



**BATSO 02**

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Manual for Evaluation of Energy Systems  
– **Secondary Lithium Batteries**

Part 2: Stationary Batteries

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## FOREWORD

The goal of the Battery Safety Organization e.V. is to increase safety of existing and new battery technologies in their specified application.

To demonstrate that a battery for its intended use was tested and is in compliance with the requirements of this manual is the concrete motivation of the Battery Safety Organization. Requirements and testing methods in this Manual have been developed by the experts of the Technical Committee of the Organisation. This Manual supports an efficient way of battery testing always with the background of state of the art requirements.

Finally with the conformity and certification scheme all parties involved in the stationary battery area will support to find and utilize safer batteries.

In this Manual following print types are used:

- Terms that are defined in clause 2 in SMALL CAPITALS.
- Notes in smaller font size

# CONTENTS

1 General	
1.1 Scope .....	5
1.2 Conditions covered by this manual .....	5
1.3 Definitions .....	5
2 Battery requirements & testing.....	8
2.1 Batteries used in stationary industrial applications .....	8
2.1.1 Batteries used under standard conditions.....	8
2.1.2 Batteries used under offshore conditions .....	9
2.1.3 Batteries used under agricultural conditions .....	9
2.2 Batteries used in stationary non industrial applications .....	9
3 Conformity and Certification.....	11
3.1 Factory inspection.....	11
3.2 Information to be provided by manufacturers.....	12
3.3 Certificate & Test mark.....	13

Annex

# 1 GENERAL

## 1.1 Scope

This Manual specifies important battery requirements and testing conditions for secondary lithium BATTERIES used in STATIONARY APPLICATIONS. Performance and functional characteristics of batteries are not part of this standard.

## 1.2 Conditions covered by this Manual

This manual addresses the environmental conditions for lithium-batteries used in stationary applications. All other applications, e.g. mobile, traction, are not covered by this Manual.

## 1.3 Definitions

### *Active protective device*

Devices integral to the BATTERY requiring active external controls that are intended for protection from or mitigation of abusive, out-of range conditions experienced by the CELL or BATTERY.

NOTE 1 – Examples are MOSFET, integrated circuits, microcontroller.

### *Ambient temperature*

Temperature of the medium in the immediate vicinity of the BATTERY.

### *Battery assembly*

Connection of two or more BATTERIES in series or parallel.

NOTE 2 – Such an assembly may or may not contain PROTECTIVE DEVICES or electronic circuits.

### *Battery cell (or Cell)*

Single encased electrochemical unit (one positive and one negative electrode), which exhibits a voltage difference across its two terminals.

### *Battery pack (or Battery)*

One or more CELLS that are electrically connected by permanent means. It may include housing, terminals, electronic circuits, markings and PROTECTIVE DEVICES.

### *BMS (Battery management system)*

The battery management unit monitors, controls, detects and calculates the state of electricity and heat of the battery and has a data communication means which allows it to communicate with the power control system (PCS).

### *Cell block*

Two or more CELLS connected in parallel.

### *Cycle*

One sequence of fully charging and fully discharging of a RECHARGEABLE BATTERY.

### *Enclosure*

A cabinet, box or container providing protection for other parts of the BATTERY.

NOTE 3 – Specific requirements applying to enclosures are detailed in sub clauses 3.4 and 5.2.

### *First cycle*

Initial CYCLE following the completion of all manufacturing processes.

### *Fresh battery*

BATTERY after the completion in the manufacturing process, but not used in an application or test.

### *Fully charged*

A RECHARGEABLE BATTERY, which has been electrically charged to its rated electrical capacity, as specified by the manufacturer.

### *Fully discharged*

A RECHARGEABLE BATTERY, which has been electrically discharged to its cut-off voltage as specified by the manufacturer.

### *Lithium ion battery*

RECHARGEABLE electrochemical BATTERY in which the positive and negative electrodes are both intercalation compounds (intercalated lithium exists in an ionic or quasi-atomic form with the lattice of the electrode material) constructed with no metallic lithium in either electrode.

Note 4 -- A lithium polymer BATTERY that uses lithium ion chemistries, as described herein is regulated as a LITHIUM ION BATTERY.

### *Nominal voltage*

Approximate value of the voltage used to designate or identify a BATTERY.

### *Parallel string*

An electrical connection of STRINGS in parallel.

### *Passive protective device*

Devices that do not require active external control for operation and which are either integral or external to the cell. Wire connections or printed circuit board traces that become open circuit during electrical tests shall be bypassed with a suitable wire connection of negligible impedance not exceeding 10 mΩ.

NOTE 5 – Examples are over-current fuse links, circuit breaker, thermal releases.

NOTE 6 – Protective devices, which were not tested according to the relevant component standard, are not considered as PROTECTIVE DEVICE.

NOTE 7 – Semiconductor devices with no interface for external control can be permitted if they are subject to testing according to the relevant component standard. Example: IEC 61643 Part 321 for avalanche breakdown diodes.

*Prismatic battery*

BATTERY whose ends are similar, equal and parallel rectilinear figures, and whose sides are parallelograms.

*Protective device*

Either an ACTIVE PROTECTIVE DEVICE OR PASSIVE PROTECTIVE DEVICE.

*Rated capacity*

Capacity, in ampere-hours, of a BATTERY as measured by subjecting it to a load, temperature and voltage cut-off point specified by the manufacturer.

NOTE 8 – Examples of standards providing guidance for determining the RATED CAPACITY of a BATTERY: IEC 61960, IEC 62133, IEC 62660-1.

*Rechargeable*

means BATTERIES OR CELLS that can be repeatedly electrically charged and discharged.

*Secondary battery*

Any BATTERY that is RECHARGEABLE by design.

NOTE 9 – In this Manual SECONDARY BATTERY is used in the same meaning as RECHARGEABLE BATTERY.

*Short circuit*

Direct connection between positive and negative terminals of a BATTERY that provides a virtual zero resistance path for current flow.

*Small battery*

A lithium BATTERY with a gross mass of not exceeding 12 kg.

*Stationary application* means, the installation and use takes place in a fixed location during its product lifetime.

*Stationary battery*

A battery, which is used in stationary application.

*String*

A series connection of CELLS OR CELL BLOCKS.

*Type*

A particular electrochemical system and physical design of a BATTERY.

*Watt-hour rating (or nominal energy)*

Unit of energy, which is calculated by multiplying the RATED CAPACITY of a BATTERY, in ampere-hours by its nominal voltage.

## 2 Battery Requirements and Testing

All following tests may be performed with a fresh sample. It is also allowed, to use samples for more than one test if applicable.

### 2.1 Batteries used in stationary industrial applications

NOTE: The requirements under this chapter are based on the assumption, that in industrial applications only electrical experts have access to this kind of batteries or the interaction with them.

#### 2.1.1 Batteries used under standard conditions

All batteries first have to be tested according to the UN Manual for the Transportation of dangerous goods, Sec. 38.3 Lithium Batteries.

Electrical safety design shall be complied according the requirements given in IEC 61508.

After successful initial testing according to UN manual for dangerous goods, the batteries have to be tested according to the following safety application tests:

#### Test 1: Fire

The battery has to withstand an externally caused fire for 30 minutes. This test must not be carried out on a battery module, minimum the housing has to be tested and the temperature inside has to be recorded and must not exceed 75 °C. The test has to be carried out according to EN 14470.

#### Test 2: Earthquake

Compliance has been verified with reference to the UN-transportation Test, Test No. T3. No additional test is necessary if the test is passed. A documentation is required with the proof of the requirement.

#### Test 3: Flooding

The battery system shall be protected against water flooding up to 30 cm.

This can be covered by the housing, or by the installing point 30 cm over backflow level.

If a floor standing system is used, the test has to be carried out according to ISO 20653, IPX8. (Depth 30 cm and 30 minutes duration).

The battery shall not develop an abnormal state like causing a break or burst.

#### Test 4: Dust

The housing of the battery system has to comply with the requirements for the degree of protection IP6X according to ISO 20653.

#### Test 5: Vibration during transport

- not specifically required -

#### Test 6: Misuse

- not specifically required -

#### Test 7: Internal fire

A battery has to be fully charged. Testing has to be performed under an ambient temperature of  $23\text{ °C} \pm 5\text{ °C}$ . One of the cells in the battery or module has to be heated until it exhibits thermal runaway by overcharge.

Charging has to be stopped when the cell starts to exhibit thermal runaway and monitored for 6 h.

The cell may be put under thermal runaway by other methods than given above.

The method by which the cell has been put under thermal runaway shall be stated in the report.

The battery housing shall not develop fire or burst. No flames may be visible outside the battery housing.

#### 2.1.2 Batteries used under offshore conditions

Additional to the tests T1 – T4 the batteries shall withstand a salt mist atmosphere test according to ISO 9227.

#### 2.1.3 Batteries used under agricultural conditions

Additional to the tests T1 – T4 the batteries shall withstand ammonia corrosion test according to IEC 62716.

### 2.2 Batteries used in stationary non-industrial applications

All batteries have to be tested according to the UN Manual for the Transportation of dangerous goods, Sec. 38.3 Lithium Batteries, first.

Electrical safety design shall be complied according the requirements given in IEC 61508.

After successful initial testing according to UN manual for dangerous goods, the batteries have to be tested according to the following safety application tests:

#### Test 1: Fire

The battery has to withstand an externally caused fire for 30 minutes. This test must not be carried out on a battery module, minimum the housing has to be tested and the temperature inside has to be recorded and must not exceed  $75\text{ °C}$ . The test has to be carried out according to EN 14470.

#### Test 2: Earthquake

Compliance has been verified with reference to the UN-transportation Test, Test No. T3. No additional test is necessary if the test is passed. A documentation is required with the proof of the requirement.

#### Test 3: Flooding

The battery system shall be protected against water flooding up to 30 cm.

This can be covered by the housing, or by the installing point 30 cm over backflow level.

If a floor standing system is used, the test has to be carried out according to ISO 20653, IPX8. (Depth 30 cm and 30 minutes duration).

The battery shall not develop an abnormal state like causing a break, burst or other critical safety situation.

**Test 4: Dust**

The housing of the battery system has to comply with the requirements for the degree of protection IP6X according to ISO 20653

**Test 5: Vibration during transport**

Additional to the UN T Test T3, the battery shall be tested according to the specific "ista" (depending on weight use procedure 2A or 2B) test manual for transport and has to comply with the applicable requirements.

**Test 6: Misuse**

The battery housing shall use screws or other fixing techniques, which cannot be removed without special tools.

**Test 7: Internal fire**

A battery or module has to be fully charged. Testing has to be performed under an ambient temperature of  $23\pm 5^{\circ}\text{C}$ . One of the cells in the battery or module has to be heated until it exhibits thermal runaway by overcharge.

Charging has to be stopped when the cell starts to exhibit thermal runaway and monitored for 6 h.

The cell may be put under thermal runaway by other methods than given above.

The method by which the cell has been put under thermal runaway shall be written in the report.

The battery case shall not develop fire or burst. No flames may be visible outside the battery housing.

Additional, according to ISO 20653, the degree of protection IP4X must be fulfilled.

## 3 Conformity and Certification

### 3.1 Factory inspection

An initial requirement for the compliance of this manual is the surveillance of the manufacturing/production process of the product under certification.

Because of the large number of possible constellations (product – manufacturer – production period – market), a single surveillance procedure may not always be the best way to ensure efficient manufacturing surveillance.

The main procedure for manufacturing surveillance is an initial factory inspection and subsequent follow-up inspections. This should be the approach whenever possible. The factory inspection is performed according to ISO 9001 and does not include research and development.

The procedure uses the EEPCA (European Electrical Products Certification Association) documentation common by IECEE (IEC System of Conformity Assessment Schemes for Electrotechnical Equipment and Components).

#### Definitions

*CIG 021 / CIG 022 / CIG 023 / CIG 024*

Permanent documents related to factory inspections issued by the Common Interest Group (CIG) of the ECS (European Certification System) of the EEPCA (European Electrical Products Certification Association).

#### *First factory inspection (Pre-licence Factory Inspection):*

Initial inspection of the production and test equipment and the QA system with regard to uniformity of the quality of the product with respect to product safety. The first inspection includes the identity verification of the products.

#### *Follow-up (Routine Factory Inspection)*

Recurring inspection of the production and test equipment and the QA system with regard to uniformity of the quality of the product with respect to product safety. The follow-up inspection includes the identity verification of the products.

If reference samples or documents are stored at the manufacturer's facilities, the follow up inspection also includes a random storage and safe-keeping inspection.

#### *Identity verification*

Inspection of a product for its conformity to the certified type.

#### *Follow-up inspection division*

A follow-up inspection division is a unit that oversees organizational aspects of the first and follow-up factory inspections. For the certification process the factory inspection unit is an obligatory part of the certification process. The certification body may delegate tasks of the follow-up division to other qualified departments familiar with the international rules of factory and product inspections.

It is always clearly specified who is responsible for the organizational aspects of the follow-up inspection.

NOTE: Certification body means an independent national organisation that performs certifications (such as TÜV Rheinland LGA Products) and is accredited by an accreditation body (such as DAkkS).

*Check test:*

Examination of a product sample that was either obtained or randomly selected for its conformity to the type tested and certified model or models in a test laboratory authorized by the Battery Safety Organisation.

### 3.2 Information to be provided by manufacturers

The following technical documentation and data of the product have to be provided:

- Dimensions
- Weight
- Capacity
- Voltage (Min/Max)
- Current (Min/Max)
- Application

#### 3.2.1 Information regarding packaging and transportation

See UN Regulations for the transport of dangerous goods.

##### 3.2.1.1 Sample classification

BATTERY samples that have not been previously tested for compliance relevant tests of UN Recommendations on the Transport of Dangerous Goods - Manual of Test and Criteria, must not be shipped via air.

NOTE – More details are provided in Annex A and related UN Special Provisions.

For UN-T tested and compliant BATTERY samples, the samples should be classified and labelled as UN 3480 lithium BATTERY.

##### 3.2.1.2 Labelling

Packages of BATTERIES shall be labelled as UN class 9 dangerous good.

##### 3.2.1.3 Packaging

The packaging of BATTERY samples shall conform to the UN packaging instructions.

##### 3.2.1.4 Transport or shipper's declaration

##### 3.2.1.5 List of content of package

A list of package contents, including item names and quantity has to be provided.

### 3.3 Certificate & Test mark

Conformity with this standard is given if the requirements and tests of chapter 2 were passed and the factory inspection requirements and the quality assurance criteria under this chapter were met. As well the required documents under subclause 3.3.1 are required.

Conformity with this standard is prerequisite for certification and marking the products with the BATSO test mark.



#### 3.3.1 Required Documents

The documents named in the following sub clauses shall be provided to the certification body.

##### 3.3.1.1 Form with data regarding the properties of substances of CELLS

NOTE – Example: Material Safety Data Sheets (MSDS), Risk and Safety Statements, UN numbers identifying hazardous substances.

##### 3.3.1.2 Handling instructions for CELLS, BATTERY PACKS and BATTERIES

Such data shall be provided in form of datasheets containing following data:

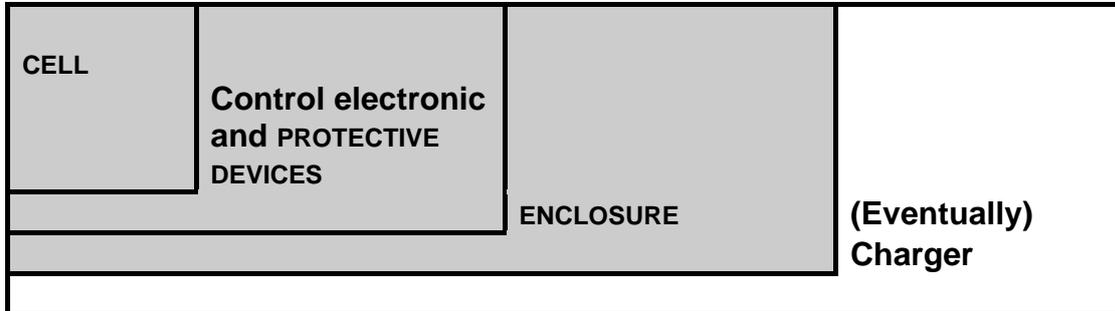
- Technical documents (e.g. circuit-drawing, mechanical layout)
- Nominal voltage
- Nominal capacity
- Nominal weight
- Minimum discharge voltage and temperature
- Maximum charge voltage and temperature
- Operating and storage temperature range
- Standard charge procedure or pattern
- Discharge cut-off voltage

##### 3.3.1.3 Operation manual of BATTERY PACKS, chargers, PCB or BMS

The manufacturer has to provide all required documents for operating the battery pack system.

### 3.3.1.4 Certificates for components and SUBSYSTEMS

This Manual was designed to assess aspects on BATTERY PACK level.  
The BATTERY PACK can be described as system comprising of following SUBSYSTEMS:



SUBSYSTEMS shall meet requirements of Table 1.1.

**Table 1.1 – SUBSYSTEM requirements**

Subsystem	Requirement
CELL	<ul style="list-style-type: none"> <li>Compliance with <i>UN Recommendations on the Transport of Dangerous Goods - Manual of Test and Criteria: Section 38.3</i><sup>NOTE</sup>, and one of the following: <ul style="list-style-type: none"> <li>IEC 62133<sup>a</sup>, or</li> <li>Other BATTERY CELL standards ensuring corresponding safety levels<sup>a</sup>.</li> </ul> </li> </ul>
PROTECTIVE DEVICES	<ul style="list-style-type: none"> <li>Corresponding IEC component standards<sup>a</sup>, or</li> <li>Other component standards ensuring corresponding safety levels<sup>a</sup>.</li> </ul>
ENCLOSURE	<ul style="list-style-type: none"> <li>Mechanical strength to withstand stress caused by normal use and rough handling</li> <li>Sufficiently resistant to degradation caused by ultraviolet radiation</li> <li>Reducing the possibility of ignition and spread of flame</li> <li>Providing suitable insulation characteristics</li> </ul>
Charger	<ul style="list-style-type: none"> <li>IEC 61851 series, or</li> <li>IEC 60335-1 and IEC 60335-2-29, or</li> <li>Other product standards ensuring corresponding safety levels, and</li> <li>IEC 60529 (if charger is designed for outdoor use)</li> </ul>
<sup>a</sup> . Valid component certificate must be available.	

### 3.3.1.5 Quality examination report of samples

The samples shall have passed the quality control procedure of the manufacturer. The manufacturer must provide a quality examination report.

### 3.3.1.6 Overview about provided samples and their respective CYCLE history

The manufacturer has to provide a document with the identifications of the samples and the history of the cycle status of each sample.

## Annex "References"

- EN 14470-1:2004 „Fire safety storage cabinets – Part 1: Safety storage cabinets for flammable liquids“- ISO 9227:2012 „Corrosion tests in artificial atmospheres - Salt spray tests”
  
- ISO 20653:2013 „Road vehicles - Degrees of protection (IP code) - Protection of electrical equipment against foreign objects, water and access”
  
- UN Recommendations on the Transport of Dangerous Goods - Manual of Test and Criteria: Section 38.3 Rev. 5 Amendment 1
  
- IEC 62133:2012 “Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications”
  
- Ista “international safe transit association” Procedure 2:2012
  
- IEC 61508:2010 “Functional safety of electrical/electronic/programmable electronic safety-related systems”
  
- IEC 61851:2013 “Electric vehicle conductive charging system”
  
- IEC 60335-1:2010 “Household and similar electrical appliances - Safety - Part 1: General requirements”
  
- IEC 60335-29:2010 “Household and similar electrical appliances; Safety - Part 2-29: Particular requirements for battery chargers”
  
- IEC 60529:2013 “Degrees of protection provided by enclosures (IP code)”
  
- IEC 62716:2013 “Photovoltaic (PV) modules - Ammonia corrosion testing”