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

Part 4: Climatic loads

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

Partie 4: Contraintes climatiques

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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 16750-4:2010), which has been technically revised.

The main changes are as follows:

— integration and harmonization of contents from ISO 19453-4:2018 (e.g. addition of 5.8 and 5.12);

— subdivision of test methods in temperature cycle test for application to DUTs of "small and lightweight" or "large and heavy" size (5.3);

— addition of test methods for large and heavy DUTs in cold water shock test (5.4);

— addition of three salt spray corrosion tests (5.5.4, 5.5.5 and 5.5.6);

— addition of concrete test method and requirements in solar radiation test (5.10);

— addition of optional test method in dust test for DUT installed in passenger compartment or luggage/load compartment (5.11);

— addition of new tests and the selection of applied cycles in rapid change of temperature with specified transition duration (Clause 6, Table 10);

— subdivision of mounting location defining the corresponding severities (Annex A);

— error correction (Annex B, Figure B.1, B.2 and Table B.1 taken over from ISO 19453-4:2018);

— clarification of technical background to determine number of cycles and severities according to the mounting location (Annex B, Clause B.4);

— subdivision of electric isolation test methods for voltage class A and voltage class B (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.

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

Part 4: **Climatic loads**

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 recommended for the specific mounting location on/in the vehicle.

This document describes climatic loads.

This document is not intended to apply to environmental requirements or testing for systems and components of motorcycles and mopeds.

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 4892-2, *Plastics — Methods of exposure to laboratory light sources — Part 2: Xenon-arc lamps*

ISO 4892-3, *Plastics — Methods of exposure to laboratory light sources — Part 3: Fluorescent UV lamps*

ISO 4892-4, *Plastics — Methods of exposure to laboratory light sources — Part 4: Open-flame carbon-arc lamps*

ISO 9227:2022, *Corrosion tests in artificial atmospheres — Salt spray tests*

ISO 11997-3, *Paints and varnishes — Determination of resistance to cyclic corrosion conditions — Part 3: Testing of coating systems on materials and components in automotive construction*

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

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

IEC 60068-1:2013, *Environmental testing — Part 1: General and guidance*

IEC 60068-2-1:2007, *Environmental testing — Part 2-1: Tests — Test A: Cold*

IEC 60068-2-2:2007, *Environmental testing — Part 2-2: Tests — Test B: Dry heat*

IEC 60068-2-11:2021, *Basic environmental testing procedures — Part 2-11: Tests — Test Ka: Salt mist*

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

IEC 60068-2-30:2005, *Environmental testing — Part 2-30: Tests — Test Db: Damp heat, cyclic (12 h + 12 h cycle)*

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

IEC 60068-2-52:2017, *Environmental testing — Part 2-52: Tests — Test Kb: Salt mist, cyclic (sodium chloride solution)*

IEC 60068-2-60:2015, *Environmental testing — Part 2-60: Tests — Test Ke: Flowing mixed gas corrosion test*

IEC 60068-2-78, *Environmental testing — Part 2-78: Tests — Test Cab: Damp heat, steady state*

IEC 60664-1:2020, *Insulation coordination for equipment within low-voltage systems — Part 1: Principles, requirements and tests*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 16750-1 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/

4 Operating temperature ranges

Choose the applicable temperature range from Table 1 to be presented in the specifications of the DUT.

In the case of hot soak, choose from Table 2 the relative temperature increase ΔT_{HS} and add it to the maximum temperature T_{max} to have the absolute hot-soak temperature (T_{maxHS}).

$$T_{max} + \Delta T_{HS} = T_{maxHS}$$

For further details, refer to 5.3.1.

The paint repair temperature (T_{maxPR}) as defined in ISO 16750-1 can be set to a higher value than the operating temperature. Specify this temperature in the specifications of the DUT.

Table 1 — Operating temperature ranges

Code	Minimum operating temperature T_{min} [°C]	Maximum operating temperature T_{max} [°C]
A	−20	65
B	−30	65

Table 1 *(continued)*

Code	Minimum operating temperature T_{min} [°C]	Maximum operating temperature T_{max} [°C]
C	−40	65
D		70
E		75
F		80
G		85
H		90
I		95
J		100
K		105
L		110
M		115
N		120
O		125
P		130
Q		140
R		150
S		155
T		160
U		165
V		170
W		175
X		180
Z	As agreed	

Table 2 — Relative temperature increase in hot soak

Code	ΔT_{HS} [°C]
a	15
b	30
c	50
z	As agreed

NOTE For DUTs with hot soak, the code letter is defined as a combination of Tables 1 and 2, e.g. Hb (T_{max} = 90 °C and ΔT_{HS} = 30 °C).

5 Tests and requirements

5.1 Tests at constant temperature

5.1.1 Low-temperature tests

5.1.1.1 Storage test

5.1.1.1.1 Purpose

This test simulates the exposure of the systems/components to low temperatures without electrical operation, e.g. during shipment of the systems/components. The failure mode is a malfunction due to insufficient frost resistance, e.g. the freezing of a coolant.

5.1.1.1.2 Test method

Perform the test in accordance with IEC 60068-2-1:2007, 5.2, Test Ab, at a temperature of −40 °C for a duration of 24 h unless otherwise indicated in the DUT specification. The operating mode is 1.1 as defined in ISO 16750-1.

5.1.1.1.3 Requirement

The functional status shall be class C as defined in ISO 16750-1.

5.1.1.2 Operation test

5.1.1.2.1 Purpose

This test simulates the exposure of the systems/components to low temperatures with electrical operation, e.g. the use of the systems/components at very low ambient temperature. The failure mode is an electrical malfunction caused by low temperature, e.g. the freezing of capacitors with liquid electrolyte.

5.1.1.2.2 Test method

Perform the test in accordance with IEC 60068-2-1:2007, 5.2, Test Ab or 5.3, Test Ad, at a temperature of T_{min} for a duration of 24 h. Test Ab is applied for non-heat-dissipating DUTs and Test Ad is applied for heat-dissipating DUTs. The operating mode is 3.3 or 4.3 as defined in ISO 16750-1.

5.1.1.2.3 Requirement

The functional status shall be class A as defined in ISO 16750-1.

5.1.2 High-temperature tests

5.1.2.1 Storage test

5.1.2.1.1 Purpose

This test simulates the exposure of the systems/components to high temperatures without electrical operation, e.g. during the shipment of the systems/components. The failure mode is insufficient heat resistance, e.g. warping of plastic housings.

5.1.2.1.2 Test method

Perform the test in accordance with IEC 60068-2-2:2007, 5.2, Test Bb, at a temperature of 85 °C for a duration of 48 h unless otherwise indicated in the DUT specification. The operating mode is 1.1 as defined in ISO 16750-1.

5.1.2.1.3 Requirement

The functional status shall be class C as defined in ISO 16750-1.

5.1.2.2 Operation test

5.1.2.2.1 Purpose

This test simulates the exposure of the systems/components to high temperatures with electrical operation, e.g. the use of the systems/components at very high ambient temperature. The failure mode is an electrical malfunction caused by high temperature, e.g. thermal degradation of components.

5.1.2.2.2 Test method

Perform the test in accordance with IEC 60068-2-2:2007, 5.2 Test Bb or 5.3 Test Bd, at a temperature of T_{max} for a duration of 96 h. Test Bb is applied for non-heat-dissipating DUTs and Test Bd is applied for heat-dissipating DUTs. The operating mode is 3.4 or 4.4 as defined in ISO 16750-1.

5.1.2.2.3 Requirement

The functional status shall be class A as defined in ISO 16750-1.

5.2 Temperature step test

5.2.1 Purpose

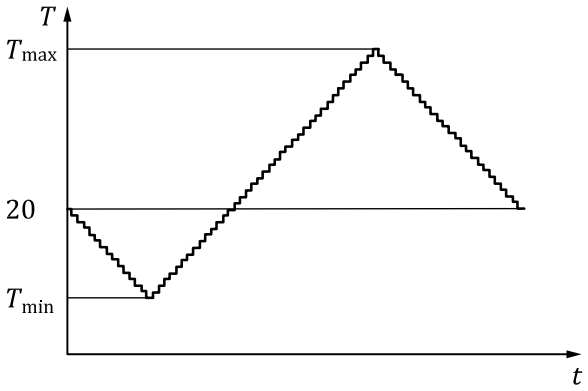
This test checks the mechanical and electrical device for malfunctions (including failure to change properly between different operating modes) which may occur within a small section of the operating temperature range.

This test mainly applies to small and lightweight components, but can also be used for large and heavy components if agreed between the customer and the supplier. See a mass classification example in ISO 16750-1:2023, Annex C.

5.2.2 Test method

Install the DUT in a temperature chamber. According to Figure 1, decrease the temperature in steps of 5 °C from 20 °C to T_{min}, then increase the temperature in steps of 5 °C from T_{min} to T_{max} and then decrease the temperature in steps of 5 °C from T_{max} to 20 °C (see Figure 1). Wait at each step until the DUT has obtained thermal equilibrium. Perform functional tests with operating mode 3.2 in accordance with ISO 16750-1 at minimum supply voltage, U_{Smin}, and at maximum supply voltage, U_{Smax}, in accordance with the specified ISO 16750-2 code letter, at each temperature step. In addition, for each temperature step transitions of the DUT between different operating modes shall also be verified (e.g. change between operating modes 3.2 and 2.1). Switch the DUT off (operating mode 2.1) during transition to the next temperature. If the DUT has a nominal supply voltage other than 12/24 V, this test shall be performed by the voltage range corresponding to functional status class A as defined in ISO 16750-1 according to agreement between the customer and the supplier. In case of 48 V, the test shall be performed at the upper and lower voltage of nominal voltage range in accordance with ISO 21780. In case of voltage class B, the test shall be performed at the upper and lower voltage of unlimited operating capability in accordance with ISO 21498-1. For DUTs with multiple voltage supply

levels, e.g. 12 V supply and voltage class B supply, the combination of test voltages for each temperature step shall be agreed between the customer and the supplier.



Key

T temperature, in °C

t time, in min

T_{min} minimum operating temperature (see Table 1)

T_{max} maximum operating temperature (see Table 1)

Figure 1 — Temperature step test

5.2.3 Requirement

For each temperature step between T_{min} and T_{max}, the DUT shall have functional status class A as defined in ISO 16750-1 for active operating modes.

5.3 Temperature cycling tests

5.3.1 Temperature cycle with specified change rate

5.3.1.1 Purpose

This test simulates varying temperatures with electrical operation of the systems/components, e.g. during the use of the system/component at changing ambient temperature. If a system/component is exposed to hot-soak temperatures (e.g. engine-mounted systems/components), an additional short temperature peak is added during the high temperature stage of the profile to ensure proper function during short temperature peaks. The electrical operation is switched off during stages of decreasing temperature to avoid electrical heat dissipation of the system/component which would inhibit reaching T_{min} inside the system/component. The failure mode is an electrical malfunction during temperature change.

The mass of the DUT is the main influence factor that determines the design of the temperature cycle. This test shall be selected from 5.3.1.2 or 5.3.1.3 in accordance with mass classification example in ISO 16750-1:2023, Annex C.

NOTE 1 This test is not intended to be a life test.

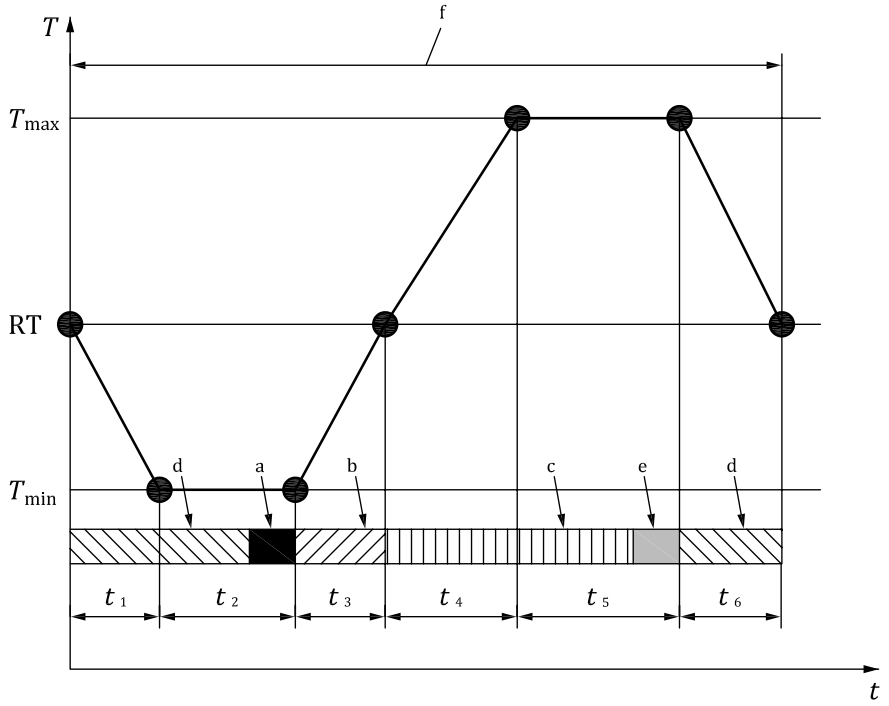
NOTE 2 For applying this test, it is important to calculate and check the temperature change rate against available test chamber capabilities. If the specified change rate is not technically feasible, the temperature profile can be changed by agreement between the customer and the supplier.

5.3.1.2 Test method for small and lightweight DUT

For a small and lightweight DUT, perform the temperature cycling in accordance with IEC 60068-2-14, Test Nb, not using its specified temperature changing rates, but using the variant given in Figure 2 and Table 3. For the test including hot-soak temperature (T_{maxHS}), also use the variant given in Figure 3 and Table 4. The test shall be performed with 30 cycles.

Perform temperature cycling with the following as one cycle. Decrease ambient temperature from room temperature (RT) to T_{min}, expose the DUT at T_{min}, increase ambient temperature from T_{min} to T_{max}, expose the DUT at T_{max} with/without including T_{maxHS} and then decrease ambient temperature from T_{max} to RT (see Figure 2 and Figure 3).

Perform a functional test at the end of T_{min} as short as possible with operating mode 3.3 or 4.3 as defined in ISO 16750-1 (see key a in Figure 2 or Figure 3). In addition, operate with operating mode 3.3 or 4.3 as defined in ISO 16750-1 (see key b in Figure 2 or Figure 3) during the section from T_{min} to RT. Change operating mode to 3.4 or 4.4 (see key c in Figure 2 or Figure 3) during the section from RT to the end of T_{max}. Perform a functional test at the end of T_{max} as short as possible with operating mode 3.4 or 4.4 as defined in ISO 16750-1 (see key e in Figure 2 or Figure 3). During the other sections, operate with operating mode 2.1 (see key d" in Figure 2 or Figure 3). For tests including T_{maxHS}, the DUT shall not be operated at the time which is over T_{max} (see key t_6, t_7, t_8 in Figure 3). If operating mode 4.3/4.4 is not technically feasible, operating mode 3.3/3.4 may be used if agreed between the customer and the supplier.



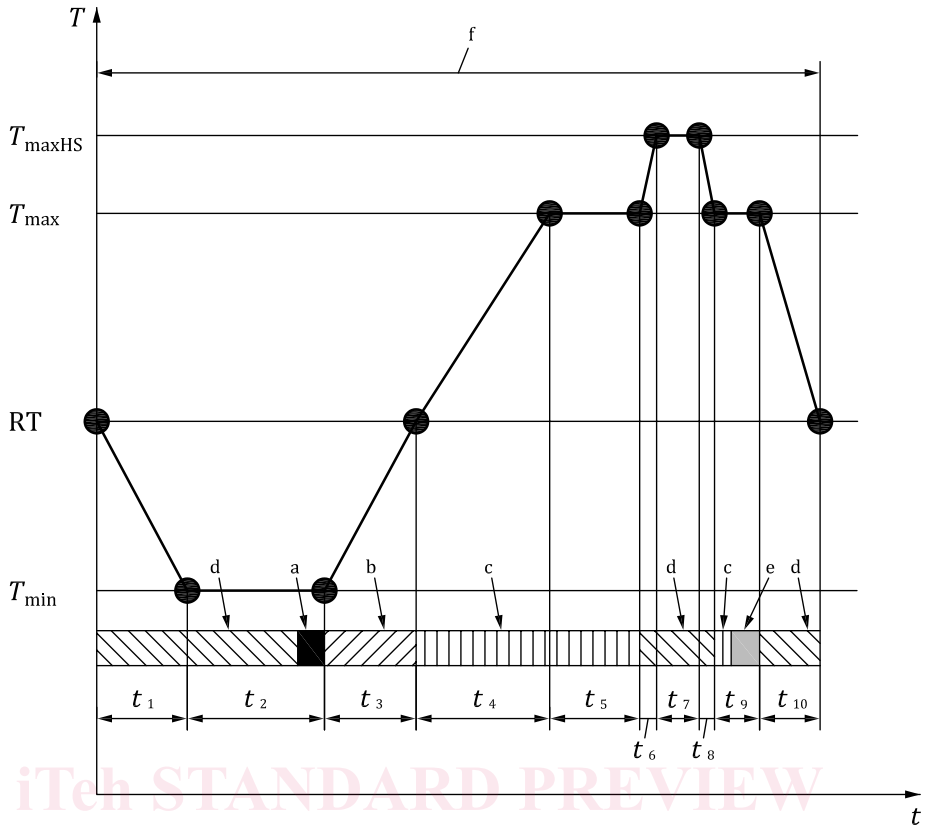
Key

T	temperature, in °C
t	time, in min
T_{min}	minimum operating temperature (see Table 1)
T_{max}	maximum operating temperature (see Table 1)
RT	room temperature (see ISO 16750-1)
t_1, t_2, t_3, t_4, t_5, t_6	time parameter as defined in Table 3
a	Functional test with operating mode 3.3 or 4.3 as defined in ISO 16750-1.
b	Operating mode 3.3 or 4.3 as defined in ISO 16750-1.
c	Operating mode 3.4 or 4.4 as defined in ISO 16750-1.
d	Operating mode 2.1 as defined in ISO 16750-1.
e	Functional test with operating mode 3.4 or 4.4 as defined in ISO 16750-1.
f	One cycle.

Figure 2 — Temperature cycle with specified change rate for small and lightweight DUT

Table 3 — Temperatures and time duration for temperature cycling for small and lightweight DUT

Parameter	Duration [min]	Temperature [°C]
t_1	60	From RT to T_{min}
t_2	90	Exposure time at T_{min}
t_3	60	From T_{min} to RT
t_4	90	From RT to T_{max}
t_5	110	Exposure time at T_{max}
t_6	70	From T_{max} to RT



Key

T	temperature, in °C
t	time, in min
T_{min}	minimum operating temperature (see Table 1)
T_{max}	maximum operating temperature (see Table 1)
T_{maxHS}	hot soak temperature (see Table 2)
RT	room temperature (see ISO 16750-1)
t_1, t_2, t_3, t_4, t_5, t_6, t_7, t_8, t_9, t_{10}	time parameter as defined in Table 4
a	Functional test with operating mode 3.3 or 4.3 as defined in ISO 16750-1.
b	Operating mode 3.3 or 4.3 as defined in ISO 16750-1.
c	Operating mode 3.4 or 4.4 as defined in ISO 16750-1.
d	Operating mode 2.1 as defined in ISO 16750-1.
e	Functional test with operating mode 3.4 or 4.4 as defined in ISO 16750-1.
f	One cycle.

Figure 3 — Temperature cycle with specified change rate and hot-soak stage for small and lightweight DUT

Table 4 — Temperatures and time duration for temperature cycling with hot-soak stage for small and lightweight DUT

Parameter	Duration [min]	Temperature [°C]
t_1	60	From RT to T_{min}
t_2	90	Exposure time at T_{min}
t_3	60	From T_{min} to RT