INTERNATIONAL STANDARD

ISO 19453-6

First edition
2020-07

Road vehicles — Environmental conditions and testing for electrical and electronic equipment for drive system of electric propulsion vehicles —

Part 6: Traction battery packs and systems

Véhicules routiers — Spécifications d'environnement et essais de l'équipement électrique et électronique pour les véhicules à propulsion électrique —

Partie 6: Packs et systèmes de batterie de traction

Reference number
ISO 19453-6:2020(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

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.

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

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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

This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 32, *Electrical and electronic components and general system aspects*.

A list of all parts in the ISO 19453 series can be found on the ISO website.

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

Introduction

For over fifty years, traction batteries for electric vehicles have been developed to achieve high energy density and high power output. Specifically, lead-acid battery, Ni-Cd battery and Ni-MH battery with aqueous electrolyte were most applied to electric vehicles in the early days. Thermal activated batteries, such as molten salt batteries like sodium sulphur battery and Zebra battery were also examined. Lithium ion battery penetrated the consumer market in portable battery application from 1991. Currently, it is the most promising candidate of traction battery for electric vehicles. ISO 6469-1 specifies safety requirement of RESS (Rechargeable Energy Storage System) and the ISO 12405 series has been published to specify performance and reliability tests. This document focuses on environmental and endurance tests of lithium ion battery systems.

The ISO 19453 series specifies the test conditions on environment and reliability for electrical and electric equipment for the drive system of electric propulsion vehicles. The battery pack or system is the electric system which charges and discharges electricity through the converter. The test condition for mechanical load in ISO 19453-3 is too severe to apply to the battery pack or system from the standpoint of frequency range and amplitude of vibration in the test input spectrum. The test conditions for climatic load in ISO 19453-4 is also excessive to apply to the battery pack or system, because lithium ion battery pack is designed to control temperature within adequate operational range. That is the reason why appropriate conditions for the lithium ion battery are specified in this document.

The purpose of this document is to assist its user in systematically defining and/or applying a set of internationally accepted environmental conditions, tests and operating requirements, which are based on the anticipated actual environment in which the equipment will be operated and exposed to during its life cycle. This document has been developed based on fundamental investigations and vehicle measurements on voltage class A and B battery pack/system. The following environmental factors have been considered in the development of the ISO 19453 series.

— World geography and climate

Electric propulsion vehicles are operated in nearly all terrestrial regions of the earth. Significant variation in environmental conditions due to climatic environment, including diurnal and seasonal cycles, can therefore be expected. Consideration has been given to worldwide ranges in the temperature, humidity, precipitation and atmospheric conditions including dust, pollution and altitude.

— Type of electric propulsion vehicle

Operating environment in an electric propulsion vehicle can depend on its electric powertrain architecture as well as its mass, size, supply voltage and so on. Consideration has been given to typical types of series production electric propulsion vehicle architectures such as hybrid electric vehicles, battery electric vehicles, range extender hybrid electric vehicles and fuel cell vehicles, but not including equipment specific for fuel cell system.

— Vehicle use conditions and operating modes

Environmental conditions in and on the vehicle vary significantly with vehicle use (e.g. driving, charging during parking, etc.). Operating modes, such as starting, driving, braking, stopping and so on, have been considered, in particular, for traction battery system.

— Battery durability

For battery system, it is necessary to be resistant to environmental conditions experienced during manufacture, shipping, handling, storage, vehicle assembly, vehicle usage and vehicle maintenance and repair.

— Component mass and volume

The mass of battery pack is generally in the range of around 20 kg up to 60 kg for HEV, 80 kg to 150 kg for PHEV, more than 200 kg for BEV (weight assumptions from year 2020). The battery pack has generally

a large volume and thermal capacity. It is necessary not only to prepare a large chamber but it will also take a long time to keep the thermal equivalent when performing a thermal shock test.

— Mounting location in the vehicle

HEV battery packs are generally installed inside the vehicle, PHEV battery packs are installed both outside and inside, and BEV battery packs are generally installed outside. The environmental condition such as water splashing, dust, salt spray, humidity or corrosion for battery packs installed outside vehicle interior is more severe than for battery packs installed inside. In this document, test conditions are specified according to mounting location.

a) Applicability to manufacturers' responsibility

Due to technology limitations or variations in vehicle design, the vehicle manufacturer may be required to place a component in a location where it cannot withstand the environmental conditions described in the ISO 19453 series. Under these circumstances, it is the responsibility of the vehicle manufacturer to provide the necessary environmental protection.

b) Applicability to wiring harnesses, cables and electrical connectors

Although some environmental conditions and tests in the ISO 19453 series may be relevant to vehicle wiring harnesses, cables and connectors, its scope is not sufficient to be used as a complete standard. It is therefore not recommended that the ISO 19453 series is directly applied to such devices and equipment.

c) Applicability to parts or assemblies inside equipment

The ISO 19453 series describes environmental conditions and tests to be applied to electrical and electronic equipment directly mounted in or on the vehicle. It is not intended for direct application to parts or assemblies that are part of the equipment. For example, the ISO 19453 series should not be directly applied to integrated circuits (ICs) and discrete components, electrical connectors, printed circuit boards (PCBs), gauges, etc. that are attached in or on the equipment. Electrical, mechanical, climatic and chemical loads for such parts and assemblies can be quite different from those described in the ISO 19453 series. Therefore, for those sub-components applying test conditions of the ISO 16750 series can be considered as a reference.

On the other hand, it is desirable to use the ISO 19453 series to help derive environmental conditions and test requirements for parts and assemblies that are intended for use in road vehicle equipment.

d) Applicability relative to system integration and validation

The user of the ISO 19453 series is cautioned to understand that its scope is limited to conditions and testing at the equipment level and therefore does not represent all conditions and testing necessary for complete verification and validation of the vehicle system, for example cold water shock tests were omitted from this document. Environmental and reliability testing of equipment parts and vehicle systems may be required. For example, the ISO 19453 series does not necessarily ensure that environmental and reliability requirements for solder joints, solderless connections, integrated circuits and so on are met. Such items are assured at the part, material or assembly level. Additionally, vehicle and system level testing might be required to validate the equipment in the vehicle application.

Road vehicles — Environmental conditions and testing for electrical and electronic equipment for drive system of electric propulsion vehicles —

Part 6: Traction battery packs and systems

1 Scope

This document specifies requirements for lithium-ion traction battery packs or systems used in battery electric, hybrid electric and fuel cell electric road vehicles. This document describes the most relevant environmental stresses and specifies tests and test boundary conditions. This document establishes a classification of battery packs or systems and defines different stress levels for testing when a classification is applicable and required. The objective of this document is to specify standard test procedures and conditions to enable the observation of the reliability of the lithium-ion traction battery in the vehicle.

This document specifies tests for a battery pack or system of voltage class A and B.

This document provides the necessary information to set up a dedicated test plan for a battery pack or system subject to agreement between the customer and supplier. If required, the relevant test procedures and/or test conditions can also be selected from this document.

NOTE This document only covers requirements and test conditions for a traction battery pack or system used in passenger cars.

2 Normative references

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

ISO 6469-3, *Electrically propelled road vehicles — Safety specifications — Part 3: Electrical safety*

ISO 6469-3:2018/Amd 1, *Electrically propelled road vehicles — Safety specifications — Part 3: Electrical safety — Amendment 1: Withstand voltage test for electric power sources*

ISO 9227, *Corrosion tests in artificial atmospheres — Salt spray tests*

ISO 19453-1, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment for drive system of electric propulsion vehicles — Part 1: General*

ISO 19453-4, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment for drive system of electric propulsion vehicles — Part 4: Climatic loads*

ISO 19453-5, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment for drive system of electric propulsion vehicles — Part 5: Chemical loads*

ISO 20653, *Road vehicles — Degrees of protection (IP code) — Protection of electrical equipment against foreign objects, water and access*

IEC 60068-2-14, *Environmental testing — Part 2-14: Tests — Test N: Change of temperature*

IEC 60068-2-27, *Environmental testing — Part 2-27: Tests — Test Ea and guidance: Shock*

IEC 60068-2-38, *Environmental testing — Part 2-38: Tests — Test Z/AD: Composite temperature/humidity cyclic test*

IEC 60068-2-60, *Environmental testing — Part 2-60: Tests — Test Ke: Flowing mixed gas corrosion test*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 19453-1, ISO 20653 and the following apply.

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

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

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

3.1
BMS
battery management system
electronic system that controls, manages, detects or calculates electric and thermal functions of the battery pack or system and that provides communication between the battery pack or system and other vehicle controllers

3.2
electric chassis
conductive parts of a vehicle that are electrically connected and whose potential is taken as reference

3.3
ITCS
internal temperature control system
internal thermal management system of a battery pack or system that can heat or cool the battery pack or system to a target temperature determined by the *BMS* (3.1)

EXAMPLE Liquid based heating/cooling system.

3.4
main contactor
electronic or mechanic switching/disconnect device for the battery pack or system *main power supply live part* (3.5)

3.5
main power supply live part
conductor or conductive part intended to be energized in normal use, but by convention not *the electric chassis* (3.2) or the class A auxiliary voltage supply

3.6
MAST
multiaxial simulation table
multiaxial system to induce vibrations or shocks in all three axial dimensions to the DUT

3.7
PSD
power spectral density
measure of signal's power content versus frequency

Note 1 to entry: A PSD is typically used to characterize broadband random signals. The amplitude of the PSD is normalized by the spectral resolution employed to digitize the signal.

3.8
rated capacity
total number of ampere-hours that can be withdrawn from a fully charged battery pack or system under test conditions defined by the battery pack or system manufacturer

3.9
technical tightness
inherent characteristic of a system that prevent fluids, gases or dusts from passing from the external to the internal environment or from the internal to the external environment, or both

4 Symbols and abbreviated terms

4.1 Symbols

1C	One-hour charge or discharge rate for the rated battery pack or system capacity.
C/3	Three-hour charge or discharge rate for the rated battery pack or system capacity.
RT	Room temperature value as defined in ISO 19453-1.
SOC_{max}	Maximum state of charge of a battery pack or system specified by the manufacturer.
SOC_{min}	Minimum state of charge of a battery pack or system specified by the manufacturer.
t_{ch}	Duration with an electrical current charging the battery pack or system.
t_{dch}	Duration with an electrical current discharging the battery pack or system.
T_{amb}	Ambient temperature of a climate/temperature chamber
T_{ITCS}	Temperature of the internal temperature control system, for example liquid coolant, of a battery pack or system.
T_{max}	Highest ambient temperature of a battery pack or system specified by the manufacturer (e.g. storage).
T^*_{max}	Maximum temperature by electric operation, can be lower than T_{max}
$T_{max, DUT}$	Highest operating temperature of a battery pack or system specified by the manufacturer.
$T_{max,ITCS}$	Highest temperature at which an internal temperature control system, for example liquid coolant, of a battery pack or system can be used. Specified by the manufacturer.
T_{min}	Lowest ambient temperature of a battery pack or system specified by the manufacturer (e.g. storage).
T^*_{min}	Low temperature, allows large currents, can be higher than T_{min}
$T_{min, DUT}$	Lowest operating temperature of a battery pack or system specified by the manufacturer.
$T_{min,ITCS}$	Lowest temperature at which an internal temperature control system, for example liquid coolant, of a battery pack or system can be used. Specified by the manufacturer.
X-axis	Vehicle driving direction.
Y-axis	Perpendicular to vehicle driving direction and vertical axis.
Z-axis	Vertical axis.

4.2 Abbreviated terms

CC/CV	Constant current /constant voltage
DOF	Degrees of freedom
DUT	Device under test. Referring to battery pack or system used for electrically propelled road vehicles
ITCS	Internal temperature control system
SOC	State of charge. Available capacity in a battery pack or system expressed as a percentage of rated capacity

5 Operating modes

5.1 General

An overview of the DUT operating modes according to this document is given in Table 1.

Operating modes defined in ISO 19453-1 cannot be applied because modes that are more specific are required for a battery pack or system.

Operation of the battery pack or system with autonomous functions, for example cell voltage balancing, in any of the operating modes shall be agreed between customer and supplier.

Table 1 — DUT operating modes

Operating mode	Class A auxiliary voltage	BMS	Main contactor	Electrical operation of main power supply live part	Internal temperature control system
5.1	Unsupplied	Non-operational	Open	No	Deactivated
5.2	Unsupplied	Non-operational	Open	No	Deactivated
6.1	Supplied	Non-operational	Open	No	Deactivated
6.2	Supplied	Operational	Open	No	Deactivated
6.3	Supplied	Operational	Closed	No	Deactivated
7.1	Supplied	Operational	Closed	Yes	Deactivated
7.2	Supplied	Operational	Closed	Yes	Activated

NOTE 1 Auxiliary voltage class A according to ISO 12405-4 refers to the voltage supply of the BMS with U_A or U_B as defined in ISO 19453-1.

NOTE 2 The difference between operating mode 5.1 and 5.2 is the presence of the wiring harness and the connection to all interfaces.

NOTE 3 The difference between operating mode 7.1 and 7.2 is that in operating mode 7.2 an ITCS is required due to self-heating effects caused by system activation.

NOTE 4 The conditions for an activated ITCS are set and controlled by the BMS regarding the thermal management strategy and the operational limits of the battery pack or system. If the ITCS is deactivated, it has no function. With deactivated ITCS, safety measures to limit the DUT temperature are still allowed at any time.

If the electronic control unit of a battery pack or system cannot provide the necessary BMS functionality, appropriate additional electric and/or electronic controllers to provide BMS functionality may be used in agreement between customer and supplier.

If the DUT has an internal temperature control system, the thermal management system and the corresponding conditioning loop at the test bench equipment shall be operational according to the given test specifications and controlled by the BMS. For the requested test procedure, the thermal management strategy and operational limits of the DUT shall be met.

Some test methods in this document require intended temperature settings for the ITCS beyond the thermal management strategy of the DUT controlled by the BMS. For these test procedures the thermal management system and conditioning loop at the test bench equipment is controlled externally by the test equipment according to the test specifications but within the battery system operational and safety limits.

If a liquid based internal temperature control system is used in the battery pack, the liquid circulating system shall be filled with the intended liquid (heat transfer medium) of the nominal volume and pressure. Up until operating mode 6.3 without use of the temperature control system, the openings can be sealed accordingly. If the fluid system is operated, the nominal flow rate as specified by the manufacturer should be used.

NOTE 1 For further information on the preparation of the DUT for testing, see ISO 12405-4:2018, 5.4.

NOTE 2 Pressure compensating devices can be needed for testing with liquid based internal temperature control systems.

5.2 Operating mode 5

No external voltages are applied to the DUT. The main contactor, if present, shall be opened.

— Operating mode 5.1

  — Not connected to wiring harness or any electrical interconnections or interfaces. Protective caps for the electrical interconnections and interfaces can be present.

— Operating mode 5.2

  — Connected to wiring harness including all electrical interconnections and interfaces simulating vehicle installation.

5.3 Operating mode 6

The DUT with all electrical connections made and connected to all interfaces is electrically operated with class A auxiliary supply voltage U_B as defined in ISO 19453-1, as in a vehicle with shut-off engine, but without operating load for the main power supply live part of the battery pack or system.

— Operating mode 6.1

  — BMS functions are not operational, no communication.

  — Battery pack or system shall be without electric operation (e.g. charging, discharging).

  — Main contactor, if present, shall be opened.

— Operating mode 6.2

  — BMS shall be fully operational according to the test specification.

  — Battery pack or system shall be without electric operation (e.g. charging, discharging).

  — Main contactor, if present, shall be opened.

— Operating mode 6.3

  — BMS shall be fully operational according to the test specification.

  — Battery pack or system shall be without electric operation (e.g. charging, discharging).

  — Main contactor, if present, shall be closed.

5.4 Operating mode 7

The DUT with all electrical connections made and connected to all interfaces is electrically operated with class A auxiliary voltage U_B as defined in ISO 19453-1 and with auxiliary machines, for example cooling system etc. The main contactor, if present, shall be closed.

— Operating mode 7.1

  — BMS shall be fully operational according to the test specification.

  — Battery pack or system with control in an electrical operating mode in which, if present, the ITCS is not operational.

— Operating mode 7.2

  — BMS shall be fully operational according to the test specification.

  — Battery pack or system shall be within control in a typical electrical operating mode, in which if needed, the ITCS is operational.

6 Functional status classification

Functional status classification is as defined in ISO 19453-1.

The verification of the required functional status takes place by means of continuous parameter monitoring or a parameter test.

Relevant control and test signals should be logged with sufficient resolution. Battery cycler and climate chamber data should be monitored

7 Functional status checks

7.1 Electrical requirements check

7.1.1 General

The tests described below are intended to ensure the insulation performance of the basic insulation measure of a voltage class B battery pack or system after completing environmental tests. The described tests shall be performed at the end of a sequence of environmental tests. If only a single environmental test is performed, they shall be performed afterwards.

NOTE 1 Performing the test sequence of an insulation resistance test followed by a withstand voltage test and finally a second insulation resistance test allows to determine whether the applied voltage level of the withstand voltage test had a permanent degrading effect on the insulation or not.

NOTE 2 Although not required for a voltage class A battery pack or system, the tests described in this section can technically also be applied to a voltage class A component, if applicable.

7.1.2 Equipotential bonding

This test ensures the required electrical resistances for equipotential bonding of conductively connected parts of the DUT. In particular as requirement for 7.1.3 and 7.1.4.

The equipotential bonding test shall be performed in accordance with ISO 6469-3.

The electrical resistance value shall meet the requirements of ISO 6469-3

7.1.3 Insulation resistance

This test measures the resistance value between main power supply live part and conductive parts of the DUT.

The insulation resistance test shall be performed in accordance with ISO 6469-3.

The insulation resistance value shall meet the requirements of ISO 6469-3.

7.1.4 Withstand voltage test

This test ensures the dielectric withstand voltage capability and detects pre-damaged parts of the insulation measure and weak points in the design, for example by conductive particles originating from production or rework, that could result in a failure of the insulation measure at later stages.

The withstand voltage test shall be performed in accordance with ISO 6469-3:2018/Amd 1.

The requirements of ISO 6469-3:2018/Amd 1 shall be met.

7.2 Mechanical requirements check

7.2.1 Technical tightness check of battery pack or system enclosure

The purpose of this test is to verify the technical tightness of the battery pack or system enclosure according to the desired degree of protection.

The method to check the technical tightness of the traction battery pack or system enclosure with specified degrees of protection in accordance with ISO 20653 via non-destructive tests and acceptance criteria shall be agreed between customer and supplier.

NOTE Non-destructive leak test techniques are listed in ISO 20653 or EN 1779. EN 13184, EN 13185 and EN 1593 support the implementation of techniques according to EN 1779.

The test method shall describe at least following items:

— technique used;

— pre-condition(s) (e.g. required room temperature, required acclimation time of the DUT at room temperature, condition of pressure compensation device);

— action(s);

— post condition(s);

— pass criteria;

— documentation content in test report;

— equipment.

7.2.2 Leak tightness check of internal temperature control system

The purpose of this test is to verify the leak tightness of the ITCS of the battery pack or system. The test shall only be performed if the DUT has a liquid medium for the ITCS, for example internal or external cooling-circuit.

The method for the leak test of the ITCS shall be agreed between customer and supplier.