (Wh) = $\int IdVd.dt$. It is the integral of the product of discharge current and voltage. The limits of integration are the start of discharge and the cut-off voltage or other specified voltage.

NOTE 2 Typical conditions can include:

- Temperature and thermal control
- Charge and discharge profiles

NOTE 3 The SI unit for energy is joule (1J = 1 W.s), but in practice, battery energy is usually expressed in watthours (Wh) (1 Wh = 3600 J)

3.2.23 energy reserve

energy available in a cell or battery when discharged from the maximum DoD or voltage cut-off expected under nominal operation to the minimum end-of-discharge voltage