BS ISO 12405-2:2012

BSI Standards Publication

Electrically propelled road vehicles — Test specification for lithium-ion traction battery packs and systems

Part 2: High-energy applications

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National foreword

This British Standard is the UK implementation of ISO 12405-2:2012.

The UK participation in its preparation was entrusted to Technical Committee PEL/69, Electric vehicles.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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INTERNATIONAL STANDARD

ISO 12405-2

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Electrically propelled road vehicles — Test specification for lithium-ion traction battery packs and systems —

Part 2: High-energy applications

Véhicules routiers à propulsion électrique — Spécifications d'essai pour des installations de batterie de traction aux ions lithium —

Partie 2: Applications à haute énergie

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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

ISO 12405-2 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 21, *Electrically propelled road vehicles*.

ISO 12405 consists of the following parts, under the general title *Electrically propelled road vehicles — Test specification for lithium-ion traction battery packs and systems*:

— *Part 1: High-power applications*

— *Part 2: High-energy applications*

The following part is under preparation:

— *Part 3: Safety performance requirements*

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Introduction

Lithium-ion based battery systems are an efficient alternative energy storage system for electrically propelled vehicles. The requirements for lithium-ion based battery systems to be used as a power source for the propulsion of electric road vehicles are significantly different from those for batteries used for consumer electronics or stationary usage.

ISO 12405 provides specific test procedures for lithium-ion battery packs and systems specially developed for propulsion of road vehicles. It specifies such tests and related requirements to ensure that a battery pack or system is able to meet the specific needs of the automobile industry. It enables vehicle manufacturers to choose test procedures to evaluate the characteristics of a battery pack or system for their specific requirements.

A coordination of test specifications for battery cells, packs and systems for automotive application is necessary for practical usage of standards.

Specifications for battery cells are given in IEC 62660-1 and IEC 62660-2.

Some tests as prescribed within this specification are based on existing specifications: *USABC, EUCAR, FreedomCar* and other sources.

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Electrically propelled road vehicles — Test specification for lithium-ion traction battery packs and systems —

Part 2: High-energy applications

1 Scope

ISO 12405 specifies test procedures for lithium-ion battery packs and systems to be used in electrically propelled road vehicles.

The specified test procedures enable the user of ISO 12405 to determine the essential characteristics of performance, reliability and abuse of lithium-ion battery packs and systems. They also assist the user in comparing the test results achieved for different battery packs or systems.

Therefore the objective of ISO 12405 is to specify standard test procedures for the basic characteristics of performance, reliability and abuse of lithium-ion battery packs and systems.

ISO 12405 enables the setting up of a dedicated test plan for an individual battery pack or system subject to an agreement between customer and supplier. If required, the relevant test procedures and/or test conditions of lithium-ion battery packs and systems can be selected from the standard tests provided in ISO 12405 to configure a dedicated test plan.

This part of ISO 12405 specifies the tests for high-energy battery packs and systems.

NOTE 1 Typical applications for high-energy battery packs and systems are battery electric vehicles (BEV) and plug-in hybrid electric vehicles (PHEV).

NOTE 2 Testing on cell level is specified in IEC 62660-1 and IEC 62660-2.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 6469-1, *Electrically propelled road vehicles — Safety specifications — Part 1: On-board rechargeable energy storage system (RESS)*

ISO 6469-3, *Electrically propelled road vehicles — Safety specifications — Part 3: Protection of persons against electric shock*

ISO 16750-1, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment — Part 1: General*

ISO 16750-3, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment — Part 3: Mechanical loads*

ISO 16750-4, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment — Part 4: Climatic loads*

IEC 60068-2-30, *Environmental testing — Part 2-30: Tests — Test Db: Damp heat, cyclic (12 h + 12 h cycle)*

IEC 60068-2-47, *Environmental testing — Part 2-47: Tests — Mounting of specimens for vibration, impact and similar dynamic tests*

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IEC 60068-2-64, *Environmental testing — Part 2-64: Tests — Test Fh: Vibration, broadband random and guidance*

3 Terms and definitions

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

3.1
battery control unit
BCU
electronic device that controls or manages or detects or calculates electric and thermal functions of the battery system and that provides communication between the battery system and other vehicle controllers

NOTE See also 5.5.1 for further explanation.

3.2
battery pack
mechanical assembly comprising battery cells and retaining frames or trays, and possibly components for battery management

NOTE See 5.4 and A.2 for further explanation.

3.3
battery system
energy storage device that includes cells or cell assemblies or battery pack(s) as well as electrical circuits and electronics

NOTE 1 See 5.5.2, 5.5.3, A.3.1 and A.3.2 for further explanation. Battery system components can also be distributed in different devices within the vehicle.

NOTE 2 Examples of electronics are the BCU and contactors.

3.4
capacity
total number of ampere hours that can be withdrawn from a battery under specified conditions

3.5
cell electronics
electronic device that collects and possibly monitors thermal and electric data of cells or cell assemblies and contains electronics for cell balancing, if necessary

NOTE The cell electronics may include a cell controller. The functionality of cell balancing may be controlled by the cell electronics or it may be controlled by the BCU.

3.6
customer
party that is interested in using the battery pack or system and therefore orders or performs the test

EXAMPLE vehicle manufacturer

3.7
device under test
DUT
battery pack or battery system

3.8
energy density
amount of stored energy related to the battery pack or system volume

NOTE 1 The battery pack or system includes the cooling system, if any, to the point of a reversible attachment of the coolant lines or air ducts, respectively.

NOTE 2 Energy density is expressed in watt hours per litre (W·h/l).

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3.9
energy round trip efficiency
ratio of the net d.c. energy delivered by a DUT during a discharge test to the total d.c. energy required to restore the initial SOC by a standard charge

NOTE The net d.c. energy is expressed as watt hours (W·h) discharge and the total d.c. energy is expressed as watt hours (W·h) charge.

3.10
high-energy application
characteristic of device or application, for which the numerical ratio between maximum allowed electric power output and electric energy output at a 1C discharge rate at RT for a battery pack or system is typically lower than 10

NOTE Typically high-energy battery packs and systems are designed for applications in BEVs.

NOTE 2 The allowed electric power output is expressed as power in watts (W) and the electric energy output is expressed as energy in watt hours (W·h).

3.11
high-power application
characteristic of device or application, for which the numerical ratio between maximum allowed electric power output and electric energy output at a 1C discharge rate at RT for a battery pack or system is typically equal to or higher than 10

NOTE 1 Typically high-power battery packs and systems are designed for applications in HEVs and FCVs.

NOTE 2 The allowed electric power output is expressed as power in watts (W) and the electric energy output is expressed as energy in watt hours (W·h).

3.12
maximum working voltage
highest value of a.c. voltage (r.m.s) or of d.c. voltage which may occur in an electric system under any normal operating conditions according to the manufacturer's specifications, disregarding transients

3.13
rated capacity
supplier's specification of the total number of ampere hours that can be withdrawn from a fully charged battery pack or system for a specified set of test conditions such as discharge rate, temperature, and discharge cut-off voltage

3.14
room temperature
RT
temperature of (25 ± 2) °C

3.15
sign of battery current
discharge current is specified as positive and the charge current as negative

3.16
specific energy
amount of stored energy related to the battery pack or system mass

NOTE 1 The battery pack or system shall include the cooling system, if any, to the point of a reversible attachment of the coolant lines or air ducts, respectively. For liquid cooled systems the coolant mass inside the battery pack or system shall be included.

NOTE 2 Specific energy is expressed in watt hours per kilogram (W·h/kg).

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3.17
state of charge
SOC
available capacity in a battery pack or system

NOTE State of charge is expressed as a percentage of rated capacity.

3.18
standard charge (SCH) for top off
additional charge which eliminates possible SOC reduction after SCH at RT followed by thermal equilibration at a different temperature

3.19
supplier
party that provides battery systems and packs

EXAMPLE battery manufacturer

3.20
voltage class A
classification of an electric component or circuit with a maximum working voltage of $0 < U \leq 30$ V a.c. r.m.s. or $0 < U \leq 60$ V d.c.

NOTE For more details, see ISO 6469-3.

3.21
voltage class B
classification of an electric component or circuit with a maximum working voltage of $30 < U \leq 1\,000$ V a.c. r.m.s. or $60 < U \leq 1\,500$ V d.c.

NOTE For more details, see ISO 6469-3.

4 Symbols and abbreviated terms

a.c.	alternating current
BCU	battery control unit
BEV	battery electric vehicle
BOL	beginning of life
C	capacity, expressed in ampere hours (A·h)
nC	current rate equal to n times the one hour discharge capacity expressed in ampere (e.g. 3C is equal to three times the 1 h current discharge rate, expressed in ampere)
d.c.	direct current
DUT	device under test
EODV	end of discharge voltage
EUCAR	European Council for Automotive Research
EV	electric vehicle
FCV	fuel cell vehicle
HEV	hybrid electric vehicle

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$I_{c,max}$	maximum continuous charge current specified by the manufacturer for energy efficiency at fast charging testing
$I_{d,max}$	maximum continuous discharge current specified by the manufacturer for energy and capacity testing
$I_{dp,max}$	maximum discharge pulse current specified by the manufacturer for power, internal resistance and energy efficiency testing
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
Li	lithium
Li-ion	lithium-ion
OCV	Open Circuit Voltage
PHEV	plug-in hybrid electric vehicle
PNGV	partnership for a new generation of vehicles
PSD	power spectral density
RESS	rechargeable energy storage system
r.m.s.	root mean square
RT	room temperature (25 ± 2) °C
SC	standard cycle
SCH	standard charge
SDCH	standard discharge
SOC	state of charge
USABC	United States Advanced Battery Consortium
η	efficiency

5 General requirements

5.1 General conditions

A battery pack or system to be tested according to this part of ISO 12405 shall fulfil the following requirements:

— The electrical safety design shall be approved according the requirements given in ISO 6469-1 and ISO 6469-3.

— The necessary documentation for operation and needed interface parts for connection to the test equipment (i.e. connectors, plugs including cooling, communication) shall be delivered together with the DUT.

A battery system shall enable the specified tests, i.e. via specified test modes implemented in the BCU, and shall be able to communicate with the test bench via common communication buses.

The battery pack subsystem as a DUT shall comprise all parts specified by the customer (e.g. including mechanical and electrical connecting points for mechanical test).

If not otherwise specified, before each test the DUT shall be equilibrated at the test temperature. The thermal equilibration is reached if during a period of 1 h without active cooling the deviations between test temperature and temperature of all cell temperature measuring points are lower than ± 2 K.

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If not otherwise specified, each charge and each SOC change shall be followed by a rest period of 30 min.

The accuracy of external measurement equipment shall be at least within the following tolerances:

— voltage ± 0,5 %

— current ± 0,5 %

— temperature ± 1 K

The overall accuracy of externally controlled or measured values, relative to the specified or actual values, shall be at least within the following tolerances:

— voltage ± 1 %

— current ± 1 %

— temperature ± 2 K

— time ± 0,1 %

— mass ± 0,1 %

— dimensions ± 0,1 %

All values (time, temperature, current and voltage) shall be noted at least every 5 % of the estimated discharge and charge time, except if it is noted otherwise in the individual test procedure.

NOTE If agreed between customer and supplier, for a battery pack or system consisting of more than one subset the tests may be applied on such subsets.

5.2 Test sequence plan

The test sequence for an individual battery pack or system, or a battery pack subsystem shall be based on agreement between customer and supplier with consideration of tests in 5.3.

An example for a list of test conditions to be agreed between customer and supplier is provided in Table C.1.

5.3 Tests

An overview about the tests is given in Figure 1, where the references to the specific clauses are also given.

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Overview of tests

General tests (Clause 6)	Performance tests (Clause 7)	Reliability tests (Clause 8)	Abuse tests (Clause 9)
Pre-conditioning cycles (Clause 6.1)	Energy and capacity at RT (Clause 7.1)	Dewing (Clause 8.1)	Short circuit protection (Clause 9.2)
Standard cycle (Clause 6.2)	Energy and capacity at different temperature and discharge rates (Clause 7.2)	Thermal shock cycling (Clause 8.2)	Overcharge protection (Clause 9.3)
Standard discharge (Clause 6.2.2.2)	Power and internal resistance (Clause 7.3)	Vibration (Clause 8.3)	Overdischarge protection (Clause 9.4)
Standard charge (Clause 6.2.2.3)	Energy efficiency at fast charging (Clause 7.4)	Mechanical shock (Clause 8.4)	
	No load SOC loss (Clause 7.5)		
	SOC loss at storage (Clause 7.6)		
	Cycle life (Clause 7.7)		

Figure 1 — Test plan – overview

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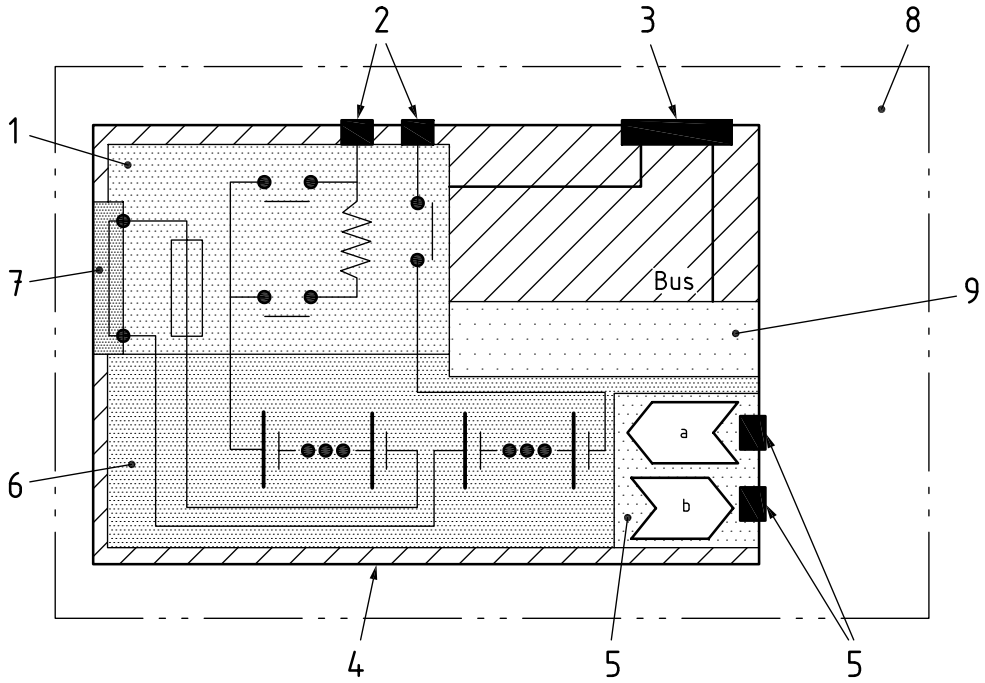
5.4 Battery pack - typical configuration



Key

1 voltage class B electric circuit (contactors, fuses, wiring)
2 voltage class B connections
3 voltage class A connections
4 normal use impact-resistant case
5 cooling device and connections
6 cell assembly
7 service disconnect
8 battery pack
9 cell electronics
a In.
b Out.

Figure 2 — Typical configuration of battery pack

A battery pack represents an energy storage device that includes cells or cell assemblies, cell electronics, voltage class B circuit and overcurrent shut-off device including electrical interconnections, interfaces for cooling, voltage class B, auxiliary voltage class A and communication. The voltage class B circuit of the battery pack may include contactors. For a battery pack of 60 V d.c. or higher, a manual shut-off function (service disconnect) may be included. All components are typically placed in a normal use impact-resistant case.

5.5 Battery system - typical configuration

5.5.1 BCU

The BCU calculates state-of-charge and state-of-health and provides battery system operational limits to the vehicle management unit. The BCU may have direct access to the main contactors of the battery system in order to interrupt the voltage class B circuit under specified conditions, e.g. overcurrent, over voltage, low voltage, high temperature. The BCU may vary in design and implementation, it may be a single electronic unit integrated into the battery system or it may be placed outside the battery pack and connected via a communication bus or input/output lines to the battery pack. The BCU functionalities may be integrated functions of one or more vehicle control units.

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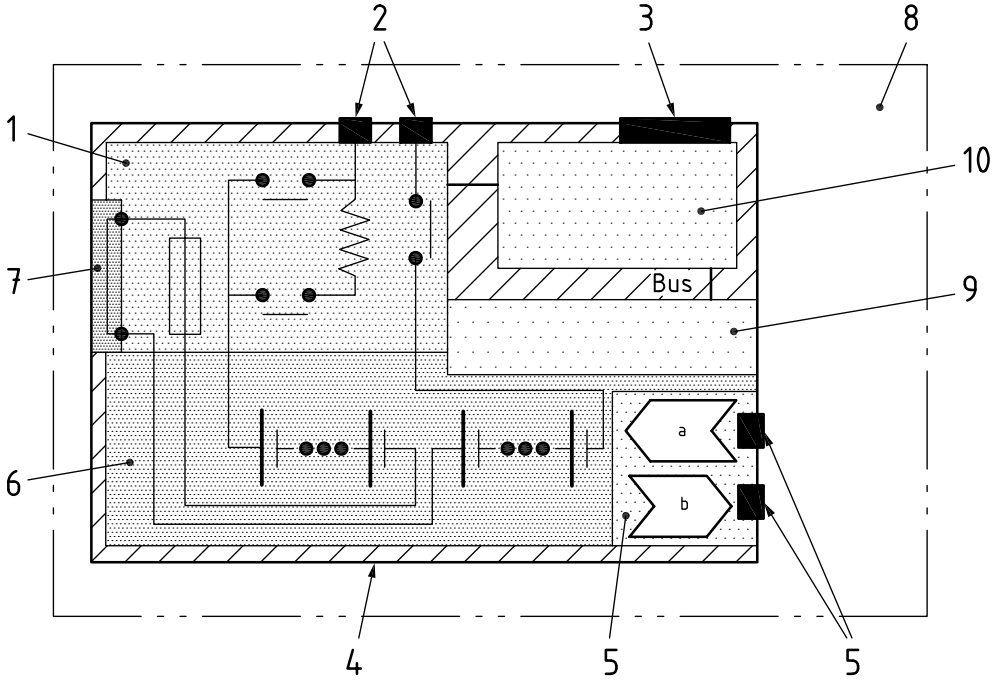
5.5.2 Battery system with integrated battery control unit (BCU)



Key

1 voltage class B electric circuit (contactors, fuses, wiring)
2 voltage class B connections
3 voltage class A connections
4 normal use impact-resistant case
5 cooling device and connections
6 cell assembly
7 service disconnect
8 battery pack
9 cell electronics
10 battery control unit
[a] In.
[b] Out.

Figure 3 — Typical configuration of battery system with integrated BCU

A battery system represents an energy storage device that includes cells or cell assemblies, cell electronics, battery control unit, voltage class B circuit with contactors and overcurrent shut-off device including electrical interconnections, interfaces for cooling, voltage class B, auxiliary voltage class A and communication. For a battery system of 60 V d.c. or higher, a manual shut-off function (service disconnect) may be included. All components are typically placed in a normal use impact-resistant case. In this example, the battery control unit is integrated inside the normal use impact-resistant case and its control functionalities are connected to the battery pack.

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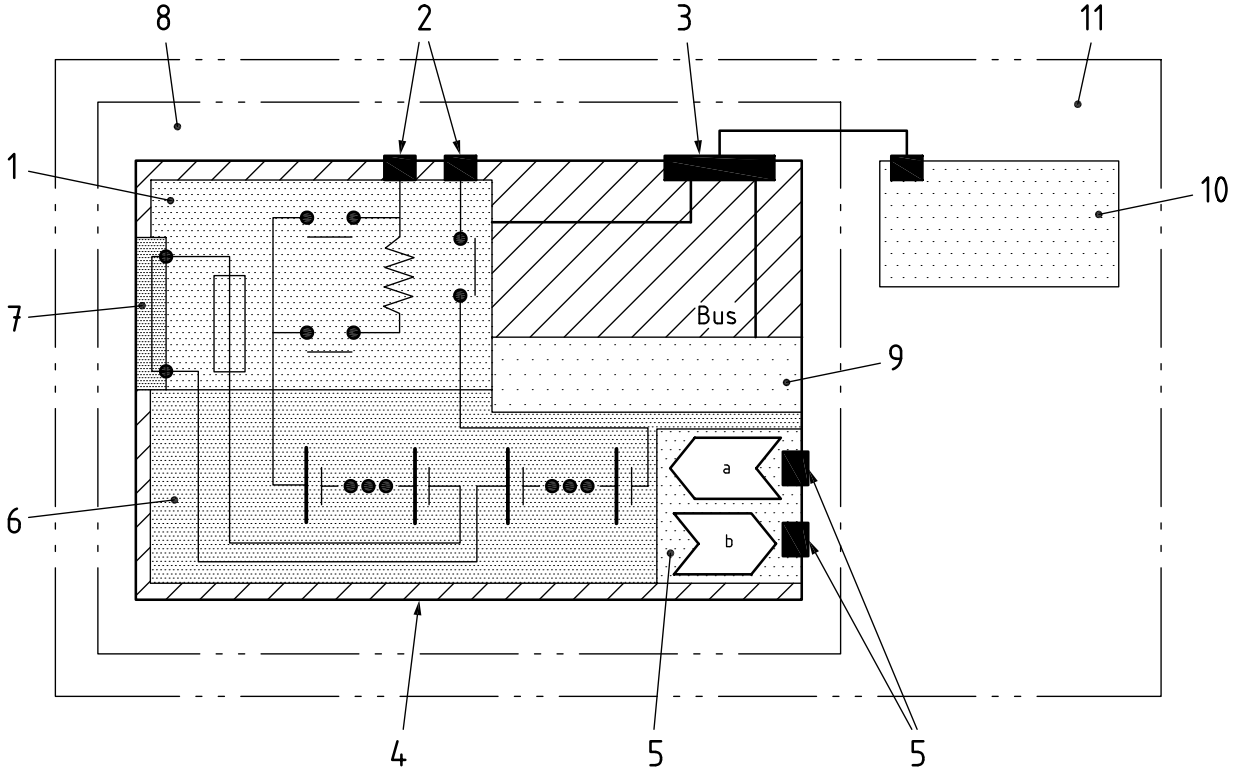
5.5.3 Battery system with external battery control unit (BCU)



Key

1 voltage class B electric circuit (contactors, fuses, wiring)
2 voltage class B connections
3 voltage class A connections
4 normal use impact-resistant case
5 cooling device and connections
6 cell assembly
7 service disconnect
8 battery pack
9 cell electronics
10 battery control unit
11 battery system
a In.
b Out.

Figure 4 — Typical configuration of battery system with external BCU

A battery system represents an energy storage device that includes cells or cell assemblies, cell electronics, battery control unit, voltage class B circuit with contactors and overcurrent shut-off device including electrical interconnections, interfaces for cooling, voltage class B, auxiliary voltage class A and communication. For a battery system of 60 V d.c. or higher, a manual shut-off function (service disconnect) may be included. All components are typically placed in a normal use impact-resistant case. In this example, the battery control unit is placed outside the normal use impact-resistant case and its control functionalities are connected to the battery pack.

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5.6 Preparation of battery pack and system for bench testing

5.6.1 Preparation of battery pack

If not otherwise specified, the battery pack shall be connected with voltage class B and voltage class A connections to the test bench equipment. Contactors, available voltage, current and temperature data shall be controlled according to the suppliers requirements and according to the given test specification by the test bench equipment. The passive overcurrent protection device shall be operational in the battery pack. Active overcurrent protection shall be maintained by the test bench equipment, if necessary via disconnection of the battery pack main contactors. The cooling device may be connected to the test bench equipment and operated according to the supplier's requirements.

5.6.1.1.1.1 Preparation of battery system

If not otherwise specified, the battery system shall be connected with voltage class B, voltage class A and cooling connections to the test bench equipment. The battery system shall be controlled by the BCU, the test bench equipment shall follow the operational limits provided by the BCU via bus communication. The test bench equipment shall maintain the on/off requirements for the main contactors and the voltage, current and temperature profiles according to the requested requirements of the given test procedure. The battery system cooling device and the corresponding cooling loop at the test bench equipment shall be operational according to the given test specifications and the controls by the BCU. The BCU shall enable the test bench equipment to perform the requested test procedure within the battery system operational limits. If necessary, the BCU program shall be adapted by the supplier for the requested test procedure. The active and passive overcurrent protection device shall be operational by the battery system. Active overcurrent protection shall be maintained by the test bench equipment, too, if necessary via request of disconnection of the battery system main contactors.

6 General tests

6.1 Pre-conditioning cycles

6.1.1 Purpose

The DUT shall be conditioned by performing some electrical cycles, before starting the real testing sequence, in order to ensure an adequate stabilization of the battery pack or system performance.

This test applies to battery packs and systems.

6.1.2 Test procedure

The procedure shall be the following.

— The test shall be performed at RT.

— The discharges shall be performed at C/3 or at a different current if suggested and/or used by the supplier in testing before delivery. The charging shall be performed according to the recommendations of the supplier.

— Three consecutive preconditioning cycles shall be performed. If agreed between customer and supplier only two cycles shall be performed.

— At end of discharge, the battery pack or system voltage shall not go below the minimum voltage recommended by the supplier (the minimum voltage is the lowest voltage under discharge without irreversible damage).

— The battery pack or system shall be considered as "preconditioned" if the discharged capacity during two consecutive discharges does not change by a value greater than 3 % of the rated capacity. If the discharge regime is equal to that used by the supplier on the same battery pack or system during factory tests, the data from the second cycle can be compared directly with the data from the supplier.

— If the preconditioning requirements cannot be fulfilled, customer and supplier shall agree on further procedure.

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6.2 Standard cycle (SC)

6.2.1 Purpose

The purpose of the standard cycle (SC) is to ensure the same initial condition for each test of a battery pack or system. A standard cycle (SC), as described below, shall be performed prior to each test.

This test applies to battery packs and systems.

6.2.2 Test procedure

6.2.2.1 General

The standard cycle (SC) shall be performed at RT. The SC shall comprise a standard discharge (SDCH), see 6.2.2.2, followed by a standard charge (SCH), see 6.2.2.3.

If, for any reason, the time interval between the end of the SC and the start of a new test is longer than 3 h, the SC shall be repeated.

6.2.2.2 Standard discharge (SDCH)

Discharge rate:

— C/3 or other specific discharge regime according to the specifications given by the supplier.

Discharge limit:

— According to the specifications given by the supplier.

Rest period after discharge to reach a stable condition:

— 30 min or a thermal equilibration at RT of the DUT is reached.

6.2.2.3 Standard charge (SCH)

Charge procedure and end of charge criteria:

— C/3 or another specific charge regime according to the specifications given by the supplier. The specifications shall cover end of charge criteria and time limits for the overall charging procedure.

— In any case, the total charge procedure shall be completed within 8 h.

Rest period after charge to reach a stable voltage condition:

— 60 min.

7 Performance tests

7.1 Energy and capacity at RT

7.1.1 Purpose

This test measures DUT capacity in A·h at constant current discharge rates corresponding to the suppliers rated C/3 capacity in A·h (e.g., if the rated three hour discharge capacity is 45 A·h, the discharge rate is 15 A). The three hour rate (C/3) is used as reference for static capacity and energy measurement and as a standard rate for pack and system level testing. In addition, if applicable, the 1C, 2C and the maximum permitted C rate shall be performed for capacity determination to meet the high-energy system application requirements. Discharge is terminated on supplier specified discharge voltage limits depending on discharge rates.

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This test applies to battery packs and systems.

7.1.2 Test procedure

The test shall be performed at RT with the discharge rates C/3, 1C, 2C (if 2C is less than $I_{d,max}$) and the maximum C rate as permitted by the supplier.

This test applies to battery packs and systems.

The test sequence shall be performed as specified in Table 1.

Table 1 — Test sequence energy and capacity test at RT

Step	Procedure	Ambient temperature
1.1	Thermal equilibration	RT
1.2	Standard charge (SCH)	RT
1.3	Standard cycle (SC)	RT
2.1	Discharge at C/3	RT
2.2	Standard charge (SCH)	RT
2.3	Discharge at 1C	RT
2.4	Standard charge (SCH)	RT
2.5	Discharge at 2C	RT
2.6	Standard charge (SCH)	RT
2.7	Discharge at $I_{d,max}$	RT
2.8	Standard charge (SCH)	RT
3.1	Standard cycle (SC)	RT

The standard charge (SCH) procedure shall follow 6.2.2.3.

The standard cycle (SC) procedure shall follow 6.2.

All discharge tests shall be terminated at the supplier's discharge voltage limits.

After discharge, the DUT shall rest at least for 30 min or shall be thermally equilibrated at the requested ambient temperature or a fixed time period shall be used to allow for thermal equilibration before starting the next step in the test sequence.

7.1.3 Requirement

If the C/3 capacity obtained during testing at 7.1.2 step no. 2.1 differs more than 5 % from the supplier's C/3 specification, this measured C/3 capacity shall be used as rated capacity and shall be the basis value for all further discharge current requirements, i.e. the value for C in each discharge current calculation nC shall be based on the measured C/3 capacity.

The following data shall be reported:

— current, voltage, DUT temperature and ambient temperature versus time at each discharge test and the following standard charge;

— discharged capacity in A·h, energy in W·h and average power in W at each discharge test;

— charged capacity in A·h, energy in W·h and average power in W following each discharge test;

— energy round trip efficiency at each discharge test;

— discharged energy in W·h as a function of SOC at each discharge test (in % of rated capacity);

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— the EODV of all available cell voltage measuring points for all performed discharge tests;

— determined C/3 rated capacity which is taken as basic value for all further discharge current requirements.

NOTE Capacity data are also used for the later calculation of capacity fades (see 7.7.2.6)

7.2 Energy and capacity at different temperatures and discharge rates

7.2.1 Purpose

This test characterizes the capacity at different temperatures at three different constant current discharge rates. The different discharge rates shall be performed in a sequence before the ambient temperature is changed and the test shall be repeated after the new temperature is achieved.

7.2.2 Test procedure

The test shall be performed at least at four different temperatures (40 °C, 0 °C, –10 °C and –18 °C, the test at T_{min} shall be optional) with the discharge rates C/3, 1C, 2C and the maximum C rate as permitted by the supplier (the maximum C rate corresponds to $I_{d,max}$).

The test sequence shall be performed as specified in Table 2.

Table 2 — Test sequence energy and capacity test at different temperature and discharge rates

Step	Procedure	Ambient temperature
1.1	Thermal equilibration	RT
1.2	Standard charge (SCH)	RT
1.3	Standard cycle (SC)	RT
2.1	Thermal equilibration	40 °C
2.2	Standard charge (SCH) for top off	40 °C
2.3	Discharge at C/3	40 °C
3.1	Thermal equilibration	RT
3.2	Standard charge (SCH)	RT
3.3	Standard cycle (SC)	RT
4.1	Thermal equilibration	40 °C
4.2	Standard charge (SCH) for top off	40 °C
4.3	Discharge at 1C	40 °C
5.1	Thermal equilibration	RT
5.2	Standard charge (SCH)	RT
5.3	Standard cycle (SC)	RT
6.1	Thermal equilibration	40 °C
6.2	Standard charge (SCH) for top off	40 °C
6.3	Discharge at 2C	40 °C
7.1	Thermal equilibration	RT
7.2	Standard charge (SCH)	RT
7.3	Standard cycle (SC)	RT
8.1	Thermal equilibration	40 °C
8.2	Standard charge (SCH) for top off	40 °C
8.3	Discharge at $I_{d,max}$	40 °C
9.1	Thermal equilibration	RT
9.2	Standard charge (SCH)	RT

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