INTERNATIONAL STANDARD

ISO 16750-1

Fourth edition
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Road vehicles — Environmental conditions and testing for electrical and electronic equipment —

Part 1: General

Véhicules routiers — Spécifications d'environnement et essais de l'équipement électrique et électronique —

Partie 1: Généralités

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Foreword

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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 document 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).

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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*.

This fourth edition cancels and replaces the third edition (ISO 16750-1:2018), which has been technically revised.

The main changes are as follows:

— integrating and harmonizing contents from ISO 19453-1:2018, (e.g. addition of 5.5);

— integrating terms from ISO 19453-1:2018 and addition of terms considering common terms in ISO 16750 series;

— modification to subdivide mounting locations matching with climate load tests of ISO 16750-4;

— addition of operating modes for 48 V DUT and voltage class B DUT (Clause 5);

— reorganization of operating mode tables for easy understanding (Clause 5);

— clarification of test procedure regarding parameter check and physical analysis (7.6, 7.7);

— update of coding system integrating voltage class A DUT and voltage class B DUT (Clause 8);

— definition of mass and volume classes related to mechanical and climatic loads (Annex C).

A list of all parts in the ISO 16750 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

The purpose of the ISO 16750 series is to assist its user in systematically defining and/or applying a set of internationally accepted environmental conditions, tests and operating requirements based on the anticipated actual environment in which the equipment will be operated in and exposed to during its life cycle.

NOTE This edition of the ISO 16750 series (2023) does not contain electrical testing conditions or requirements in ISO 16750-2 for the voltage class B circuits of voltage class B components as well as 48 V circuits of 48 V components. For electrical testing conditions or requirements for voltage class B components and 48 V circuits of 48 V components, see instead the ISO 21498 series (voltage class B components) and ISO 21780 (48 V components).

The following environmental factors have been considered in the development of this document.

— World geography and climate

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

— Type of vehicle

Environmental conditions in and on road vehicles can depend on vehicle design attributes, such as whether to equip an internal combustion engine and/or an electric motor for vehicle propulsion, vehicle mass, vehicle size, electrical supply voltage and so on. Considerations have been given to typical series production vehicles, including passenger cars, light duty trucks and commercial (heavy) buses and trucks not only propelled by diesel or gasoline engines but also propelled by electric motors. These considerations include hybrid electric vehicles, battery electric vehicles, range extender hybrid electric vehicles and fuel cell vehicles, but does not include the equipment specific for fuel cell systems.

— Vehicle use conditions and operating modes

Environmental conditions in and on the vehicle vary significantly with road quality, types of road surface, road topography, vehicle use (e.g. commuting, towing, cargo transport, etc.) and driving habits. Operating modes such as storage, starting, driving, stopping and so on have been considered. Additionally, it has been taken into account that there is a difference of engine speed distributions between conventional vehicles and hybrid electric vehicles where driving modes with shut-off combustion engine exist.

— Equipment life cycle

Electrical and electronic equipment is intended to be resistant to environmental conditions experienced during manufacture, shipping, handling, storage, vehicle assembly and vehicle maintenance and repair. Such conditions and tests (e.g. handling drop to be tested by free-fall test) are within the scope of this document.

— Vehicle supply voltage

Supply voltage varies with vehicle use, operating mode, electrical distribution system design and even climatic conditions.

— Component mass and volume

The component mass and volume has a significant impact on the response of the device under test (DUT) to environmental loads, especially with respect to vibration and thermal load. For thermal loads the higher thermal capacity of the DUT is the major influence. For vibration loads the high dynamic system coupling (caused by high mass and moment of inertia as well as the centre of gravity) becomes relevant. Current components of the drive system of electrically propelled road vehicles, such as electric motors, inverters or DC-DC converters, tend to be much larger and heavier than small and lightweight E/E equipment, such as small sensors, ECUs or fuel injection equipment. Adding such equipment, the size and mass of components of the electric powertrain have been considered in this document, for example, by taking the inertia mass of those components into account as an effect on the measured excitation during vibration measurements. Also, the size and mass significantly influence the necessary exposure time at low and high temperatures when applying a thermal profile, such as in ISO 16750-4, as it takes much longer to reach the intended temperature in the core of the component (stabilisation time). For performing proper tests according to different component mass and volume, one of the typical solutions is to apply different test profiles based on a mass classification. This document shows an example of such mass classification (see Annex C).

— Mounting location in the vehicle

In current or future vehicle concepts, systems/components are mounted in almost any location of the vehicle. The environmental requirements for each specific application highly depend on its mounting location. Each location in a vehicle has its distinct set of environmental loads. As an example, the range of temperatures in the engine/electric motor compartment differs significantly from the range in the passenger compartment. This is also true for the vibration loads, except that in this case, not only are the vibration levels different, but the type of vibration load also varies. Body mounted components are typically exposed to random vibrations whereas for engine mounted systems/components the additional sine vibration from the engine is considered. Moreover, devices installed in doors are exposed to a high number of mechanical shocks from door slamming.

It is desirable for the vehicle manufacturer to group the different environmental load types and levels in a reasonable number of standard requirement sets. This strategy makes it possible to carry systems/components from one vehicle project to another. Furthermore, the exact requirement levels are often unknown when designing a component for a future vehicle concept. The expected environmental loads are usually compiled from other vehicle concepts with similar conditions. The grouping is normally done by mounting location, but it is difficult to define the right number of different mounting locations and respective load profiles, because there is a conflict of aims between having only few requirement classes and tailoring the requirement levels to each application. The reason is that the environmental loads are not only depending on the mounting location. There are other major factors that affect the stress levels for systems/components. For example, body styles, drive-train concepts or package densities can create absolutely different requirement levels for devices that are installed in different vehicles at almost the same location.

The purpose of the ISO 16750 series is to define requirement classes for separate load types. It distinguishes between electrical, mechanical, thermal, climatic and chemical loads. For each load type, several requirement classes are defined. Every requirement class is determined by a specific code letter. The complete environmental requirement set is created by defining the code letter combination. The code letters are defined in the respective clauses of this document. Additionally, tables in the annexes of each part show the usual mounting locations and give examples of their respective code letters. For normal applications, these code letters are used. If an application is very specific and therefore, the given code letter combinations cannot be used, it is possible to create new code letter combinations to serve this purpose. In case none of the given code letters are usable, new requirement levels can be created by using the code letter Z. In this case, the specific requirements are defined separately, but it is desirable not to change the test methods.

At a minimum, the following mounting locations referred to in Clause 4 should be considered for a DUT with respect to thermal, mechanical, climatic and chemical loads.

a) Applicability to manufacturer's responsibility

Due to technology limitations or variations in vehicle design, the vehicle manufacturer can be required to place a component in a location where it cannot withstand the environmental conditions described in the ISO 16750 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 16750 series can 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 16750 series is directly applied to such devices and equipment.

c) Applicability to parts or assemblies in or on equipment

The ISO 16750 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 16750 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 16750 series.

On the other hand, it is desirable to use the ISO 16750 series to help derive environmental conditions and test requirements for parts and assemblies that are intended for use in road vehicle equipment. For example, a temperature range from −40 °C to 90 °C may be specified for parts or assemblies contained inside a piece of equipment having a temperature range of −40 °C to 70 °C and an additional temperature rise of 20 K.

d) Applicability relative to system integration and validation

The user of the ISO 16750 series is cautioned that the scope of the ISO 16750 series 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. Environmental and reliability testing of equipment parts and vehicle systems can be required.

For example, the ISO 16750 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 ensured at the part, material or assembly level. Additionally, vehicle and system level testing can be required to validate the equipment in the vehicle application.

e) Applicability to high voltage battery packs and systems or components inside

Although some environmental conditions and tests of mechanical loads in ISO 16750-3 and climatic loads in ISO 16750-4 can be relevant to high voltage battery packs (e.g. for traction) and systems or components inside, their scope is not sufficient to be used as a complete standard. It is therefore not recommended that the ISO 16750 series is directly applied to such devices and equipment. The dedicated International Standard, ISO 19453-6, is taken into account.

Road vehicles — Environmental conditions and testing for electrical and electronic equipment —

Part 1: General

1 Scope

This document applies to electric and electronic systems and components for vehicles including electric propulsion systems and components with maximum working voltages according to voltage class B. It describes the potential environmental stresses and specifies tests and requirements for the specific mounting location on/in the vehicle.

This document contains the terminology for the ISO 16750 series and general requirements.

This document is not intended to apply to environmental requirements or testing for systems and components of motorcycles and mopeds. Electromagnetic compatibility (EMC) is not covered by this document.

Systems and their components released for production, or systems and their components already under development prior to the publication date of this document, can be exempted from fulfilling the changes in this edition compared to the previous one.

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 16750-2, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment — Part 2: Electrical loads*

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*

ISO 16750-5, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment — Part 5: Chemical loads*

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

ISO 21498-1, *Electrically propelled road vehicles — Electrical specifications and tests for voltage class B systems and components — Part 1: Voltage sub-classes and characteristics*

ISO 21780, *Road vehicles — Supply voltage of 48 V — Electrical requirements and tests*

EN 13018, *Non-destructive testing — Visual testing — General principles*

3 Terms and definitions

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

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

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

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

3.1
active operating mode
operating mode with electric operation and control in some load

Note 1 to entry: This term is a substitute to avoid redundant repeats, used in requirements when describing operating modes aforementioned in test method.

EXAMPLE The term “active operating modes” described in requirements substitutes for “operating mode 3.2, 3.3 and/or 3.4” in test method.

3.2
customer
party that is using electrical and electronic equipment

3.3
DUT
device under test
single component or combination of components (system) as defined to be tested

3.4
dwell time
time when the systems/components have reached and stay within the specified conditions (e.g. temperature, voltage, engine speed)

3.5
electric propulsion system
combination of traction motor, power electronics and their associated controls for the conversion of electric to mechanical power and vice versa

[SOURCE: ISO 6469-1:2019, 3.8, modified — The term was originally "electric drive".]

3.6
electric propulsion vehicle
vehicle with one or more *electric propulsion system(s)* (3.5) for vehicle propulsion

[SOURCE: ISO 6469-1:2019, 3.9, modified — The term was originally "electrically propelled vehicle".]

3.7
exposure time
complete time that the systems/components are exposed to constant test conditions (e.g. temperature, humidity)

3.8
functional test
basic test to verify that the systems/components perform as designed specifically to satisfy the representative functions or characteristics such as output signals, output power and insulation performance, etc.

Note 1 to entry: Functional tests are performed in the shortest possible time to avoid temperature rise of the systems/components due to self-heating. Performed and checked functions or characteristics in the possible shortest time are determined by agreement between the *customer* (3.2) and the *supplier* (3.19).

3.9
hot-soak temperature
T_{maxHS}
maximum value of the ambient temperature which may temporarily occur in the engine/electric motor compartment after the vehicle has stopped and the engine is turned off

3.10
maximum operating temperature
T_{max}
maximum value of the ambient temperature at which the systems/components are designed to be operated in

3.11
maximum working voltage
highest value of AC voltage (RMS) or of DC voltage that can occur under any normal operating conditions according to the *customer's* (3.2) specifications, disregarding transients and ripple

3.12
minimum operating temperature
T_{min}
minimum value of the ambient temperature at which the systems/components are designed to be operated in

3.13
nominal voltage
U_N
voltage value used to describe the 12/24 V electrical system of a vehicle

3.14
paint repair temperature
T_{maxPR}
maximum temperature which occurs during vehicle paint repair

3.15
peak to peak voltage
U_{pp}
superimposed AC voltage

3.16
redundant supply
voltage supply source (e.g. DC-DC converter, battery, alternator, integrated starter generator, etc.) in the vehicle supply voltage network(s) that operates independently of other voltage supply source

EXAMPLE Two separate 12 V lead acid batteries, each supplying a separate, independent, 12 V grid in the vehicle.

3.17
redundantly supplied DUT
DUT (3.3) which has two or more power supply ports (can include both voltage lines as well as ground lines), allowing continued operation with full or reduced capacity, if the supply is interrupted or disturbed on one of the power supply ports

EXAMPLE A DUT with two duplicated internal circuits to achieve the same function, that are supplied by two independent (e.g. voltage Class A) power supplies for the purpose of increasing availability, allowing fault detection, or providing functional tolerance to single faults, most commonly used to ensure availability of safety critical applications.

3.18
stabilisation time
time needed for the systems/components to reach within the specified conditions (e.g. temperature, humidity)

3.19
supplier
party that provides electrical and electronic equipment

3.20
supply voltage
U_S
voltage of the electrical system of a vehicle that varies with the system load and the operating condition of the power supply (e.g. DC-DC converter, battery, alternator, integrated starter generator, etc.)

3.21
supply voltage maximum
U_{Smax}
highest *supply voltage* (3.20) in the specified supply *voltage range* (3.31) of the *DUT* (3.3) while performing in accordance with functional status class A

3.22
supply voltage minimum
U_{Smin}
lowest *supply voltage* (3.20) in the specified supply *voltage range* (3.31) of the *DUT* (3.3) while performing in accordance with functional status class A

3.23
supply voltage operating mode 2
U_B
supply voltage (3.20) from 12/24 V battery without applied charging

3.24
supply voltage for 48 V system operating mode 3 and 4
U_{48N}
supply voltage (3.20) from 48 V battery/DC-DC converter without applied charging

3.25
supply voltage operating mode 3 and 4
U_A
supply voltage (3.20) from 12/24 V battery with applied charging

3.26
test voltage
voltage(s) applied to the *DUT* (3.3) during a test

EXAMPLE U_A and U_B (see Table 4)

3.27
thermal equilibrium
state when the temperature of all parts in/on the systems/components are within 3 K of their final temperature, unless otherwise indicated by the systems'/components' specification

Note 1 to entry: The tolerance of 3 K is according to IEC 60068-1:2013, 3.11: thermal stability which provides technical information of testing devices with and without heat dissipation.

3.28
unlimited operating capability voltage
U_X
specified *supply voltage* (3.20) in the *voltage range* (3.31) of *voltage class B* (3.30) for which the *DUT* (3.3) performs in accordance with functional status class A

3.29
voltage class A
classification of an electric component or circuit with a *maximum working voltage* (3.11) of ≤ 30 V a.c. (RMS) or ≤ 60 V d.c. respectively

