



BATSO 01

Third edition

2013-10

**Manual for Evaluation of Energy Systems for Light Electric
Vehicle (LEV) – Secondary Lithium Batteries**

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FOREWORD

BATSO is a trademarked abbreviation of **Battery Safety Organization**.

As a test seal, BATSO demonstrates that a battery was tested and complied with the requirements of one or more BATSO test manuals.

The goal of BATSO is to increase safety of existing and new lithium battery technologies.

Testing methods of this Manual have been developed by the BATSO Technical Committee. This Manual will support a fast and economic way of battery testing. The BATSO test seal will help all parties involved in the Light Electric Vehicle business to find and utilize safer batteries.

This third edition of BATSO 01 cancels and replaces the second edition of BATSO 01, issued in 2011, and constitutes a technical revision. Major changes as compared with the second edition of BATSO 01 are given in Annex J. It also reflects requirements of section 38.3 of the 5th and revised edition of *Manual of Tests and Criteria of UN Recommendations on the Transport of Dangerous Goods*, including its Amendment 1.

In this Manual following print types are used:

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

CONTENTS

Foreword	3
1 General	5
1.1 Scope	5
1.2 Conditions covered by this Manual	6
1.3 Subsystem requirements	6
2 Definitions and Terms	7
2.1 Batteries	7
2.2 Light Electric Vehicles	9
2.3 Others	9
3 Safety considerations	10
3.1 Special considerations for LEV	10
3.2 Precautions when conducting tests	10
3.3 Evaluation of protective devices and electronic circuits	11
3.4 Thermoplastic materials exposed to sunlight	11
3.5 Design variations requiring additional testing	11
3.6 Batteries providing protection against ingress of foreign objects and water	11
4 Test setup	12
4.1 Test equipment	12
4.2 General conditions for tests	13
4.3 Sample preparation	13
4.4 Test sequence and number of samples	14
5 Type tests	16
5.1 Electrical tests	16
5.2 Mechanical tests	19
5.3 Environmental tests	20
6 Compliance criteria	20
6.1 Compliance criteria for test items.....	20
6.2 Compliance criteria during final observation period	23
Annex A Transport regulations (informative)	24
Annex B Environmental Management System Evaluation (normative)	26
Annex C Marking (normative)	27
Annex D Test stamp for crush test (normative)	28
Annex E Test probe (normative)	29
Annex F Information to be provided by manufacturers (informative)	30
Annex G Miscellaneous (informative)	32
Annex H References (normative)	38
Annex I Bibliography (informative)	39
Annex J Changes in this edition (informative)	40

1 GENERAL

1.1 Scope

This Manual specifies test methods and requirements for secondary lithium BATTERIES for the safe use in LEV.

NOTE 1 – This Manual may be applied to secondary lithium BATTERIES in other equipment. Attention is drawn to the fact that in such case additional requirements may apply.

Transport safety tests are specified in addition. Performance and functional characteristics of batteries are not covered.

This Manual provides two test options:

Test option 1

BATTERY usage safety tests and transport safety tests are conducted during this type testing program following the *UN Recommendations on the Transport of Dangerous Goods - Manual of Tests and Criteria: Section 38.3*.

NOTE 2 – Annex G.1 provides details on how this Manual covers all aspects of Section 38.3 of *Manual of Tests and Criteria of UN Recommendations on the Transport of Dangerous Goods*.

Test option 2

Same as Option 1 but transport safety tests following the *UN Recommendations on the Transport of Dangerous Goods - Manual of Tests and Criteria: Section 38.3* are performed independently from this TYPE testing program. Test reports issued by an ILAC, APLAC or similar accredited party are acceptable for the BATTERY complying with all aspects of Section 38.3 of *Manual of Tests and Criteria of UN Recommendations on the Transport of Dangerous Goods* for this test option.

Environmental aspects related to manufacturing and handling of BATTERIES will be assessed in future editions of this Manual.

NOTE 3 – Details will be provided in Annex B.

This Manual does not apply to:

- Lithium CELLS
- BATTERIES other than lithium ion types

NOTE 4 – Lithium metal batteries are excluded from the scope of this Manual.

- Primary BATTERIES (including lithium types)
- Lithium BATTERIES with a gross weight exceeding 12 kg
- LITHIUM ION BATTERY ASSEMBLIES
- Fuel cells

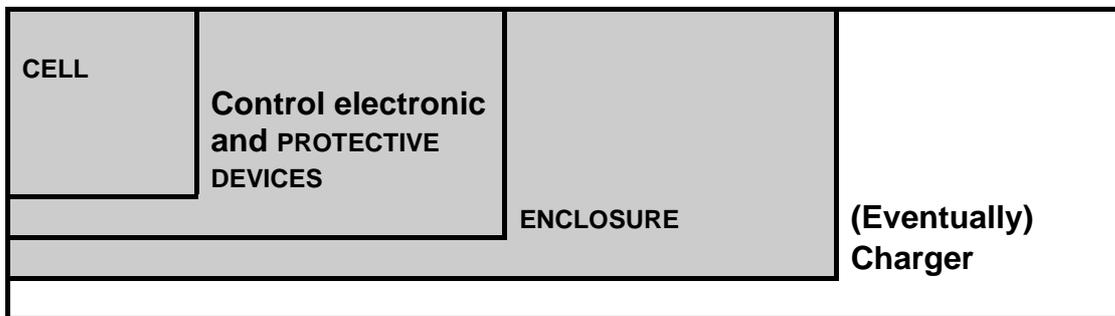
1.2 Conditions covered by this Manual

Test items were selected to simulate conditions likely to occur during the transport of BATTERIES (either transported separately or when installed into the LEV), during the handling of BATTERIES (e.g. removal or replacement) or during the operation of LEV. They cover conditions of normal operation, rough handling and as well likely conditions of misuse or negligent handling.

Additional requirements might apply to BATTERIES or vehicles during or after the integration into the vehicle resulting from national or regional regulations and are not dealt with in this Manual. Same applies to hazards from electric shock.

1.3 SUBSYSTEM requirements

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"> Compliance with <i>UN Recommendations on the Transport of Dangerous Goods - Manual of Tests and Criteria: Section 38.3^{NOTE}</i>, and one of the following: <ul style="list-style-type: none"> Relevant international BATTERY CELL standard ^a, or Other BATTERY CELL standards ensuring corresponding safety levels ^a.
PROTECTIVE DEVICES	<ul style="list-style-type: none"> Corresponding IEC component standards ^a, or Other component standards ensuring corresponding safety levels ^a.
ENCLOSURE	<ul style="list-style-type: none"> Mechanical strength to withstand stress caused by normal use and rough handling Sufficiently resistant to degradation caused by ultraviolet radiation Reducing the possibility of ignition and spread of flame Providing suitable insulation characteristics
Charger	<ul style="list-style-type: none"> IEC 61851 series, or IEC 60335-1 and IEC 60335-2-29, or Other product standards ensuring corresponding safety

Subsystem	Requirement
	levels, and <ul style="list-style-type: none"> • IEC 60529 (if charger is designed for outdoor use)
<p>^a. Valid component certificate must be available and components must be applied according to their specified ratings.</p>	

NOTE – Test reports issued by an ILAC, APLAC or similar accredited party are acceptable; only relevant for *test option 2* (see subclause 1.1).

2 DEFINITIONS AND TERMS

2.1 Batteries

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.

Cell block

Two or more CELLS connected in parallel.

Cycle

One sequence of fully charging and fully discharging 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 subclauses 3.4 and 5.2.

First cycle

Initial CYCLE following the completion of all manufacturing processes.

BATSO 01
2013-10

Fresh battery

BATTERY after the completion of all manufacturing processes.

Fully charged

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. 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

A parallel connection of STRINGS.

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

NOTE 5 – Protective devices, which were not tested according to the relevant component standard, are not considered as PROTECTIVE DEVICE.

NOTE 6 – 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 321:2001 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 7 – Examples of standards providing guidance for determining the RATED CAPACITY of a BATTERY: IEC 61960, IEC 62133, IEC 62660-1.

Rechargeable

Applies to BATTERIES or CELLS that can be repeatedly electrically charged and discharged.

Secondary battery

Any BATTERY that is RECHARGEABLE by design.

NOTE 8 – 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.

String

A series connection of CELLS or CELL BLOCKS.

Subsystem

A major portion or module that comprises the overall system.

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.

2.2 Light Electric Vehicles

Light Electric Vehicle (LEV)

A road or off-road vehicle that uses an energy storage system along with an electric drive as its source of energy for motive power. LEV cover, but are not limited to, following vehicles:

- Electric bicycles or Pedelecs
- Electric scooters
- Electric wheelchairs

NOTE – Some specific examples are electric golf carts, personal mobility devices, last mile transportation.

2.3 Others

Fault condition

Equipment operated not in accordance with the manufacturer's specification and accompanying documents and markings. Conditions can occur as result of negligent use (foreseeable misuse), accident, failure of components or materials or other situations.

Normal condition

Equipment operated in accordance with the manufacturer's specification and accompanying documents and markings.

Single fault

Single failure of any protection means integral to the BATTERY design. When the application of a single fault condition is required by tests of this Manual, the equipment, circuit diagrams, and component specifications are to be examined to determine those fault conditions that are likely to occur. Consideration shall be taken for any ACTIVE PROTECTIVE DEVICES and PASSIVE PROTECTIVE DEVICES, which could be either electrical protection means or mechanical protection means.

NOTE 1 – Examples of single faults include but are not limited to:

- a) Short circuits and open circuits of semiconductor devices and capacitors;
- b) Faults causing continuous dissipation in resistors designed for intermittent dissipation;
- c) Internal faults in integrated circuits causing excessive dissipation;
- d) Any mechanical design to bridge or open the circuits.

NOTE 2 – Single faults can be the result of misuse of the BATTERY or the partial or complete loss of function of components.

Steady state condition

The state reached when the temperature rise of the several parts of the BATTERY does not vary by more than a gradient of 2 K per hour.

NOTE 3 – Steady state condition may be determined from the time-temperature rise plot when the straight lines between points at the beginning and end of two successive reasonable intervals each have a gradient of less than 2 K per hour.

3 SAFETY CONSIDERATIONS

3.1 Special considerations for LEV

Utilization and associated risks of LEV lie somewhere between BATTERY powered portable applications and car sized electric vehicles. Most of the test items were not newly developed; the content of this Manual was based on various documents (see Annex H) and adjusted accordingly.

It might be necessary to conduct one or more test items when the BATTERY is installed into the vehicle.

NOTE – Example: a BATTERY without outer rigid housing, which requires installation into the metal frame of an electric bike.

All tests, which could be negatively influenced by integration of the BATTERY into the vehicle (e.g. installation into the frame of an LEV), shall be tested with the BATTERY integrated into the vehicle. Such tests can be conducted on specially prepared samples (e.g. parts of frames of vehicle) provided that the results are representative of the results of testing the assembled product (battery installed in LEV).

3.2 Precautions when conducting tests

Some of the tests specified can be hazardous to the persons carrying them out; all appropriate measures to protect personnel and affected environment from possible chemical, burn or explosion hazards should be taken.

NOTE – More details are provided in Annex G.2.

3.3 Evaluation of protective devices and electronic circuits

Evaluation option 1: ACTIVE PROTECTIVE DEVICES bypassed

NOTE 1 – On request of the applicant PASSIVE PROTECTIVE DEVICES can be bypassed in addition. This condition shall be stated in the corresponding test report.

NOTE 2 – For affected test items refer to subclauses 5.1.1 a), 5.1.2 a) and 5.1.4.

Evaluation option 2: All protective circuits operating

Software and firmware evaluation is currently under investigation. As a consequence *evaluation option 2* testing is not permitted at this stage.

NOTE 3 – SINGLE FAULT tests are conducted for components and assembly – refer to subclause 2.3.

3.4 Thermoplastic materials exposed to sunlight

All non-metallic materials exposed to UV radiation (sunlight) shall be tested according to ISO 4892-2 condition A. The test has to be performed without cells in the housing, but the temperature inside the housing must be recorded.

NOTE – Examples of materials that could be affected: thermoplastic ENCLOSURE materials, wire and cable insulation, thermoplastic parts of connectors.

3.5 Design variations requiring additional testing

BATTERIES are considered to be different from a tested TYPE if any of the following applies:

- An increase of nominal voltage of more than 20 %
- A change in Watt-hours of more than 20 %
- A change of TYPE, application or ratings of PROTECTIVE DEVICES
- A change that would lead to failure of any of the tests described in this Manual

NOTE – Examples for changes can be found in subclause 38.3.2.2 of Amendment 1 of Section 38.3 of *Manual of Tests and Criteria of UN Recommendations on the Transport of Dangerous Goods*.

All tests have to be conducted with all alternative sources of CELLS.

In such a case such a different BATTERY TYPE shall be subject to all tests of clause 5 for the chosen *test option* (see subclause 1.1).

3.6 Batteries providing protection against ingress of foreign objects and water

ENCLOSURES of BATTERIES or parts of it that are not enclosed during normal use shall comply with IP54 of IEC 60529 or better.

NOTE – If enclosed after installation into the vehicle the degree of protection provided by the vehicle should be IP54 of IEC 60529, or whatever is required in relevant national or regional regulations.

4 TEST SETUP

4.1 Test equipment

4.1.1 Parameter measurement tolerances

Measurement values taken during tests shall be obtained with instruments with accuracies within following limits, if not otherwise specified for specific test items:

- Capacity: $\pm 1 \%$
- Current: $\pm 1 \%$
- Force: $\pm 6 \%$
- Linear dimension: $\pm 0.01 \text{ mm}$ (up to 25 mm) or $\pm 0.5 \%$ (above 25 mm)
- Mass: $\pm 1 \%$
- Resistance: $\pm 5 \%$
- Temperature: $\pm 2 \text{ }^\circ\text{C}$ ^{NOTE 1}
- Time: $\pm 0.1 \%$
- Voltage: $\pm 1 \%$

NOTE 1 – Thermocouple not included.

NOTE 2 – ISO/IEC 17025 provides rules for the estimation of measurement uncertainty for testing laboratories.

The details of the instrumentation used for testing shall be provided in the test report.

4.1.2 Temperature measurements

The temperature on the surface of the ENCLOSURE of the BATTERY shall be monitored during the tests described in subclauses 5.1.1, 5.1.2, 5.1.3, 5.1.4 and 5.2.1. The thermocouples used for temperature measurements consist of wires with diameter not exceeding 0.21 mm^2 (24 AWG) and not smaller than 0.05 mm^2 (30 AWG). The thermocouple must be held tightly against the outer ENCLOSURE of the BATTERY.

The temperature measuring point shall be that specified by the manufacturer, as a location that most closely reflects the electrolyte temperature or, if not specified, the point shall be at the centre of the longer side of the BATTERY top ENCLOSURE.

For all test items referenced above with exception of subclause 5.2.1, the CELL temperature shall be monitored.

4.1.3 Equipment requirements

The power source used shall be capable to deliver a 1C rate charge current at a minimum operation voltage of 6 times the number of CELLS connected in series inside the BATTERY.

NOTE 1 – Example: for a BATTERY with 10 cells in series the power source should have a minimum operation voltage of 60 V.

NOTE 2 – The term “1C rate” refers to a normalized rate equal to the nominal capacity of the cell. It refers to the current that a BATTERY can be discharged at for 1 hour to the cut-off voltage declared by the manufacturer.

The used adjustable load shall be capable to discharge the BATTERY with ratings as specified by the manufacturer or as required by this Manual.

Conductors external to the BATTERY shall have a negligible impedance of not exceeding 10 mΩ.

NOTE 3 – Examples for such wiring are conductors to power sources, conductors to loads and conductors used during tests requiring SHORT CIRCUITS.

4.2 General conditions for tests

Ambient temperature

Test of subclause 5.1.1 a):	Maximum temperature for charging declared by the manufacturer with a minimum of 20 °C, tolerances defined with ± 5 °C
Test of subclause 5.1.2 a) + b):	55 °C \pm 2 °C
Other test items:	20 °C \pm 5 °C

NOTE – Tests can be conducted at higher temperatures for *test option 2*, if declared so by the manufacturer. This should be stated in the corresponding test report section.

Humidity, air pressure

There are no limits defined for ambient humidity and air pressure. However, laboratory conditions shall be recorded in the test report.

Sample orientation

During tests a sample orientation as specified by the manufacturer, or (in absence of such data or several orientations are specified) the orientation resulting in worst results shall be applied.

Selection and conducting of tests

BATTERY settings, configuration, adjustment, load and introduction of SINGLE FAULTS and selection of test points shall be such as to result in the most unfavourable outcome.

4.3 Sample preparation

Manufacturer shall provide a quantity of CYCLED samples as defined in subclause 4.4.

Afterwards each BATTERY shall be pre-conditioned at an ambient temperature of 20 °C \pm 5 °C by charging and discharging for three CYCLES as described below.

During pre-conditioning of test samples temperatures shall be measured and described in the test report (corresponds to normal operation). The charger used shall be stated and described in the test report. The discharge capacity is to be recorded.

NOTE 1 – Obtained information will provide important details for the BATTERY application in the end product.

Unless otherwise specified, FRESH BATTERIES are to be provided for the test described in clause 5. BATTERIES are to be recharged to the required state prior to testing as indicated in Table 4.1.

Pre-conditioning

- Charge the BATTERY with the designated charger or according to the specification given by the BATTERY manufacturer.
- Discharge the BATTERY with a constant discharging current at a maximum possible, but not exceeding 1C, rate and reach the conditions recommended by the manufacturer. Record the capacity of the BATTERY.

The test program shall be terminated if the capacity obtained during the pre-conditioning differs more than 5 % from the initial capacity.

NOTE 2 – Capacity can be either calculated or recorded by suitable test equipment.

4.4 Test sequence and number of samples

4.4.1 Number of samples

The number of samples to be used in each test is shown in table 4.1. Requirements regarding the use of new samples or samples from earlier conducted tests see subclause 4.4.2.

Table 4.1 – Number of samples required

Category	Sub-clause	Test item	BATSO 01 - Test option 1				BATSO 01 - Test option 2			
			Number of FRESH samples at first CYCLE		Number of samples after 50 CYCLES		Number of FRESH samples at first CYCLE		Number of samples after 50 CYCLES	
			FC	FD	FC	FD	FC	FD	FC	FD
Electrical	5.1.1 a)	Overcharge	3	-	3	-	3	-	3	-
	5.1.1 b)		4	-	4	-	-	-	-	-
	5.1.2 a)	External SHORT CIRCUIT	3	-	3	-	3	-	3	-
	5.1.2 b)		4	-	4	-	-	-	-	-
	5.1.3 a)	Vibration	3	-	3	-	3	-	3	-
	5.1.3 b)		4	-	4	-	-	-	-	-
5.1.4	Partial SHORT CIRCUIT	-	3	-	3	-	3	-	3	
Mechanical	5.2.1	Crush	2	-	2	-	2	-	2	-
	5.2.2	Shock	4	-	4	-	3	-	3	-
	5.2.3	Drop	3	-	3	-	3	-	3	-
Environmental	5.3.1	Altitude simulation	4	-	4	-	3	-	3	-
	5.3.2	Temperature test	4	-	4	-	3	-	3	-

NOTE – For the purpose of Table 4.1 following abbreviations were introduced: FC = FULLY CHARGED, FD = FULLY DISCHARGED.

4.4.2 Test sequences

The intent of the test sequences is to minimizing the number of sample used to conduct all tests of the chosen *test option*.

The sequence of tests is shown in table 4.2. The tests within a sequence are arranged in order of increasing severity. It is expected that the sample will survive each test in the sequence with sufficient integrity to be used for the next test in the same sequence.

Sequences 1 and 2 of *test option 1* follow *UN Recommendations on the Transport of Dangerous Goods - Manual of Tests and Criteria: Section 38.3*. Tests must be conducted in sequence 1 *test option 1* on the same sample. The manufacturer may decide to conduct test item 5.1.1 b) with new samples or samples from tested and functional samples from sequence 1.

In other sequences of *test option 1* and for all sequences of *test option 2*, it is acceptable to use a new sample for each test item, and to change the order of sequences, and the order of tests within each sequence.

The following procedure describes the recommended testing program:

Tests of the respective *test option* may be conducted in increasing numerical order of sequence.

NOTE 1 – Example: BATSO 01 *test option 2* will start with tests of sequence 1 and finish with the test of sequence 5.

Within each sequence tests may be conducted in the stated order (starting with the test item indicated by letter “A”).

NOTE 2 – Example: Test sequence 3 of BATSO 01 *test option 1*: first conduct test of subclause 5.1.3 a) – indicated by letter “A” – followed by test of subclause 5.2.3 – indicated by letter “B”.

Before conducting the next test item in the sequence, the necessary examination procedure specified by the manufacturer should be performed on the test sample. If a sample survives a complete sequence and is still functional, it can be used for another sequence.

Table 4.2 – Test sequences ^{NOTE 3}

Category	Sub-clause	Test item	BATSO 01 - <i>Test option 1</i>							BATSO 01 - <i>Test option 2</i>				
			Sequence #:	1	2	3	4	5	6	7	1	2	3	4
Electrical	5.1.1 a)	Overcharge						A					A	
	5.1.1 b)			A										
	5.1.2 a)	External SHORT CIRCUIT							A					A
	5.1.2 b)		E											
	5.1.3 a)	Vibration			A						A			

Category	Sub-clause	Test item Sequence #:	BATSO 01 - Test option 1							BATSO 01 - Test option 2				
			1	2	3	4	5	6	7	1	2	3	4	5
	5.1.3 b)		C											
	5.1.4	Partial SHORT CIRCUIT					A					B		
Mechanical	5.2.1	Crush				A					B			
	5.2.2	Shock	D							B				
	5.2.3	Drop			B					C				
Environmental	5.3.1	Altitude simulation	A								A			
	5.3.2	Thermal test	B									A		

NOTE 3 – Changes to the order of sequences and changes to the order of tests within a sequence are only permitted for *test option 2* and sequences 3 to 7 of *test option 1*.

5 TYPE TESTS

NOTE 1 – For details of the compliance criteria refer to clause 6.

NOTE 2 – For term “*test option*” refer to subclause 1.1.

NOTE 3 – As currently only *evaluation option 1* is available refer to subclause 3.3 for treatment of ACTIVE PROTECTIVE DEVICES.

5.1 Electrical tests

5.1.1 Overcharge

5.1.1 a) Overcharge (test options 1 and 2)

Purpose

This test evaluates the ability of a RECHARGEABLE BATTERY to withstand an overcharge condition.

Test

Each FULLY CHARGED BATTERY is to be subjected to a constant charging current at a maximum possible, but not exceeding, 1C rate, using a supply voltage sufficient to maintain the before described current throughout the duration of the test, but not exceeding 6 times the number of CELLS connected in series inside the BATTERY.

NOTE – Example: for a BATTERY with 10 cells in series the voltage shall not exceed 60 V.

The voltage of BATTERIES and charging current are to be recorded. The temperature is to be measured on the outside of the ENCLOSURE of the BATTERY.

Overcharge until the BATTERY explodes, vents or the temperature of the outside of the ENCLOSURE reaches STEADY STATE CONDITIONS or returns to ambient temperature.

Criteria

No disassembly, no fire.

5.1.1 b) Overcharge (test option 1)

See subclause 38.3.4.7 of *UN Recommendations on the Transport of Dangerous Goods - Manual of Tests and Criteria* (Test T.7, "Overcharge").

5.1.2 External short circuit

5.1.2 a) External short circuit (test options 1 and 2)

Purpose

This test simulates a SHORT CIRCUIT external to the BATTERY.

Test

Each FULLY CHARGED BATTERY is to be SHORT CIRCUITED by connecting the positive and negative terminals of the BATTERY with a suitable wire connection of negligible impedance not exceeding 10 mΩ.

The BATTERY is to be discharged until a fire or explosion is obtained, or until it is completely discharged, or until the inside of the ENCLOSURE of the BATTERY temperature has peaked or reached a STEADY STATE CONDITION. The BATTERY must be observed for a further 6 hours for the test to be concluded.

Criteria

No disassembly, no fire. The temperature of the inside of the ENCLOSURE of the BATTERY shall not exceed 150 °C within 6 hours.

5.1.2 b) External short circuit (test option 1)

See subclause 38.3.4.5 of *UN Recommendations on the Transport of Dangerous Goods - Manual of Tests and Criteria* (Test T.5, "External short circuit").

5.1.3 Vibration

5.1.3 a) Vibration endurance (test options 1 and 2)

Purpose

This test simulates vibration as experienced during the operation of LEV.

Test

While vibrated, each FULLY CHARGED BATTERY is to be discharged according to the manufacturer's recommended minimum discharge voltage at the manufacturer's recommended maximum continuous discharge current.

BATSO 01
2013-10

The vibration shall have a sinusoidal waveform with a logarithmic sweep between 7 Hz and 200 Hz and back to 7 Hz traversed in 15 minutes. This cycle shall be repeated 12 times for a total of 3 hours for each of three mutually perpendicular directions. One of the directions of vibration must be perpendicular to the terminal face. After completion of each cycle the battery shall be fully charged.

The logarithmic frequency sweep is as follows: from 7 Hz peak acceleration of 1 gn is maintained until 18 Hz is reached. The amplitude is then maintained at 0.8 mm (1.6 mm total excursion) and the frequency increased until a peak acceleration of 8 gn occurs (approximately 50 Hz). A peak acceleration of 8 gn is then maintained until the frequency is increased to 200 Hz.

NOTE – Symbol “gn” stands for standard acceleration of gravity (9.81 m/s²).

Criteria

No leakage, no venting, no disassembly, no fire, no rupture.

5.1.3 b) Vibration (test option 1)

See subclause 38.3.4.3 of *UN Recommendations on the Transport of Dangerous Goods - Manual of Tests and Criteria* (Test T.3, “Vibration”).

5.1.4 Partial short circuit (test options 1 and 2)

Purpose

The partial SHORT CIRCUIT test is designed to evaluate the effects of SHORT CIRCUITS that internally occur across a significant portion of the BATTERY during charging.

Test

The BATTERY shall be tested at ambient temperature. Each FULLY DISCHARGED BATTERY is to be charged with the designated charger or defined charge pattern provided by the manufacturer. After the charging current reaches steady-state condition, the adjacent CELLS as described below are to be SHORT CIRCUITED with a suitable wire connection of negligible impedance not exceeding 10 mΩ.

Charge until the BATTERY explodes, vents or the temperature of the outer ENCLOSURE reaches STEADY STATE CONDITIONS or returns to ambient temperature.

Number and location of cells to be SHORT CIRCUITED shall follow Table 5.1. The SHORT CIRCUIT shall be introduced as close as possible around the center of one STRING.

Table 5.1 – Number and location of CELLS to be SHORT CIRCUITED

Battery with 2-5 CELLS or CELL BLOCKS in series	Battery with 6-10 CELLS or CELL BLOCKS in series	Battery with 11-15 CELLS or CELL BLOCKS in series	Battery with >15 CELLS or CELL BLOCKS in series
SHORT CIRCUIT of one centrally located CELL or CELL BLOCK	SHORT CIRCUIT of two centrally located adjacent CELLS or CELL BLOCKS	SHORT CIRCUIT of three centrally located adjacent CELLS or CELL BLOCKS	SHORT CIRCUIT of four centrally located adjacent CELLS or CELL BLOCKS

NOTE – If the BATTERY contains PARALLEL STRINGS SHORT CIRCUITING of CELL(s) or CELL BLOCK(S) is only required in one STRING.

Criteria

No disassembly, no fire.

5.2 Mechanical tests

5.2.1 Crush (test options 1 and 2)

Purpose

This test evaluates the ability of a RECHARGEABLE BATTERY to withstand a mechanical damage caused e.g. by a traffic accident, or being dropped during transport between the vehicle and the charge location, or the BATTERY exposed to external forces like in a trash compactor.

Test

This test shall be conducted with two sample orientations. FULLY CHARGED BATTERIES are to be used. A test stamp (see Figure D.3) is used to crush the BATTERIES. The width of the test stamp shall be 10% larger than the width W (see Figure D.4) of the tested battery. In the first orientation the BATTERIES (one FRESH BATTERY, and one BATTERY after 50 CYCLES, see Table 4.1) will be placed with the longest side flat on the test stand (as pictured in Figure D.1) and crushed with the test stamp in the center with a speed of 15 mm/s ± 5 mm/s not exceeding a peak force on the test stamp of 100 kN. In the second orientation the test will be repeated with the BATTERIES (one FRESH BATTERY, and one BATTERY after 50 CYCLES, see Table 4.1) "standing" on the narrower side as shown in Figure D.2.

The voltage of BATTERIES and the crush force are to be recorded. The temperature is to be measured on the BATTERY ENCLOSURE. The test shall be continued until:

- The test stamp has compressed the ENCLOSURE by 30 % depth, the temperature of the outer ENCLOSURE reaches steady state conditions or returns to ambient temperature, or
- The BATTERY explodes or vents.

Criteria

No disassembly, no fire.

5.2.2 Shock (test options 1 and 2)

See subclause 38.3.4.4 of *UN Recommendations on the Transport of Dangerous Goods - Manual of Tests and Criteria* (Test T.4, “Shock”).

5.2.3 Drop (test options 1 and 2)

Purpose

This test simulates dropping of a BATTERY (for example, portable, swappable user exchangeable BATTERY types).

NOTE – Such situations are likely to occur during the charging procedure in vehicles without integrated charger.

Test

Each sample is to be freely dropped from a height of 1 m on a flat surface made of concrete in the position that is most likely to produce the most adverse result. Each sample is to be dropped three times.

Criteria

No fire, no disassembly, no rupture.

5.3 Environmental tests

5.3.1 Altitude simulation (test options 1 and 2)

See subclause 38.3.4.1 of *UN Recommendations on the Transport of Dangerous Goods - Manual of Tests and Criteria* (Test T.1, “Altitude simulation”).

5.3.2 Temperature test (test options 1 and 2)

See subclause 38.3.4.2 of *UN Recommendations on the Transport of Dangerous Goods - Manual of Tests and Criteria* (Test T.2, “Thermal test”).

NOTE – This test can be performed in a single chamber whose temperature is changed or in three separate chambers at different test temperatures.

6 COMPLIANCE CRITERIA

6.1 Compliance criteria for test items

Table 6.1 contains an overview of the requirements for electrical, mechanical and environmental tests described in clause 5. For more detailed compliance criteria refer to the text of specific test items in clause 5.

Table 6.1 – Summary of type tests and requirements

Category	Sub-clause	Test item	Requirements
Electrical	5.1.1 a)	Overcharge	ND, NF
	5.1.1 b)		ND, NF Additional criterion: BATTERIES shall be monitored for seven days.
	5.1.2 a)	External SHORT CIRCUIT	ND, NF Additional criterion: The temperature of the ENCLOSURE of the BATTERY does not exceed 150 °C.
	5.1.2 b)		ND, NF, NR Additional criterion: The temperature of the ENCLOSURE of the BATTERY does not exceed 170 °C.
	5.1.3 a)	Vibration	ND, NF, NL, NR, NV
	5.1.3 b)		ND, NF, NL, NR, NV Additional criterion: The open circuit voltage of each BATTERY after testing is not less than 90 % of its voltage immediately prior to testing.
	5.1.4	Partial SHORT CIRCUIT	ND, NF
Mechanical	5.2.1	Crush	ND, NF
	5.2.2	Shock	NF, ND, NL, NR, NV Additional criterion: The tested BATTERY shall have 95 % of discharged capacity after shock test.
	5.2.3	Drop	ND, NF, NR
Environmental	5.3.1	Altitude simulation	ND, NF, NL, NV, NR Additional criterion: The post-testing OCV of BATTERY shall remain at least 90 % of its original value.
	5.3.2	Temperature test	ND, NF, NL, NV, NR Additional criterion: The post-testing OCV of BATTERY shall remain at least 90 % of its original value.

List of abbreviations used in Table 6.1:

ND: No disassembly
NF: No fire
NL: No leakage
NR: No rupture
NV: No venting
OCV: Open circuit voltage

No disassembly

No venting or rupturing occurred where solid parts of the BATTERY have penetrated a wire mesh screen (annealed aluminium wire with a diameter of 0.25 mm and a grid density of 6 to 7 wires per cm) placed 25 cm away from the BATTERY.

NOTE 1 – In other publications the term explosion is used in the same meaning.

No fire

No emission of flames from a BATTERY.

NOTE 2 – Smoke is not considered as fire. However, Annex B applies (after amended).

Cheesecloth shall be placed in 100 mm distance above the battery sample. After the test, this cheesecloth shall remain intact.

NOTE 3 – Cheesecloth: bleached cotton cloth of approximately 40 g / m² (derived from IEC 62368-1:2010).

No leakage

No visible escape of electrolyte or other material, or the loss of material (except battery casing, handling devices or labels) such that the mass loss of the BATTERY exceeds 0.1 % calculated as following:

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

where

m₁ is the mass before the test

m₂ is the mass after the test

NOTE 4 – Samples tested in orientation(s) as described by the manufacturer.

NOTE 5 – Leakage is evidenced by liquid or condensed electrolyte composition external to the BATTERY.

No rupture

No mechanical failure of a BATTERY ENCLOSURE induced by an internal or external cause, resulting in expulsion of gas or spillage of liquids but not ejection of solid materials. Furthermore, the BATTERY shall not allow the test finger (see Annex E)

- To enter the ENCLOSURE for 10 mm or more, or
- To contact any uninsulated part inside the ENCLOSURE

with a force of 30 N ± 3 N applied over a period of 5 s.

No venting

No release of excessive internal pressure from a BATTERY in a manner intended by design to preclude rupture or disassembly.

6.2 Compliance criteria during final observation period

Samples which have completed

- Test sequences 3 to 7 of *test option 1* (see Table 4.2), or
- Test sequences 1 to 5 of *test option 2* (see Table 4.2)

shall be observed in a suitable environment at a temperature of $20\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ for five days immediately following the last test item of the respective test sequence. The temperature at the outside of the ENCLOSURE of the BATTERY shall be controlled.

The observation outcome is negative if any battery catches fire or disassembles. The BATTERY is considered to be not in compliance with requirements of this Manual.

The observation period is successfully completed if the temperature at the outside of the ENCLOSURE of the BATTERY reached ambient temperature after a five days interval.

NOTE – If the temperature did not reach ambient temperature after a five days observation period, another five days period is initiated. This is repeated until either the outside of the ENCLOSURE of the BATTERY has cooled down to ambient temperature, or a negative observation outcome is observed.

ANNEX A Transport regulations (informative)

NOTE 1 - Commercial transport of LITHIUM BATTERIES is subject to dangerous goods legislation. Transport preparations and transport are exclusively to be carried out by appropriately trained persons and/or the process has to be accompanied by corresponding experts or qualified companies.

LITHIUM BATTERIES are subject to the following dangerous goods regulations and exceptions to them - in the version applicable in each case:

Class 9

UN 3090:	lithium metal BATTERIES
UN 3091:	lithium metal BATTERIES contained in equipment, or lithium metal batteries packed with equipment
UN 3480:	lithium ion BATTERIES (including lithium-ion-polymer batteries)
UN 3481:	LITHIUM ION BATTERIES contained in equipment, or lithium ION BATTERIES PACKED with equipment (including LITHIUM ION polymer BATTERIES)
Packaging group:	II, Tunnel category E

Special and packaging regulations:

ADR, RID: 188, 230, 310, 376, 636,661/ P903, P903a, P903b

NOTE 2 - For ADR, Europe see

www.bmvbs.de/SharedDocs/DE/Artikel/UI/Gefahrgut/gefahrgut-recht-vorschriften-strasse.html.

IATA:

A88, A99, A154, A164, P965, P966, P967, P968, P969, P970

NOTE 3 - For the IATA Guidance Document on LITHIUM BATTERIES see

<http://www.iata.org/whatwedo/cargo/dgr/Pages/lithium-batteries.aspx>.

IMDG Code:

188, 230, 310, P903
EmS: F-A, S-I
Stowage category: A

Test and inspection specifications

In accordance with the dangerous goods regulations for LITHIUM BATTERIES, each new type of CELL or BATTERY must have passed all tests listed in the UN Manual of Tests and Criteria, Part III, Section 38.3. This particularly applies also if multiple CELLS or BATTERIES have been linked into new BATTERIES (BATTERY PACKS OR BATTERY ASSEMBLIES).

NOTE 4 - For the UN Manual see www.unece.org/trans/danger/publi/manual/Rev5/ManRev5-files_e.html.
For a German translation, see

www.bam.de/de/service/publikationen/publikationen_medien/handbuch_befoerderung_gefaehrlicher_gueter.pdf.

Used BATTERIES are also subject to these regulations. In the case of used BATTERIES which are intact and undamaged, usually the regulations for new BATTERIES can be applied.

Defective or damaged BATTERIES are subject to more stringent regulations, ranging all the way to complete prohibition of transport. The prohibition of transport applies to air transport carriers (ICAO T.I., IATA DGR - special provision A154). However, for the transport of used - but not damaged - batteries, refer also to the corresponding special regulations (636), and/or packaging instructions (P903a and P903b / ADR).

Waste BATTERIES and BATTERIES which are sent for recycling or disposal are prohibited from air transport (IATA Special provision A 183).

Exceptions are to be approved by the responsible national authority of the country of departure and the respective nation of the airline company.

BATSO 01
2013-10

ANNEX B Environmental Management System Evaluation (normative)

Empty – Reserved for future use.

ANNEX C Marking (normative)

C.1 General marking requirements

Each BATTERY shall carry clear and durable marking on the outer ENCLOSURE providing all of the following information:

- Rechargeable Li or Li-ion
- Model- or type-designation of the BATTERY
- Polarity of terminals (unless standardized, polarized connectors are used)
- Date of manufacture (which may be in code)
- Name or identification (trademark) of manufacturer or supplier
- Rated capacity
- NOMINAL VOLTAGE

NOTE 1 – Marking requirements are derived from subclause 5.3 of IEC 61960:2003.

NOTE 2 – Model- or type-designation of the BATTERY could be a model name, or a marking as regulated in IEC 61960:2003, or any other suitable method.

- Electrical ratings of externally accessible protective devices

NOTE 3 – Example: fuse, for which rated voltage, rated current, type of current, special fusing characteristics (if applicable) would apply; marking should be placed close to fuse holder.

- Symbols

NOTE 4 – Example: symbol making reference to the accompanying documents for providing there further details, see ISO 7000 (Graphical symbols for use on equipment).

C.2 BATSO marking

The BATSO marking shall have the following form:



Figure C.1 – BATSO marking

NOTE – A vector graphic file format of the BATSO marking is available on the internet web site of Battery Safety Organisation.

ANNEX D Test stamp for crush test (normative)

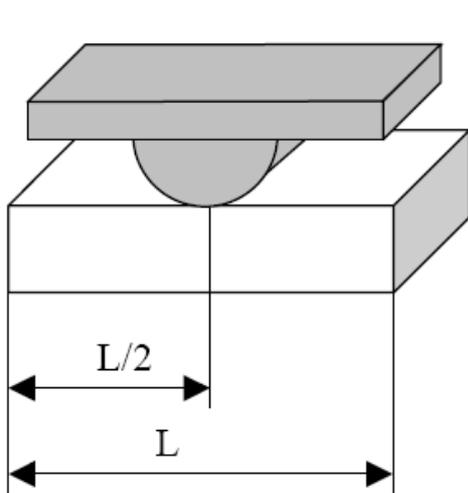


Figure D.1

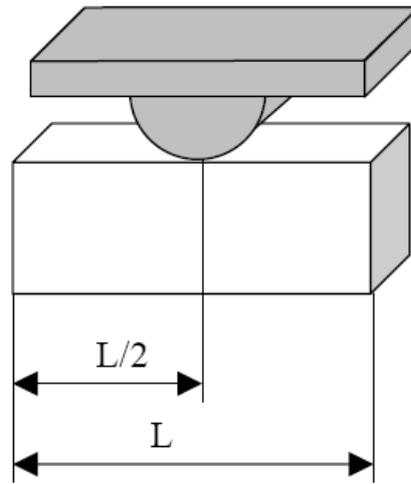
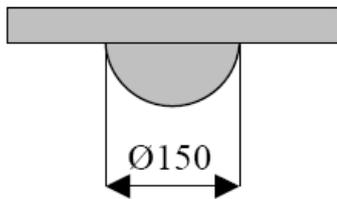


Figure D.2

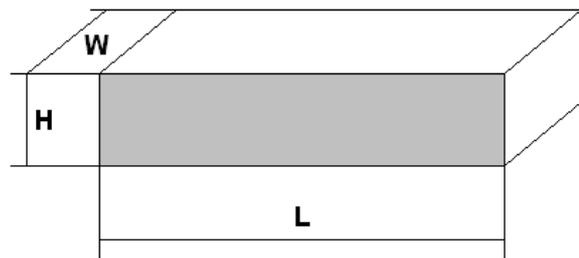


Dimension in millimeters

The surface of the (half-) cylinder shall be made of non-conductive material.

NOTE – Example: glass-fiber epoxy coating on a steel stamp.

Figure D.3



Definition of terms applying to the enclosure of a BATTERY: Length L, width W and height H are assigned in such way that following applies:

$$L \geq W \geq H$$

Figure D.4

ANNEX E Test probe (normative)

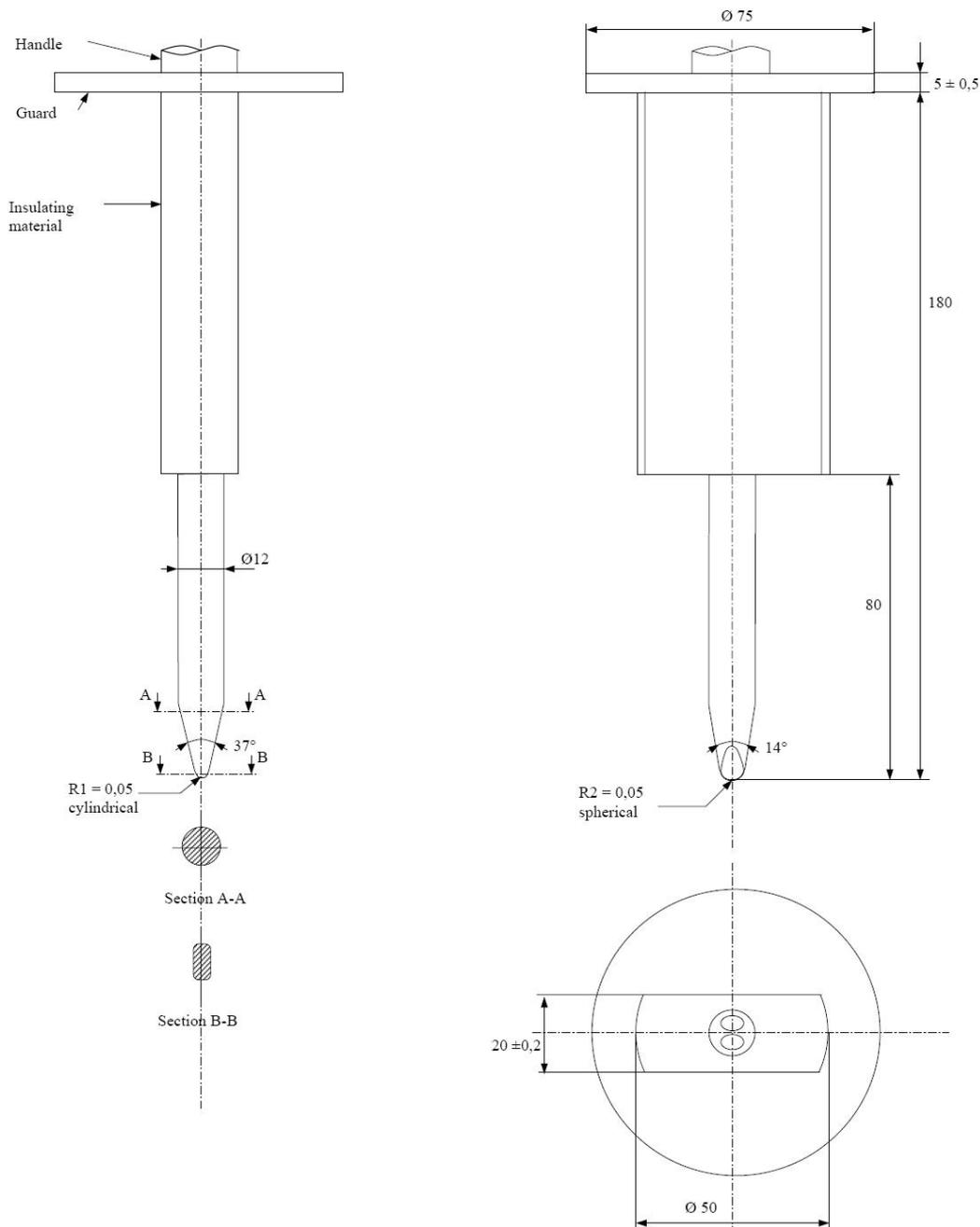


Figure E.1 – Test probe (“test finger”)

NOTE 1 – The test finger is derived from Figure 2, test probe B of IEC 61032:1997. However, no joints are provided.

NOTE 2 – Linear dimensions are in millimetres.

NOTE 3 – Material of finger: metal, except where otherwise specified.

NOTE 4 – Tolerances on dimensions without specified tolerances:

- on angles: $+0 / -10^\circ$
 - on linear dimensions:
- | | |
|---------------|----------------------|
| ≤ 25 mm: | $+0$ mm / $-0,05$ mm |
| >25 mm: | $\pm 0,2$ mm |

ANNEX F Information to be provided by manufacturers (informative)

F.1 Information regarding packaging and transportation

F.1.1 Sample classification

BATTERY samples that have not been previously tested for compliance with BATSO 01 (*test option 1 or 2*) or relevant tests of *UN Recommendations on the Transport of Dangerous Goods - Manual of Tests 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 ION BATTERY.

F.1.2 Labelling

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

F.1.3 Packaging

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

F.1.4 Transport or shipper's declaration

F.1.5 List of content of package

List of package contents, including item names and quantity.

F.2 Documents

F.2.1 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.

F.2.2 Handling instructions and guidelines for CELLS and BATTERY PACKS

Such data should 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

F.2.3 Operation manual of BATTERY PACKS, chargers, PCB or BMS

F.2.4 Certificates for components and SUBSYSTEMS

Refer to Table 1.1 for details about required certificates.

F.2.5 Quality examination report of samples

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

F.2.6 Overview about provided samples and their respective CYCLE history

F.3 Additional information

F.3.1 Instructions on bypassing PROTECTIVE DEVICES

The BATTERY manufacturer should provide following information:

- Procedure to open and re-assemble the ENCLOSURE of the BATTERY with highlighting points of special attention.
- Type, location and bypassing method of PROTECTIVE DEVICES.

NOTE – Such information can be provided in form of drawings, graphs or photographs.

F.3.2 Other information

The battery manufacturer is suggested to provide following information to help laboratories understand the samples and conduct tests:

- CYCLING data measured by the BATTERY manufacturer
- Intended application(s) or use of the BATTERY
- Additional information needed by test laboratories to understand the BATTERY in order to setup and conduct tests of this Manual

ANNEX G Miscellaneous (informative)

G.1 Coverage of UN Recommendations on the Transport of Dangerous Goods - Manual of Tests and Criteria: Section 38.3

Tests and conditions as specified in *UN Recommendations on the Transport of Dangerous Goods - Manual of Tests and Criteria: Section 38.3* are covered as part of the testing of this Manual when *test option 1* (see subclause 1.1) is chosen.

As these tests address primarily the behaviour of the BATTERY during transport conditions, additional tests were defined which are either not covered by *UN Recommendations on the Transport of Dangerous Goods - Manual of Tests and Criteria: Section 38.3* or which are modified in conditions or compliance criteria.

Table G.1 provides a quick overview about covered test items. Tests of the *UN Recommendations on the Transport of Dangerous Goods - Manual of Tests and Criteria: Section 38.3* are shown in column "UN-T".

Table G.1 – Comparison of test items

Test name	UN-T ^{NOTE 1}	BATSO 01 - <i>Test option 1</i> ^{NOTE 2}	BATSO 01 - <i>Test option 2</i> ^{NOTE 2}
Overcharge	Test T.7	5.1.1 a) + 5.1.1 b)	5.1.1 a)
External SHORT CIRCUIT	Test T.5	5.1.2 a) + 5.1.2 b)	5.1.2 a)
Vibration	Test T.3	5.1.3 a) + 5.1.3 b)	5.1.3 a)
Partial SHORT CIRCUIT	--	5.1.4	5.1.4
Crush	--	5.2.1	5.2.1
Shock	Test T.4	5.2.2	5.2.2
Drop	--	5.2.3	5.2.3
Altitude simulation	Test T.1	5.3.1	5.3.1
Temperature test	Test T.2	5.3.2	5.3.2

NOTE 1 – Test T.6 and Test T.8 of *UN Recommendations on the Transport of Dangerous Goods - Manual of Tests and Criteria: Section 38.3* apply only to CELLS and not to a BATTERY.

NOTE 2 – Term "test option" refers to subclause 1.1.

NOTE 3 – Following listing groups test items that are identical:

- UN-T Test T.1 = BATSO 01, subclause 5.3.1
- UN-T Test T.2 = BATSO 01, subclause 5.3.2
- UN-T Test T.3 = BATSO 01, subclause 5.1.3 b)
- UN-T Test T.4 = BATSO 01, subclause 5.2.2
- UN-T Test T.5 = BATSO 01, subclause 5.1.2 b)
- UN-T Test T.7 = BATSO 01, subclause 5.1.1 b)

G. 2 BATSO recommendations for conducting of testing and general BATTERY handling

G.2.1 Important notice for information provided in subclause G.2

Following safety instructions for testing BATTERIES and user recommendations are based on present knowledge. Nevertheless, BATSO does not accept liability for the correctness and completeness of the information provided in this subclause G.2. Everybody involved in the handling or testing of lithium BATTERIES is responsible for analyzing the

recommendations of these subclauses and take appropriate measures to ensure required levels of safety with respect to the given conditions. It is generally recommended to consult the manufacturer of the BATTERY in case of doubt.

G.2.2 General information



Keep away from open flame and great heat. Danger of explosion and fire.



Danger of explosion and fire due to short circuit, overheating or other electrical/mechanical misuse.



Read documents accompanying the BATTERY.



Use protective goggles and gloves working with BATTERIES. Wash your hands when done.



Make sure safe accommodation and fastening. Use approved packaging for transport of hazardous material.

NOTE - BATTERIES might be semi-charged upon delivery. Avoid short circuit between +/- poles, as CELLS can provide a high SHORT CIRCUIT current. Only use in an appropriate testing environment or with appropriate charging devices approved for LITHIUM ION BATTERIES! Any kind of damage can result in separation or destruction of the BATTERIES. The damaged BATTERIES may not be used again. Damaged BATTERIES are to be stored securely and to be kept safe from unwarranted access and use. Please heed instructions by the producer.

G.2.3 Guiding principle

Only qualified and properly instructed personnel at suitable controlled facilities should conduct the testing. It is recommended that at least two persons at a time should conduct a test.

G.2.4 Possible hazardous situations, especially in the case of misuse tests

- Contact with solid material may lead to skin corrosion and severe eye damage.
- Inflammable, explosive mixtures of gas and air may be created in water and humidity.
- Danger of formation of toxic pyrolytic products, hydrogen fluoride (HF) may be set free in case of fire.
- Self-ignition may be caused by heat build-up.
- Reactions with water, carbonic acid and halon (gaseous fire suppression agent) may cause danger of fire or explosion.
- Risk of formation of highly flammable gas mixtures, and other combustion products such as carbon monoxide, carbon dioxide, manganese, nickel and aluminium oxide.
- Heating may lead to rising pressure; bursting and explosion cannot be ruled out.

G.2.5 Personal safety equipment

- Always wear adequate, heatproof protective gloves.
- Tightly closed pair of goggles.
- Keep eye wash bottle with pure water at hand.
- Keep respirator mask at hand.
- In case of fire – see instructions of subclause G.2.8 below.

G.2.6 General measures to be taken by test personnel

- Test facilities must be accessible only to authorised personnel.
- No personnel shall be present inside the test room during testing.
- Test personnel must fully understand the scenarios in which injuries can arise in their workplace.
- Test personnel must be given adequate first-aid training.
- Test facilities must have suitable warnings indicating that testing is in progress and must provide means preventing unauthorized access.
- No open flames, no smoking at the workplace.
- Stay on the side directed towards the air-flow (so you are not exposed to fumes).
- Contact fire-fighters in case of large fire.
- Upon unscheduled rise in temperature or emergence of fumes: pay special attention, as fire and explosion are likely to follow and prepare for suitable action.

G.2.7 Storage of LITHIUM ION BATTERIES

- Recommended storage temperature: -10 °C to below 30 °C (if not otherwise specified by the manufacturer)
- Well ventilated area
- Store short circuit safe, not on top of metal objects
- Store at dry places, away from open flames and food
- Store in closed original packaging until use, do not jumble them
- Avoid big temperature changes
- Keep adequate clearance between walls and batteries
- Do not store close to heating devices, avoid direct sunlight
- Preferred storage at 50 % of the nominal capacity (if not otherwise specified by the manufacturer)
- Temperature above 70 °C may result in battery leakage and rupture (if not otherwise specified by the manufacturer)
- Storage of large amounts: if possible, store the batteries in original packaging; a fire alarm system is recommended; implement fire fighting measures

G.2.8 Fire

- Keep water away; cautiously remove other BATTERIES if possible.
- Evacuate all persons from immediate area of fire.
- Use extinguishing media suitable for the materials that are burning.

NOTE 1- Examples of suitable extinguishing agents: dry powder, metal extinguisher, metal dry powder, dry sand.

NOTE 2- Examples of extinguishing media with limited suitability: carbon dioxide (CO₂), water jet, and cold water in large volume are applicable for incipient fire. Do not use warm or hot water.

- Use fire extinguisher and fire blankets only against small fires. Do not extinguish container fires this way, but start adequate extinguishing systems immediately.
- Use respiratory protective devices (e.g. masks).
- It is recommended keeping a sufficient number of suitable fire extinguishers in close proximity.
- Upon emergence of smell, deformation of test chambers, unscheduled rise in temperature or emergence of fumes: immediately place CELLS or BATTERIES in an adequate metal container (open) and remove it from the building, if possible without risking own safety. Remember to put protective clothes on beforehand! If heated above 125 °C CELLS can explode or vent.

G.2.9 First aid

- Involve personnel familiar with first aid immediately.
- If substances have gotten in contact with eyes, please wash out with a large amount of water for several minutes and consult a doctor.
- Remove clothes that are contaminated with the product immediately and wash skin with soap and water.
- In case of burnings of the skin, cool the skin immediately and as long as possible with cold water.
- Medical aid will be required in case of symptoms obviously caused by respiration or swallowing of combustion gases or contact with skin or eyes.
- After inhalation: leave area immediately. Fresh air. Seek for medical assistance.
- After skin contact: remove solid particles immediately. Flush affected areas with plenty of water (at least for 15 minutes). Remove contaminated clothes immediately. Seek for medical attention.
- After eye contact: flush the eye gently with plenty of water (at least for 15 minutes). Shield unaffected eye. Seek for medical assistance.
- After ingestion: drink plenty of milk or water and induce vomiting. Seek for medical attention.

G.2.10 General safety information and recommendations

G.2.10.1 Recommendations for application and testing

- Only choose BATTERIES of the right size and sufficient resilience, appropriate for the intended use. Keep information supplied with the devices to be able to access information and help for selecting the right BATTERIES later.
- Replace all BATTERIES of one set at a time.
- Please clean the contacts of the BATTERY and the device before installation.
- Please make sure that polarity of a BATTERY is correct when installed.
- Remove BATTERIES if a device is not to be used for a prolonged time.
- Promptly remove used (exhausted) BATTERIES.

G.2.10.2 Other basic recommendations

The following table contains a basic summary of general good recommendations (as well valid for lead-acid, Nickel-Cadmium or Nickel-Metalhydrid batteries). Some items are not applicable if specific test procedures provide conflicting instructions.

BATSO 01
2013-10

- a) Do not open, chop up or disassemble rechargeable CELLS or BATTERIES at any times.
- b) Do not expose CELLS or BATTERIES to great heat or fire.
- c) Do not short circuit CELLS or BATTERIES. Do not leave CELLS or BATTERIES without protection in a box or drawer, where a short circuit may be caused by stacking or by other metal parts.
- d) Take CELLS or BATTERIES out of their original package, when needed.
- e) Do not expose CELLS or BATTERIES to strong mechanical impacts.
- f) Do not use a charging device other than the one made for use with your device.
- g) Plus (+) and minus (-) – signs on CELLS, BATTERIES and devices must be heeded at all times. It has to be made sure that they are used appropriately.
- h) Do not use CELLS by different producers with varying capacities, measurements or construction designs together in the same device.
- i) Keep BATTERIES away from the reach of children.
- j) Keep BATTERIES dry and clean. If BATTERY poles are soiled, they can be wiped with a clean and dry cloth. Plastic surfaces, such as cases or lids, may only be wiped with a cloth dipped in water. Do not use any detergents.
- k) BATTERIES may not be in contact with solvent materials (i.e. dilution, alcohol, oil, anti-corrosive) or chemicals that impact surfaces (i.e. detergents).
- l) Rechargeable BATTERIES have to be charged before being used. Only the proper, correct charging device may be used. For charging, please heed the producer's instructions or the instructions in the manual of the device.
- m) Do not leave BATTERIES charging permanently if they are not being used.
- n) After a prolonged storage time, it may be necessary to charge and discharge the BATTERIES multiple times to get back to performance.
- o) Rechargeable BATTERIES have the greatest performance when kept and used at normal room temperature ($20\text{ }^{\circ}\text{C} \pm 5\text{ K}$).
- p) Keep original printed papers with product information for later consultation.
- q) Only put BATTERIES to applications that they were designed for.
- r) If possible, remove BATTERIES from device, if they are not being needed.
- s) Please heed enclosed special disposal instructions about BATTERIES.

G.2.11 Cleaning after test, especially in the case of fire

- Take up solid parts mechanically.
- Take up residues with absorbent material (i.e. Vermiculite, sand, lime, diatomaceous earth). Dispose of absorbed material according to local regulations. Then clean with water.
- Avoid leached substances to penetrate into the ground, canalization or water.
- Clean affected areas with suitable cleansing material (including ventilation tubes and air-conditioners), eventually replace filters.

G.3 Immersion test

Immersion of large lithium BATTERIES in salt water was tested as described in the *Electrical Energy Storage System Abuse Test Manual for Electric and Hybrid Electric Vehicle Applications*. Test results demonstrated that such exposure did not result in hazardous situations. Therefore, this test item is currently not considered relevant for BATSO 01.

G.4 Future projects within BATSO 01

G.4.1 Software and firmware evaluation

G.4.2 Environmental aspects related to manufacturing and handling of batteries

NOTE – Details will be provided in Annex B.

ANNEX H References (normative)

IEC 60335-1:2006 (4.2 ed.) *Household and similar electrical appliances - Safety - Part 1: General requirements*

IEC 60335-2-29:2010 (4.2 ed.) *Household and similar electrical appliances - Safety - Part 2-29: Particular requirements for battery chargers*

IEC 60529:2001 (2.1 ed.) *Degrees of protection provided by enclosures (IP code)*

IEC 61032:1997 (2nd ed.) *Protections of persons and equipment by enclosures – Probes for verification*

IEC 61643 Part 321:2001 *Components for low-voltage surge protective devices - Part 321: Specifications for avalanche breakdown diode (ABD)*

IEC 61851-1:2001 (1st ed.) *Electric vehicle conductive charging system - Part 1: General requirements*

IEC 61851-21:2001 (1st ed.) *Electric vehicle conductive charging system - Part 21: Electric vehicle requirements for conductive connection to an a.c./d.c. supply*

IEC 61851-22:2001 (1st ed.) *Electric vehicle conductive charging system - Part 22: AC electric vehicle charging station*

IEC 61960:2003 (1st ed.) *Secondary cells and batteries containing alkaline or other non-acid electrolytes - Secondary lithium cells and batteries for portable applications*

IEC 62133:2012 (2nd ed.) *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*

IEC 62368-1:2010 (1st ed.) *Audio/video, information and communication technology equipment - Part 1: Safety requirements*

ISO 4892-2:2006 (2nd ed.) *Plastics – Methods of exposure to laboratory light sources – Part 2: Xenon-arc lamps*

ISO 7000:2004 *Graphical symbols for use on equipment – Index and synopsis*

ISO/IEC 17025:2005 (2nd ed.) *General requirements for the competence of testing and calibration laboratories*

UN Recommendations on the Transport of Dangerous Goods - Manual of Tests and Criteria:2009-12 (5th rev. ed. plus Amendment 1 from 2011) *Section 38.3 – Lithium batteries*

ANNEX I Bibliography (informative)

FreedomCAR:2005 *Electrical Energy Storage System Abuse Test Manual for Electric and Hybrid Electric Vehicle Applications*

IATA Dangerous Goods Regulations (51st ed.)

IEC 62660-1:2010 (1st ed.) *Secondary lithium-ion cells for the propulsion of electric road vehicles - Part 1: Performance testing*

UL 1642 (4th ed.) *Lithium Batteries*

UL Subject 2271 (2010-03) *Batteries for use in light electric vehicle (LEV) applications*

UN 3480 *Lithium Ion Battery*

UN 3481 *Lithium Ion Batteries packed with equipment*

VDA-Initiative "Energy storage system for HEV" – Release 1.0:2007: *Test specification for Li-Ion Battery Systems for Hybrid Electric Vehicles*

ANNEX J Changes in this edition (informative)

The principle changes in this edition as compared with the second edition of BATSO 01 are as listed below. Minor changes are not shown.

Subclause 1.1: adding Note 4 as clarification
Subclause 1.3: revision of footnote "a" of Table 1.1
Subclause 2.1: adding definition of "cell block"
Subclause 2.1: adding definition of "nominal voltage"
Subclause 2.1: adding definition of "parallel string"
Subclause 2.1: adding Note 7 as clarification
Subclause 2.1: adding definition of "string"
Subclause 2.2: adding clarifying Note
* Subclause 3.5: adding clarifying Notes 1 and 2
Subclause 4.1.2: clarification of test location
Subclause 4.4.2: general revision to formally allow more stringent testing by choosing a lower number of tested samples by reusing tested samples for consecutive test items.
Subclause 5.1.1 a): clarification of test location
Subclause 5.1.2 a): clarification of test location
Subclause 5.1.3 a): clarification of test instruction
Subclause 5.1.4: clarification of test instruction
Subclause 6: clarification of test location in Table 6.1
* Subclause 6: revision of definition of "no leakage"
Subclause 6: adding conditions for observation period as new subclause 6.2
Annex A: general revision
Annex C.1: revision of marking requirements
Annex C.1: clarification of model- or type-designation requirements in Note 2
Annex F.3.1: editorial change of text only
Annex H: updating dates of IEC 62133 and UN Recommendations on the Transport of Dangerous Goods - Manual of Tests and Criteria
Annex I: adding IEC 62660-1

NOTE – Items with a preceding asterisk (*) indicate changes related to the new edition / amendment of UN Recommendations on the Transport of Dangerous Goods - Manual of Tests and Criteria:2009-12 (5th rev. ed., including Amendment 1) *Section 38.3 – Lithium batteries*.