
**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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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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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 16750-4 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 3, *Electrical and electronic equipment*.

This second edition cancels and replaces the first edition (ISO 16750-4:2003), which has been technically revised.

ISO 16750 consists of the following parts, under the general title *Road vehicles — Environmental conditions and testing for electrical and electronic equipment*:

- *Part 1: General*
- *Part 2: Electrical loads*
- *Part 3: Mechanical loads*
- *Part 4: Climatic loads*

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

Part 4: Climatic loads

1 Scope

ISO 16750 applies to electric and electronic systems/components for road vehicles. It describes the potential environmental stresses and specifies tests and requirements recommended for the specific mounting location on/in the vehicle.

This part of ISO 16750 describes the climatic loads.

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 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*

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

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

IEC 60068-2-11, *Environmental testing — Part 2: Tests. Test Ka: Salt mist*

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

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

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

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

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

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

3 Terms and definitions

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

4 Operating temperature ranges

Table 1 defines operating temperature ranges. The applicable temperature ranges shall be chosen from Table 1 and shall be given in the specification of the *device under test* (DUT).

Table 1 — Operating temperature ranges

Code	T_{\min} °C	T_{\max} °C
A	-20	65
B	-30	65
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	
Z	as agreed upon	

In case of hot-soak requirements ($T_{\max\text{HS}}$), add 15 °C to T_{\max} . For details see 5.3.1.

The paint repair temperature ($T_{\max\text{PR}}$) can be higher than the operating temperature and shall be given in the specification of the DUT. An applicable test shall be agreed between supplier and vehicle manufacturer.

5 Tests and requirements

5.1 Tests at constant temperature

5.1.1 Low-temperature tests

5.1.1.1 Storage

5.1.1.1.1 Purpose

This test simulates the exposure of the DUT to low temperatures without electrical operation, e.g. during shipment of the system/component. Failure mode is insufficient frost resistance, e.g. freezing of liquid crystal displays.

5.1.1.1.2 Test

Perform the test according to IEC 60068-2-1 cold at a temperature of $-40\text{ }^{\circ}\text{C}$ for a duration of 24 h unless otherwise specified in the DUT specification. The operating mode of the DUT is 1.1 as defined in ISO 16750-1.

5.1.1.1.3 Requirement

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

5.1.1.2 Operation

5.1.1.2.1 Purpose

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

5.1.1.2.2 Test

Perform the test according to IEC 60068-2-1 cold at a temperature of T_{\min} for a duration of 24 h. The operating mode of the DUT is 3.2 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

5.1.2.1.1 Purpose

This test simulates the exposure of the DUT to high temperatures without electrical operation, e.g. during the shipment of the system/component. Failure mode is insufficient heat resistance, e.g. warping of plastic housings.

5.1.2.1.2 Test

Perform the test according to IEC 60068-2-2 dry heat at a temperature of $85\text{ }^{\circ}\text{C}$ for a duration of 48 h unless otherwise specified in the DUT specification. The operating mode of the DUT 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

5.1.2.2.1 Purpose

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

5.1.2.2.2 Test

Perform the test according to IEC 60068-2-2 dry heat at a temperature of T_{max} for a duration of 96 h. Use operating mode 3.2 as defined in ISO 16750-1.

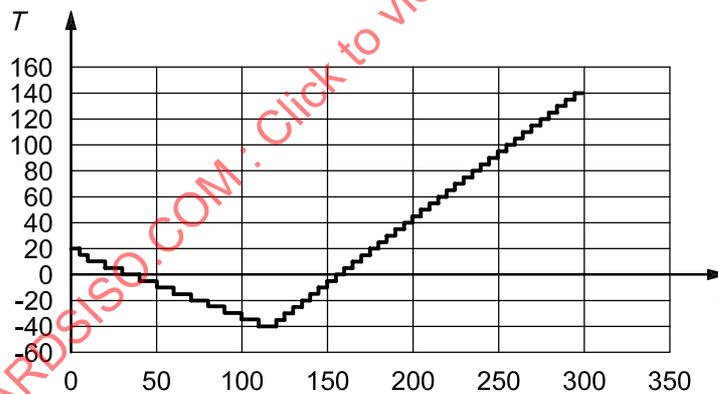
5.1.2.2.3 Requirement

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

5.2 Temperature steps

5.2.1 Purpose

This test checks the mechanical and electrical device for malfunctions which may occur within a small section of the operating temperature range. See Figure 1.



Key

- T temperature, °C
- t time, min

Figure 1 — Temperature step test (example illustrates code “Q” according to Table 1)

5.2.2 Test

Install the DUT in a temperature chamber, decrease the temperature in steps of 5 °C from 20 °C to T_{min} and then increase the temperature in steps of 5 °C from T_{min} to T_{max} (see Table 1). Wait at each step until the DUT has reached the new temperature. Perform functional tests operating mode 3.2 according to ISO 16750-1 at U_{Smin} and U_{Smax} according to the specified code letter ISO 16750-2 at each new temperature step. Switch the DUT off during transition to the next temperature.

5.2.3 Requirement

The DUT shall take up its normal function at each temperature between T_{\min} and T_{\max} , i.e. the functional status shall be class A as defined in ISO 16750-1.

5.3 Temperature cycling

5.3.1 Temperature cycle with specified change rate

5.3.1.1 Purpose

This test simulates varying temperatures with electrical operation of the DUT, e.g. during the use of the system/components at fast-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 phase of the profile to ensure proper function during short temperature peaks. The electrical operation is switched off during phases of decreasing temperature to avoid electrical heat dissipation of the system/component which would inhibit reaching T_{\min} inside the system/component. Failure mode is electrical malfunction during temperature change.

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

5.3.1.2 Test

Perform the temperature cycling according to IEC 60068-2-14, Nb.

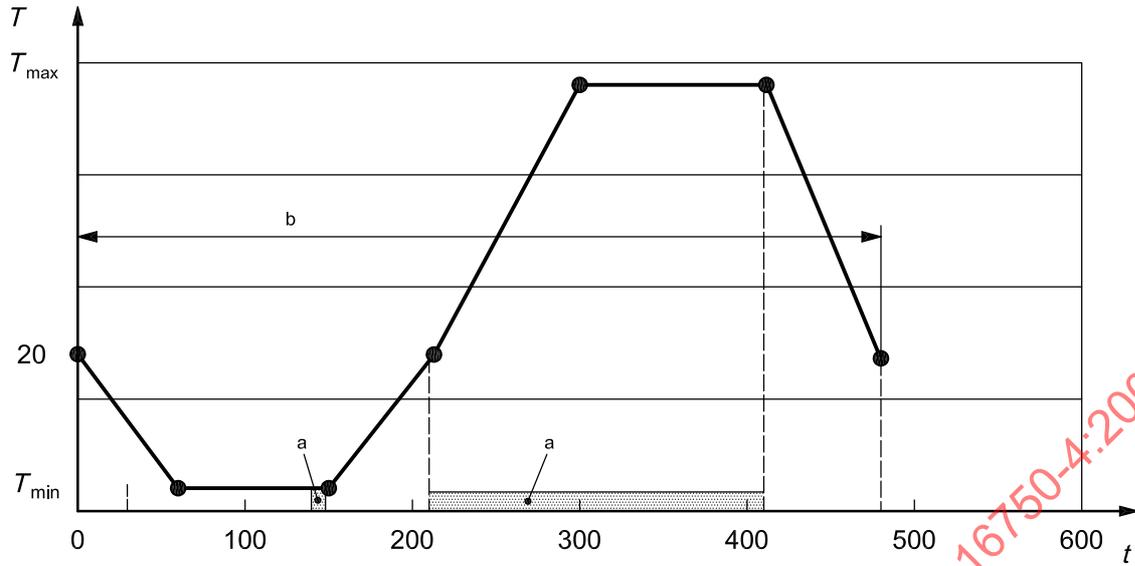
Operate the DUT electrically (functional test) after the whole device has reached T_{\min} for the shortest possible duration to check the correct function of the device. In addition, operate it electrically between 210 min and 410 min of the cycle (see Figure 2). Use operating mode 3.2 as defined in ISO 16750-1 for the phases with electrical operation.

The changes in temperature shall correspond to the specifications given in Table 2. For tests including hot-soak temperature ($T_{\max\text{HS}}$), see Figure 3 and Table 3.

The long period of electrical operation is started at 20 °C in order to allow possible condensation of humidity on the DUT. A permanent operation starting at T_{\min} would prevent this due to the electrical power dissipation.

Additional drying of the test chamber air is not permitted.

Perform 30 test cycles as specified.



Key

T temperature, °C
 t time, min

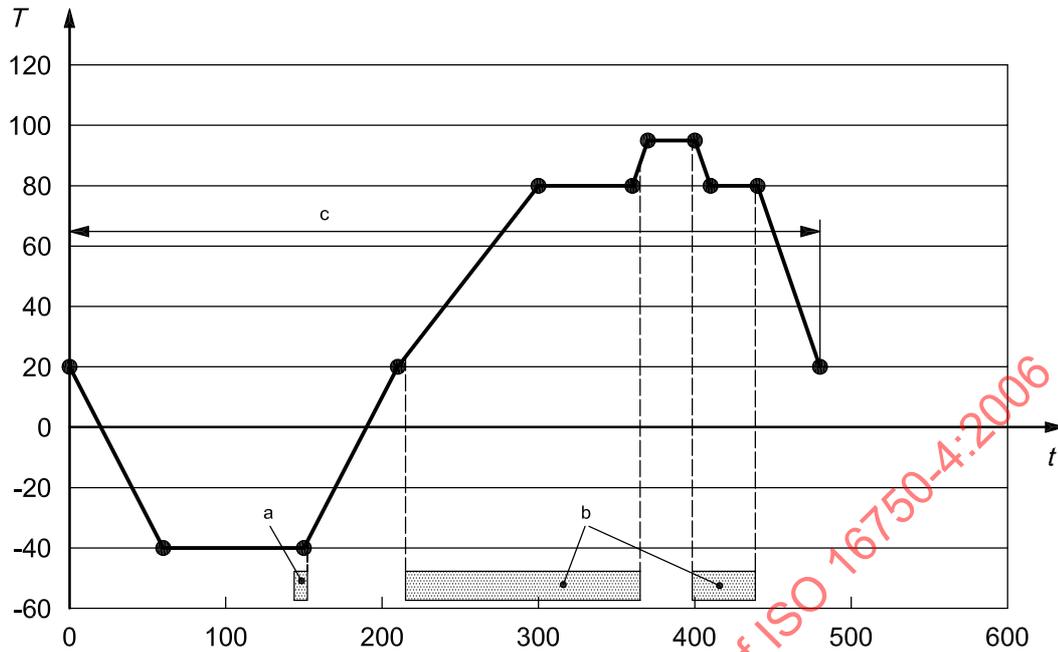
- a Operating mode 3.2 according to ISO 16750-1.
- b One cycle.

Figure 2 — Temperature cycles with specified change rate (T_{min} and T_{max} see Table 1)

Table 2 — Temperatures and time duration for temperature cycling (see Figure 2)

Time min	Code according to Table 1
	Temperature °C
0	20 °C
60	T_{min}
150	T_{min}
210	20 °C
300	T_{max}
410	T_{max}
480	20 °C

NOTE In the vehicle environment, some equipment might experience different conditions regarding temperatures, temperature gradients and duration. In all these cases, use code Z.

**Key** T temperature, °C t time, min

a Functional test operating mode 3.2 according to ISO 16750-1.

b Operating mode 3.2 according to ISO 16750-1.

c One cycle.

Figure 3 — Example for a temperature cycle with hot-soak phase (illustrates code “F” according to Table 1)

Table 3 — Temperatures and time duration for temperature cycling with hot-soak phase (see Figure 3) (illustrates code “F” according to Table 1)

Time min	Temperature °C
0	20
60	-40
150	-40
210	20
300	80
360	80
370	95 ($T_{\max\text{HS}}$)
400	95 ($T_{\max\text{HS}}$)
410	80
440	80
480	20

5.3.1.3 Requirement

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

5.3.2 Rapid change of temperature with specified transition duration

5.3.2.1 Purpose

This is an accelerated test which simulates a very high number of slow temperature cycles in the vehicle. The acceleration is possible due to a much higher temperature change rate and a bigger temperature change in one cycle in comparison to real vehicle stress. Failure modes are cracking of materials or seal failures caused by ageing and different temperature expansion coefficients. Because this test creates mechanical defects (cracks), electrical operation is not required.

5.3.2.2 Test

Perform the temperature cycling according to IEC 60068-2-14, Na.

Raise the temperature from T_{\min} to T_{\max} within 30 s or less. Keep the DUT, depending on its size and other properties, at each of these temperatures for 20 min, 40 min, 60 min or 90 min. Use operating mode 1.1 as defined in ISO 16750-1. See Table 4 for the number of cycles.

Upon agreement, this test may be performed during the development of a DUT with opened housing or without a housing.

5.3.2.3 Requirement

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

5.4 Ice water shock test

5.4.1 Purpose

These tests simulate a thermal shock induced by ice water and apply to products in the splash areas of the vehicle. The purpose of this test is to simulate ice water splashing over a hot system/component. This happens when driving on wet roads during the winter. Failure modes are mechanical cracking of materials or seal failures caused by different temperature expansion coefficients. An additional failure mode not addressed in 5.3.2.1 is a loss of tightness and the intrusion of water into the system/component.

There are two possible methods to perform the test (see 5.4.2 and 5.4.3).

NOTE This is not a corrosion test.

5.4.2 Splash water test

5.4.2.1 Test

Heat the DUT in a hot air oven at T_{\max} for the specified holding time (t_h). Then splash the DUT with ice water for 3 s.

If the DUT is splashed in the vehicle from only one direction, splash it from this direction only while it is in an as-installed position. If the equipment is splashed from various directions in the vehicle, then these directions shall be taken into account. In this case use a new DUT for each splash direction. The width of the splash directed at the DUT shall always be greater than the width of the DUT. If DUTs of considerable size are splashed that prove too big for one jet, arrange several jets in a row to produce a line of splash impact on the DUT. See Figures 4 to 6.

Test parameters include:

- Number of cycles: 100;
- Holding time t_h at T_{max} : 1 h or until DUT temperature stabilisation is reached;
- Transition duration: < 20 s (for manual transition of DUT between temperature storage and splashing);
- Test fluid: de-ionized water;
- Water temperature: 0 °C to +4 °C;
- Water flow: (3 l to 4 l)/3 s (splash duration);
- Distance between jet and DUT surface: (325 ± 25) mm (water shall be applied over the complete width of the DUT);
- Operating modes: see Figure 5;
- Orientation of the DUT: as in the vehicle.

Dimensions in millimetres

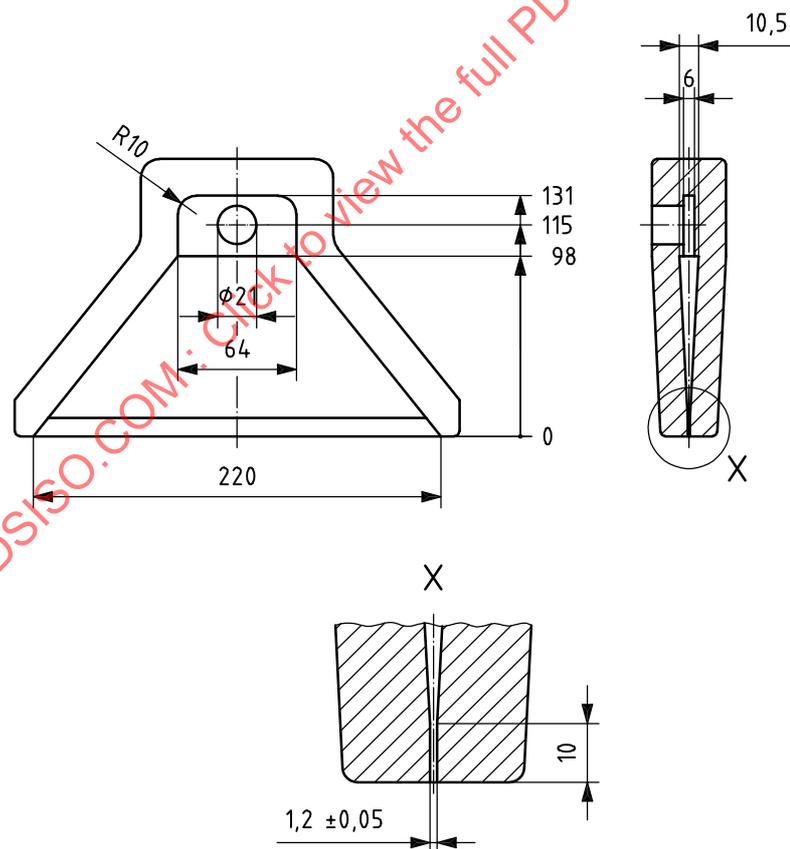
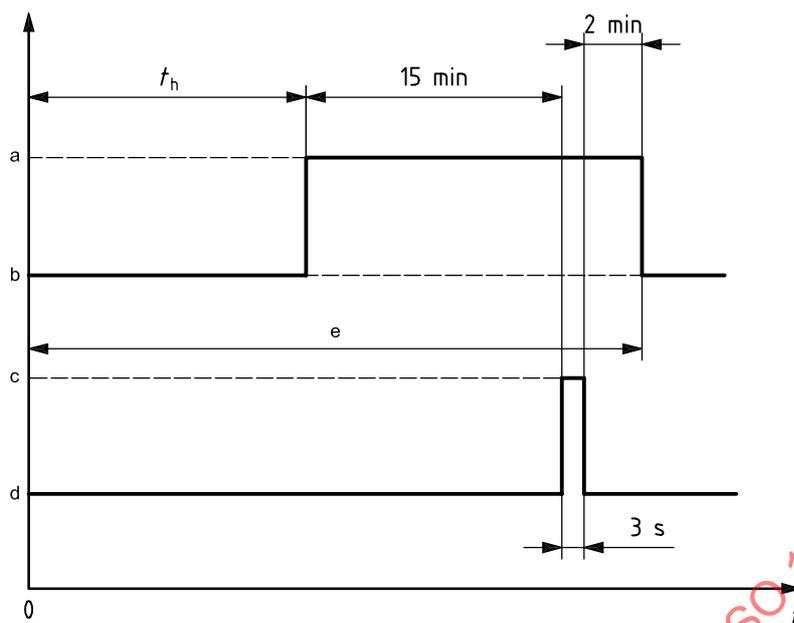


Figure 4 — Jet



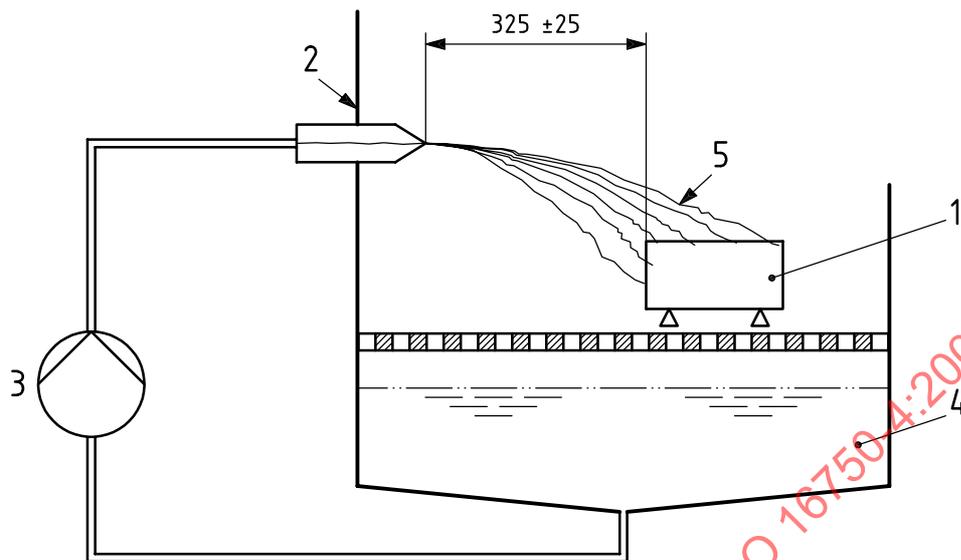
Key

- a Operating mode 3.2 according to ISO 16750-1.
- b Operating mode 1.2 according to ISO 16750-1.
- c Splash on.
- d Splash off.
- e One cycle.

Figure 5 — Test cycle for splash water test

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Dimensions in millimetres

**Key**

- 1 DUT
- 2 slot jet
- 3 pump
- 4 splash water
- 5 splash

Figure 6 — Test set-up for splash water test**5.4.2.2 Requirement**

The functional status shall be class A during the operating mode 3.2 as defined in ISO 16750-1.

5.4.3 Submersion test**5.4.3.1 Test**

Connect the DUT to the test equipment. Operate the DUT in a hot air oven at T_{\max} for the specified holding time (t_h). With the device still operating, submerge it for 5 min in an ice water tank, in a depth of more than or equal to 10 mm.

Test parameters include:

- Number of cycles: 10;
- Holding time t_h at T_{\max} : 1 h or until DUT temperature stabilization is reached;
- Transition duration: < 20 s;
- Test fluid: de-ionized water;
- Water temperature: 0 °C to +4 °C;
- Immersion time: 5 min;
- Operating mode: 3.2 according to ISO 16750-1;
- Orientation of the DUT: as in the vehicle.

5.4.3.2 Requirement

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

5.5 Salt spray

5.5.1 Corrosion

5.5.1.1 Purpose

This test checks the resistance of materials and surface-coatings of a system/component to salt mist and salt water on streets in winter. This test generates corrosion similar to reality. Failure mode is corrosion.

Visual examination as detailed below shall allow identification, appearance, workmanship and finish of the item to be checked against the relevant specification.

5.5.1.2 Test

Perform the test according to IEC 60068-2-52. Select a severity from Table 4 and Annex A of this part of ISO 16750. Use operating mode 1.2 as specified in ISO 16750-1.

Carry out a visual examination with the naked eye, at normal strength of vision, normal colour perception, at the most favourable distance and with suitable illumination.

5.5.1.3 Requirement

There shall be no changes that could impair normal performance (e.g. sealing function, marking and labelling shall remain visible).

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

5.5.2 Leakage and function

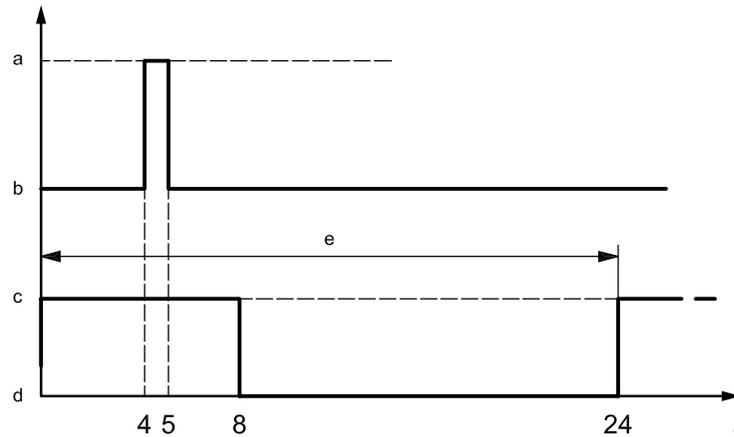
5.5.2.1 Purpose

This test checks the resistance of a system/component to salt mist and salt water on winter streets. Failure mode is electrical malfunction due to leakage currents caused by the ingress of salt water.

5.5.2.2 Test

Perform the test cycle given in Figure 7, based on IEC 60068-2-11, Ka. The duration of one cycle is 24 h. Spray the DUT for 8 h, then stop spraying for a rest period of 16 h. Operate the DUT with operating mode 3.2 according to ISO 16750-1 between the fourth and fifth hour of each cycle.

Test duration: 6 cycles = 6 days as a minimum.

**Key**

t time, h

- a Operating mode 3.2 according to ISO 16750-1.
- b Operating mode 1.2 according to ISO 16750-1.
- c Salt spray on.
- d Salt spray off.
- e One cycle.

Figure 7 — Test cycle for the salt spray test

5.5.2.3 Requirement

Intrusion of salt water into the housing is not permitted.

Functional status class A is required in phases with electrical operation (mode 3.2) as defined in ISO 16750-1.

5.6 Humid heat, cyclic**5.6.1 Purpose**

This test simulates the use of the system/component under high ambient humidity. The failure modes addressed are electrical malfunction(s) caused by moisture (e.g. leakage current caused by a printed circuit board which is soaked with moisture). Additional failure mode is a breathing-effect which transports moisture inside the housing when the air inside the system/components cools down and ambient air with high humidity is drawn into the system/components.

5.6.2 Test**5.6.2.1 General**

Perform one of the following tests based on Table 4 and Annex A of this part of ISO 16750.

5.6.2.2 Test 1: Damp heat cyclic

Perform the test as specified in IEC 60068-2-30, Db, Variant 1:

- Upper temperature: +55 °C,
- Number of cycles: 6.

Perform a functional test (operating mode 3.2 according to ISO 16750-1) when the maximum cycle temperature is reached.