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ISO 16750-4

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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

Reference number
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Foreword

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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*.

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*

— *Part 5: Chemical loads*

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

Part 4: Climatic loads

1 Scope

This part of ISO 16750 describes the climatic loads that can affect of electric and electronic systems and components in respect of their mounting location directly on or in road vehicles and specifies the corresponding tests and requirements.

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 12103-1, *Road vehicles — Test dust for filter evaluation — Part 1: Arizona test dust*

ISO 16750-1:2003, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment — Part 1: General*

ISO 16750-2:2003, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment — Part 2: Electrical loads*

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: Tests — Test Db and guidance: Damp heat, cyclic (12 + 12-hour 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*

DIN 40050-9, *Road vehicles; degrees of protection (IP-code); protection against foreign objects; water and contact; electrical equipment*

3 Terms and definitions

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

4 Operating temperature ranges

The applicable temperature ranges shall be chosen from Table 1 and 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	–40	70
E	–40	80
F	–40	85
G	–40	90
H	–40	100
I	–40	110
J	–40	120
K	–40	125
L	–40	130
M	–40	140
N	–40	150
O	–40	155
P	–40	160
Z	As agreed upon	

In case of hot-soak requirements ($T_{max,HS}$), add 15 °C to T_{max}. For details see 5.3.2.

The paint repair temperature ($T_{max,PR}$) can be higher than the operating temperature and shall be given in the specification of the DUT.

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 a system/component to low temperatures without electrical operation, for example during shipment. 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 °C for a duration of 24 h, unless otherwise specified in the DUT specification. Use Operating mode 1.1 in accordance with ISO 16750-1:2003, Clause 5.

5.1.1.1.3 Requirement

The functional status shall be Class C as defined in ISO 16750-1:2003, Clause 6.

5.1.1.2 Operation

5.1.1.2.1 Purpose

This test simulates the exposure of a system/component to low temperatures with electrical operation, for example use 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 at a temperature of T_{min} for a duration of 24 h. Use Operating mode 3.2 in accordance with ISO 16750-1:2003, Clause 5.

5.1.1.2.3 Requirement

The functional status shall be Class A as defined in ISO 16750-1:2003, Clause 6.

5.1.2 High-temperature tests

5.1.2.1 Storage

5.1.2.1.1 Purpose

This test simulates the exposure of a system/component to high temperatures without electrical operation, for example during shipment. 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 at a temperature of +85 °C for a duration of 48 h, unless otherwise specified in the DUT's specification. Use Operating mode 1.1 in accordance with ISO 16750-1:2003, Clause 5.

5.1.2.1.3 Requirement

The functional status shall be Class C as defined in ISO 16750-1:2003, Clause 6.

5.1.2.2 Operation

5.1.2.2.1 Purpose

This test simulates the exposure of the system/component to high temperatures with electrical operation, for example, use 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 at a temperature of T_{max} for a duration of 96 h. Use Operating mode 3.2 in accordance with ISO 16750-1:2003, Clause 5.

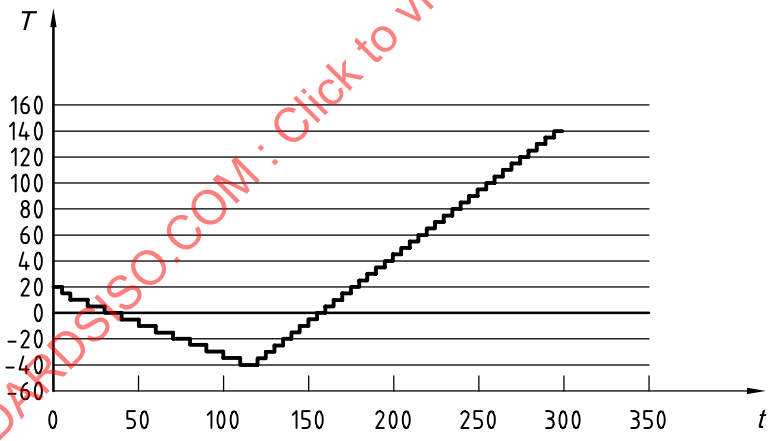
5.1.2.2.3 Requirement

The functional status shall be Class A as defined in ISO 16750-1:2003, Clause 6.

5.2 Temperature steps

5.2.1 Purpose

This test is for checking the mechanical and electrical device for malfunctions which may occur within a small section of the operating temperature range.



Key

T temperature, °C

t time, min

Figure 1 — Temperature step test — Example (illustrates code “M” 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 and Figure 1). Wait at each step until the DUT has reached the new temperature. Perform functional tests using operating mode 3.2 in accordance with ISO 16750-1:2003, Clause 5, at U_{min} and U_{max}, using the appropriate code in accordance with ISO 16750-2:2003, Table 1, at each new temperature. 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 16750-1:2003, Clause 6.

5.3 Temperature cycling

5.3.1 General

Temperature cycling is based on IEC 60068-2-14.

5.3.2 Temperature cycle with specified change rate

5.3.2.1 Purpose

This test simulates varying temperatures during electrical operation of a system/component, for example during use at fast-changing ambient temperature. If the 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 functioning during short temperature peaks. The electrical operation is switched off during phases of decreasing temperature in order to avoid electrical heat dissipation of the DUT which would inhibit the reaching of T_{min} inside it. Failure mode is electrical malfunction during temperature change.

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

5.3.2.2 Test

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

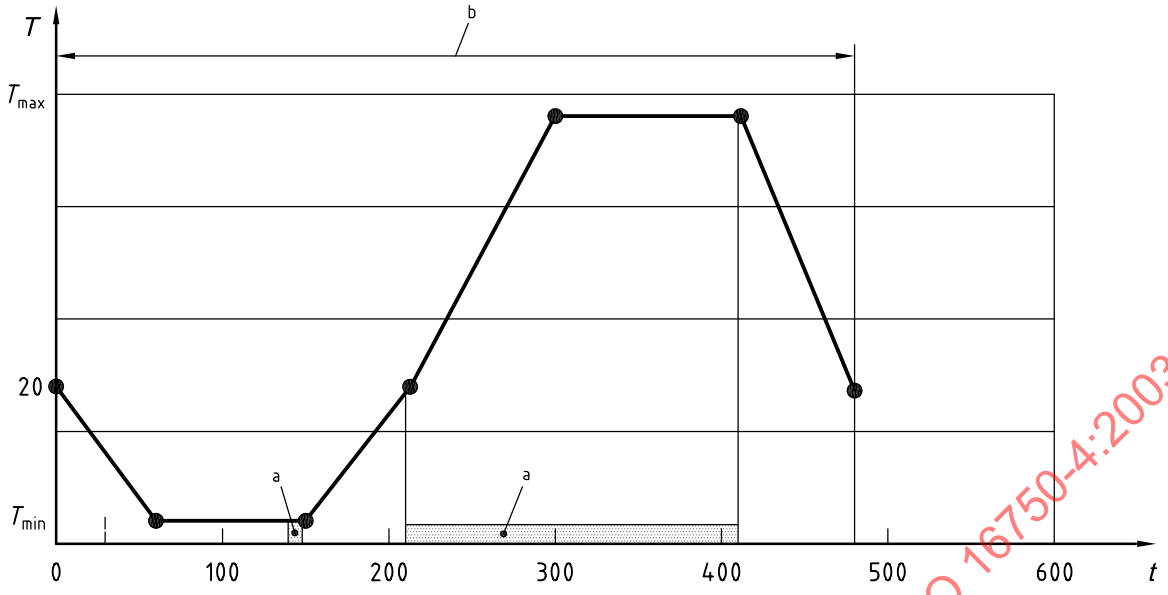
Operate the DUT electrically (functional test) after the whole device has reached T_{min} for the shortest possible duration, in order to check that the device functions correctly. In addition, operate it electrically between 210 min and 410 min of the cycle (see Figure 2). Use Operating mode 3.2 in accordance with ISO 16750-1:2003, Clause 5 for the phases with electrical operation.

The changes in temperature shall be in accordance with Table 2. For tests including hot-soak temperature ($T_{max,HS}$), see Table 3.

Start the long period of electrical operation at 20 °C in order to allow possible condensation of humidity on the DUT. A permanent operation starting at T_{min} would prevent this, owing 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 (see ISO 16750-1).

b One cycle.

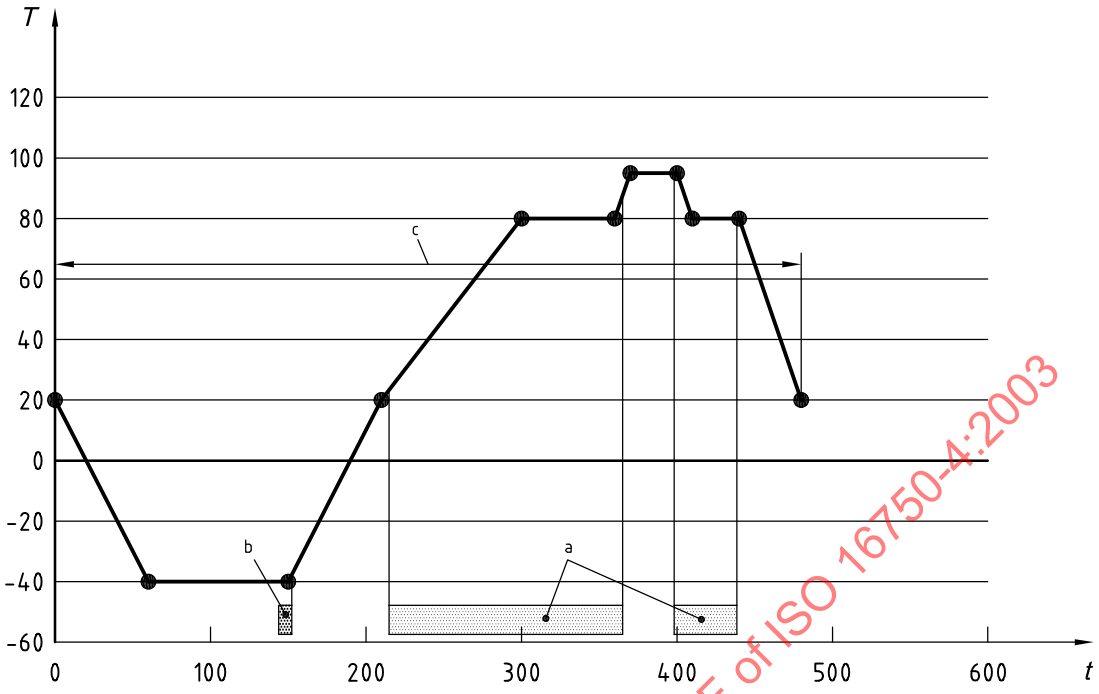
Figure 2 — Temperature cycles with specified change rate (T_{min} and T_{max})

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

	Code (see Table 1)																
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Z[a]
Time min	**Temperature** °C																
0	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	
60	–20	–30	–40	–40	–40	–40	–40	–40	–40	–40	–40	–40	–40	–40	–40	–40	
150	–20	–30	–40	–40	–40	–40	–40	–40	–40	–40	–40	–40	–40	–40	–40	–40	
210	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	
300	65	65	65	70	80	85	90	100	110	120	125	130	140	150	155	160	
410	65	65	65	70	80	85	90	100	110	120	125	130	140	150	155	160	
480	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	

In the vehicle environment, some equipment could experience a faster rate of temperature change or require longer stabilization times than those shown in Figures 2 and 3 and given in Table 2. In such cases, use Code Z.

a As agreed.



Key

T temperature, °C

t time, min

a Operating mode 3.2 (see ISO 16750-1).

b Functional test Operating mode 3.2 (see ISO 16750-1).

c One cycle.

Figure 3 — Example for a temperature cycle with hot-soak phase — Example (illustrates Code E according to Table 1)

Table 3 — Temperatures and time duration for temperature cycling with hot-soak phase (see Figure 3) — Illustration of Code E (see Table 1)

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

5.3.2.3 Requirement

The functional status shall be Class A as defined in ISO 16750-1:2003, Clause 6.

5.3.3 Rapid change of temperature with specified transition duration

5.3.3.1 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.

5.3.3.2 Test

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

Raise the temperature from T_{min} to T_{max} within $\leqslant$ 30 s. 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 in accordance with ISO 16750-1:2003, Clause 5. See Table 6 for the required number of cycles.

By agreement, this test may be performed during the development of a system/component with an opened housing or without a housing.

5.3.3.3 Requirement

The functional status shall be Class C as defined in ISO 16750-1:2003, Clause 6.

5.4 Ice water shock test

5.4.1 Purpose

This test simulates a thermal shock induced by cold water and is applicable to products in the splash areas of the vehicle. The purpose is to simulate cold water splashing over a hot system/component, as can happen when a vehicle is driven on wet roads in winter. Failure modes are mechanical cracking of materials or seal failures caused by different temperature expansion coefficients. An additional failure mode, not addressed in 5.3.3, is a loss of tightness and the intrusion of water into the system/component.

There are two alternative methods for performing the test (see 5.4.2 and 5.4.3).

5.4.2 Splash water method

5.4.2.1 Test

Heat the DUT in a hot air oven at T_{max} for the specified holding time (t_h). Then use a jet to splash the DUT with cold 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 and a new DUT used for each splash direction. The width of the splash directed at the DUT shall always be greater than the width of the DUT. If a splashed DUT of considerable size proves too big for a single jet, arrange several jets in a row to produce a line of splash impact on the DUT. See Table 4.

See Figures 4, 5 and 6.

Table 4 — Splash water test

Number of cycles	100
Holding time t_h at T_{max}	1 h or until DUT temperature stabilization is reached
Transition duration	< 20 s (for manual transition of DUT between temperature storage and splashing)
Test fluid	De-ionized water with 3 % fine Arizona dust according to ISO 12103-1; 5 % NaCl may be added
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 (ISO 16750-1)	See Figure 5
Orientation of DUT	As in the vehicle

Dimensions in millimetres

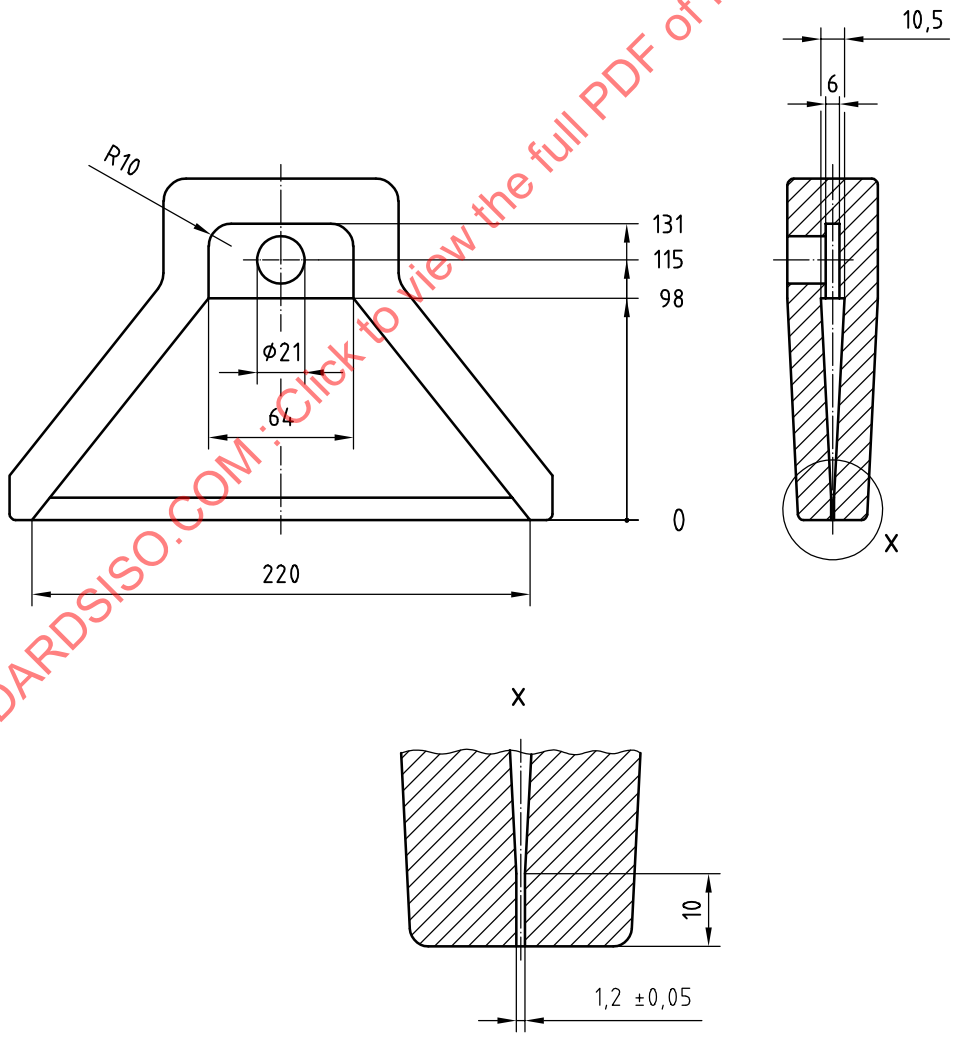
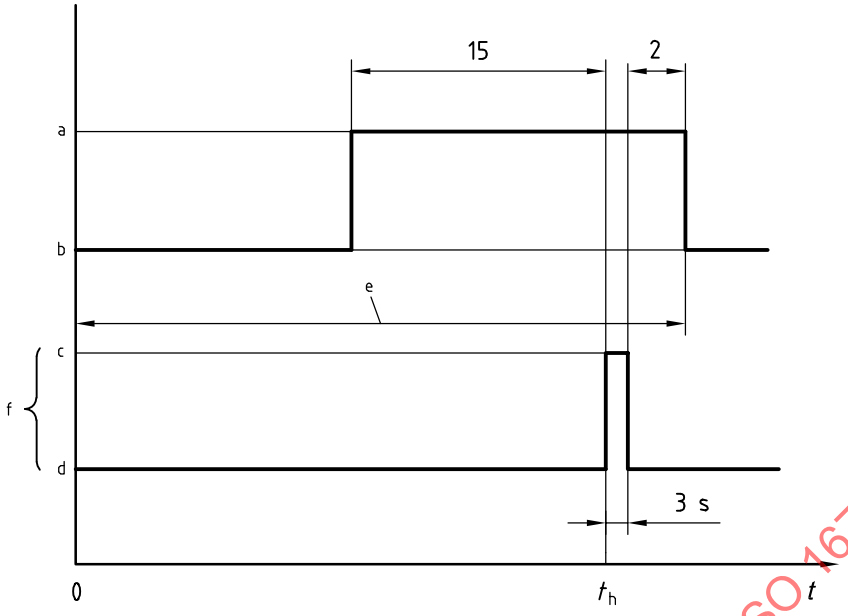


Figure 4 — Splash water method — Jet



Key

t time, min

a Operating mode 3.2 (see ISO 16750-1).

b Operating mode 1.2 (see ISO 16750-1).

c On.

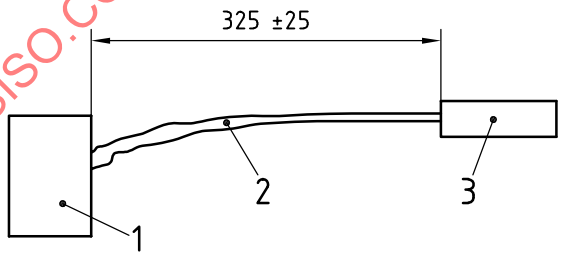
d Off.

e One cycle.

f Splash.

Figure 5 — Splash water method — Test cycle

Dimensions in millimetres



Key

1 DUT

2 splash

3 slot jet

Figure 6 — Splash water method — Test set-up

5.4.2.2 Requirement

The functional status shall be Class A using Operating mode 3.2 in accordance with ISO 16750-1:2003, Clause 5.

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 a cold water tank, at a depth of $\geqslant$ 10 mm. See Table 5.

Table 5 — Submersion test

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; 5 % NaCl may be added
Water temperature	0° C to +4°C
Immersion time	5 min
Operating modes (ISO 16750-1)	3.2
Orientation of DUT	As in the vehicle.

5.4.3.2 Requirement

The functional status shall be Class A as defined in ISO 16750-1:2003, Clause 6.

5.5 Salt spray

5.5.1 Corrosion

5.5.1.1 Purpose

This test is for checking the resistance of materials and surface-coatings of a system/component to salt mist and salt water on streets in winter. It 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 6 and Annex A of this part of ISO 16750. Use Operating mode 1.2 in accordance with ISO 16750-1:2003, Clause 5.

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

5.5.1.3 Requirement

There shall be no changes that could impair normal performance — for example, sealing function; marking and labelling shall remain visible.

The functional status shall be Class C as defined in ISO 16750-1:2003, Clause 6.

5.5.2 Leakage and function

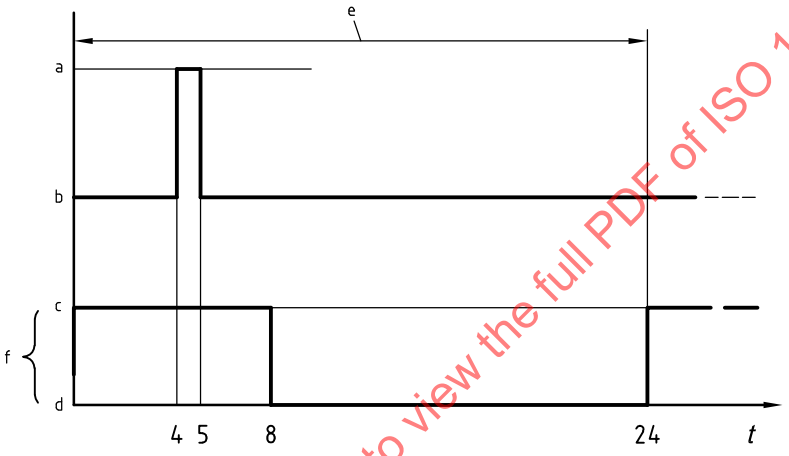
5.5.2.1 Purpose

This test is for checking 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 as shown in Figure 7, based on the test according to IEC 60068-2-11 Ka. The duration of one cycle shall be 24 h. Spray the DUT for 8 h, then stop spraying for a rest period of 16 h. Operate the DUT in Operating mode 3.2 in accordance with ISO 16750-1:2003, Clause 5 between the fourth and fifth hour of each cycle.

Test duration: six cycles = six days min.



Key

t time, h

a Operating mode 3.2 (see ISO 16750-1).

b Operating mode 1.2 (see ISO 16750-1).

c On.

d Off.

e One cycle.

f Salt spray

Figure 7 — Test cycle for salt spray test

5.5.2.3 Requirement

There shall be no intrusion of salt-water into the housing.

Functional status shall be Class A in phases, with Operating mode 3.2 in accordance with ISO 16750-1:2003, Clauses 6 and 5, respectively.

5.6 Humid heat, cyclic

5.6.1 Purpose

This test simulates the use of a system/component under high ambient humidity. The failure modes addressed are electrical malfunctions caused by moisture, for example from leakage current caused by a printed circuit board soaked with moisture. An additional failure mode is a “breathing effect” that transports moisture inside the housing when the air inside the DUT cools down and ambient air with high humidity is drawn into it.

5.6.2 Test

Perform one or the other of the following tests (see Table 6 and Annex A).

— **Damp heat cyclic test**

a) Perform the test according to IEC 60068-2-30 (1980-01) for six cycles, with an upper temperature of + 55 °C and a lower temperature of room temperature, (23 ± 5)°C.

b) Perform a functional test (Operating mode 3.2 in accordance with ISO 16750-1:2003, Clause 5) when the maximum cycle temperature is reached.

— **Composite temperature/humidity cyclic test**

a) Perform the test according to IEC 60068-2-38 for 10 cycles, with a lower temperature of −10 °C.

b) Perform a functional test (Operating mode 3.2 in accordance with ISO 16750-1:2003, Clause 5) when the maximum cycle temperature is reached.

5.6.3 Requirement

The functional status shall be Class A as defined in ISO 16750-1:2003, Clause 6.

5.7 Damp heat, steady-state

5.7.1 Purpose

This test also (see 5.6.1) simulates the use of a system/component under high ambient humidity. Failure mode is electrical malfunction caused by moisture (e.g. leakage current caused by a printed circuit board which is soaked with moisture).

5.7.2 Test

Perform the test according to IEC 60068-2-78 for a duration of 21 days, using an operating mode in accordance with ISO 16750-1:2003, Clause 5 — use Operating mode 2 up to the last hour and Operating mode 3.2 during the last hour.

5.7.3 Requirement

For systems which are powered while the engine is shut off, functional status shall be Class A as defined in ISO 16750-1:2003, Clause 6, during the entire test duration. Other systems shall meet the requirements of functional status Class C up to the last hour and those of Class A for the last hour.