

Classification of environmental conditions —

**Part 4-5: Guidance for the correlation
and transformation of environmental
condition classes of IEC 60721-3 to the
environmental tests of IEC 60068 —
Ground vehicle installations**

ICS 19.040; 19.080

National foreword

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The UK participation in its preparation was entrusted to Technical Committee GEL/104, Environmental conditions, classification and testing, which has the responsibility to:

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Classification des conditions d'environnement –

Partie 4-5:

**Guide pour la corrélation et la transformation
des classes de conditions d'environnement
de la CEI 60721-3 en essais d'environnement
de la CEI 60068 –
Installations des véhicules terrestres**

Classification of environmental conditions –

Part 4-5:

**Guidance for the correlation and transformation
of environmental condition classes of IEC 60721-3
to the environmental tests of IEC 60068 –
Ground vehicle installations**



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

CLASSIFICATION OF ENVIRONMENTAL CONDITIONS –

**Part 4-5: Guidance for the correlation and transformation
of environmental condition classes of IEC 60721-3
to the environmental tests of IEC 60068 –
Ground vehicle installations**

FOREWORD

- 1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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IEC 60721-4-5, which is a technical report, has been prepared by IEC technical committee 104: Environmental conditions, classification and methods of test.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
104/61/CDV	104/111/RVC

Full information on the voting for the approval of this technical report can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 3.

The committee has decided that the contents of this publication will remain unchanged until 2002. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

This document which is purely informative is not to be regarded as an International Standard.

INTRODUCTION

It is essential to emphasise the guidance nature of this report since it is virtually impossible to specify mandatory requirements for worldwide use. However, for those cases which require different tests from those recommended in this report, the guidance given should establish principles and methodology to determine alternative tests.

Transformation guidance is provided where the parameters used to define conditions in IEC 60721-3-5 are different from those used to define the tests and/or the severities in IEC 60068-2.

The reasons for correlation are provided to enable specification writers to modify a test if their application warrants it. Where differences in values of parameters exist between IEC 60721-3-5 and IEC 60068-2, the nearest severities of the IEC 60068-2 test procedures are used. If it is necessary to deviate from an IEC 60068-2 severity, the reasons are detailed in the report and an alternative test is recommended in the tables.

CLASSIFICATION OF ENVIRONMENTAL CONDITIONS –

Part 4-5: Guidance for the correlation and transformation of environmental condition classes of IEC 60721-3 to the environmental tests of IEC 60068 – Ground vehicle installations

1 Scope and object

This part of IEC 60721 is a technical report dealing with the correlation and transformation of the conditions given in IEC 60721-3-5 to the environmental tests defined in IEC 60068-2.

An environment may consist of a number of environmental conditions such as dynamic, climatic and biological and other effects due to chemically and mechanically active substances. In this report, only dynamic and climatic conditions have been considered.

The purpose of this technical report is to provide the specification writer with guidance, together with a set of easy-to-use tables which correlate and transform these conditions.

2 Reference documents

IEC 60068-1:1988, *Environmental testing – Part 1: General and guidance*

IEC 60068-2-1:1990, *Environmental testing – Part 2: Tests – Tests A: Cold*

IEC 60068-2-2:1974, *Environmental testing – Part 2: Tests – Tests B: Dry heat*

IEC 60068-2-5:1975, *Environmental testing – Part 2: Tests – Test Sa: Simulated solar radiation at ground level*

IEC 60068-2-6:1995, *Environmental testing – Part 2: Tests – Test Fc: Vibration (sinusoidal)*

IEC 60068-2-13:1983, *Environmental testing – Part 2: Tests – Test M: Low air pressure*

IEC 60068-2-14:1984, *Environmental testing – Part 2: Tests – Test N: Change of temperature*

IEC 60068-2-18:1989, *Environmental testing – Part 2: Tests – Test R and guidance: Water*

IEC 60068-2-27:1987, *Environmental testing – Part 2: Tests – Test Ea and guidance: Shock*

IEC 60068-2-30:1980, *Environmental testing – Part 2: Tests – Test Db and guidance: Damp heat, cyclic (12 + 12 hour cycle)*

IEC 60068-2-56:1988, *Environmental testing – Part 2: Tests – Test Cb: Damp heat, steady state, primarily for equipment*

IEC 60068-2-64:1993, *Environmental testing – Part 2: Test methods – Test Fh: Vibration, broad-band random (digital control) and guidance*

IEC 60068-2-75:1997, *Environmental testing – Part 2-75: Tests – Test Eh: Hammer tests*

IEC 60721-2-3:1987, *Classification of environmental conditions – Part 2: Environmental conditions appearing in nature – Air pressure*

IEC 60721-2-4:1987, *Classification of environmental conditions – Part 2: Environmental conditions appearing in nature – Solar radiation and temperature*

IEC 60721-3-5:1997, *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 5: Ground vehicle installations*

IEC 60721-4-0, *Classification of environmental conditions – Part 4-0: Guidance for the correlation and transformation of the environmental condition classes of IEC 60721-3 to the environmental tests of IEC 60068 – Introduction*¹⁾

ISO 554:1976, *Standard atmospheres for conditioning and/or testing – Specifications*

ISO 2533:1975, *Standard atmosphere – Addendum 1 (1985), Addendum 2 (1997)*

3 Overview

3.1 General remarks concerning IEC 60721

IEC 60721-3-5 establishes classes of groups of environmental parameters with their associated environmental conditions to which products may be exposed during transportation. Parameters in these classes are given individually, but the products may be exposed to them simultaneously. Some of the parameters are independent whilst others may be strongly correlated, for example, solar radiation and temperature.

3.2 General remarks concerning IEC 60068

IEC 60068-2 establishes a series of environmental test procedures and appropriate test severities. Selection of test severities depends upon the failure consequences of the product. Two types of product may be placed at locations covered by the same environmental class. However, one type of product may be tested under significantly more severe conditions than the other because of its different failure consequences. This report only addresses normal failure consequences; for higher failure consequences the test severity may need to be increased on the basis of specialist knowledge of the product.

¹⁾ To be published.

3.3 Severities

IEC 60721-3-5 establishes classes of environmental conditions, having a low probability of being exceeded, which cover the extreme short-term conditions to which products may be exposed. The suggested test severities given in the tables of this report take this into account. For further information, refer to IEC 60721-4-0, which serves as an introduction to the IEC 60721-4 series.

3.4 Recommended tests

In the following tables two types of test are shown. The first details the equivalent IEC 60068-2 test using the nearest recommended severities. The second is the recommended test method and severities, which are considered to be more suitable for testing most electrotechnical products.

3.5 Environmental tests for ground vehicle installations

The ground vehicle classes specify the environmental conditions to which a product (not forming part of the vehicle) is exposed whilst being used. Environmental conditions created by co-located product within an enclosure are not included in these classes. Although these classes are not designed for products forming part of the vehicle, the environmental conditions may also be used for some exchangeable parts.

The relevant specification should specify when, during the environmental test programme, the product is in its operational state, and which performance requirements should be measured before, during and after the test, together with the failure criteria.

3.6 Test durations

The durations recommended in tables 1 to 5 are selected on the basis that experience has shown them to be sufficient to demonstrate the effect of the condition on most products. However, the user may change these values if experience of specific applications warrants it. To assist the user, the notes associated with the tables in this report explain why the recommended duration was chosen.

3.7 Ambient

The term "ambient" which is used for some recommended tests refers to the standard atmospheric conditions described in 5.3.1 of IEC 60068-1, that is, between 15 °C and 35 °C and from 25 % to 75 % RH with a maximum absolute humidity of 22 g/m³ and at air pressure between 86 kPa and 106 kPa. Details of the standard atmosphere conditions are provided in ISO 2533 and its addenda, whilst a summary is provided in IEC 60721-2-3. A reference condition for testing is described in ISO 554.

4 Climatic conditions

Table 1 – Recommended tests for IEC 60721-3-5 – Class 5K2
(enclosed or partly open, heated or unheated unventilated compartments)

IEC 60721-3-5 – Climatic conditions		IEC 60068-2 – Climatic tests				
Environmental parameter ^a	Class 5K2	Nearest IEC 60068-2		Recommended test		Note No.
		Test method	Severity	Test method	Severity	
a) Low air temperature	–25 °C	As recommended test		60068-2-1: Ab	–25 °C, 16 h	1)
b) High temperature, air in ventilated compartments (except engine compartments) or outdoor air	+40 °C	As recommended test		60068-2-2: Bb	+40 °C, 16 h	2)
c) High temperature, air in unventilated compartments except engine compartments	+70 °C	As recommended test		60068-2-2: Bb	+70 °C, 16h	2)
d) High temperature, air in engine compartments	+70 °C	As recommended test		60068-2-2: Bb	+70 °C, 16 h	2)
e) Change of temperature: air/air	–25 °C +30 °C	As recommended test		60068-2-14: Na	–25 °C to ambient, five cycles $t_1 = 3 \text{ h}$ $t_2 < 3 \text{ min}$	3)
f) Gradual change of temperature, air/air, except engine compartments	–25 °C +30 °C 5 °C/min	60068-2-14: Nb	–25 °C to +30 °C, two cycles 5 °C/min $t_1 = 3 \text{ h}$	Test normally not required – See note 4)		4)
g) Gradual change of temperature, air/air, in engine compartments	–25 °C +60 °C 10 °C/min	60068-2-14: Nb	–25 °C to +60 °C, two cycles 5 °C/min $t_1 = 3 \text{ h}$	60068-2-14: Nb	–25 °C to +60 °C, two cycles 10 °C/min $t_1 = 3 \text{ h}$	5)
h) Change of temperature, air/water, except in engine compartments	No					
i) Change of temperature, air/water, in engine compartments	+60 °C +5 °C	No IEC 60068-2 test		No IEC 60068-2 test		6)
j) Change of temperature, air/snow, in engine compartments	+60 °C –5 °C	No IEC 60068-2 test		No IEC 60068-2 test		6)
k) Relative humidity, not combined with rapid temperature changes, except in engine compartment of vehicles powered by internal combustion engines	95 %, +40 °C	As recommended test		60068-2-56: Cb	40 °C, 93 % RH, 96 h	7)
l) Relative humidity, not combined with rapid temperature changes, in engine compartment of vehicles powered by internal combustion engines	No					
m) Relative humidity, combined with rapid temperature changes: air/air at high relative humidities. Not in close proximity to refrigerated air conditioning systems	95 %, –25 °C +30 °C	As recommended test		Damp heat, steady-state test (test Cb in this table) followed immediately by the rapid change-of-temperature test (test Na)		8)
n) Relative humidity, combined with rapid temperature changes: air/air at high relative humidities. In close proximity to refrigerated air conditioning systems	95 %, +10 °C +70 °C	As recommended test		Damp heat, steady-state test (test Cb in this table) followed immediately by the rapid change-of-temperature test (test Na)		8)

o) Absolute humidity, combined with rapid temperature changes: air/air at high water content.	60 g/m ³ +70 °C +15 °C	As recommended test		60068-2-30: Db Variant 2	+55 °C, 90 % to 100 % RH Two cycles	9)
p) Low relative humidity	10 % +30 °C	No IEC 60068-2 test				10)
q) Low air pressure	70 kPa	60068-2-13: M	70 kPa, 30 min	Test normally not required – See note 11)		11)
r) Movement of surrounding medium, air	20 m/s	No IEC 60068-2 test		Test normally not required – See note 12)		12)
s) Precipitation, rain	No					
t) Solar radiation	700 W/m ²	60068-2-5: Sa Procedure C	1 120 W/m ² , 72 h, 40 °C	Add 10 °C to the dry heat test and evaluate materials for photochemical reactions		13)
u) Radiation: heat, not in engine compartments	600 W/m ²	No IEC 60068-2 test		Test normally not required – See note 14)		14)
v) Radiation: heat, in engine compartments	600 W/m ²	No IEC 60068-2 test		Test normally not required – See note 14)		14)
w) Water from sources other than rain	0,3 m/s	No IEC 60068-2 test		60068-2-18: Ra/Rb	See note 15)	15)
x) Wetness – Conditions of wet surfaces		No IEC 60068-2 test		Test normally not required – See note 16)		16)
NOTE "No" in the class column means that no IEC 60721-3-5 condition is specified.						
^a No climatograms are shown for the climatic classes since they are not included in IEC 60721-3-5.						

Explanatory notes for table 1 – Class 5K2

- 1) The test temperature is equivalent to the environmental parameter of IEC 60721-3-5 for this class; however, the effects of solar irradiation should also be taken into account (see note 13). The choice of the duration of 16 h is considered to be sufficient for most heat-dissipating products to demonstrate that their design is adequately tolerated to function at this temperature.
- 2) The test temperature is equivalent to the environmental parameter of IEC 60721-3-5 for this class. The choice of the duration of 16 h is considered to be sufficient for most heat-dissipating products to demonstrate that their design is adequately tolerated to function at this temperature.
- 3) The change of temperature test is normally used to check design tolerancing and the range is not important. However, in this class, condensation may occur, so a range is proposed which encompasses the lower temperatures in order to promote condensation for low heat-dissipating products. Ambient conditions as described in 3.7 are proposed as the upper temperature to allow the single-chamber method to be used, thus making the test economical to perform.
- 4) The change-of-temperature test is normally used to check design tolerancing and the range is not important. However, in this class, condensation may occur, so a range is proposed which encompasses the lower temperatures in order to promote condensation for low heat-dissipating products. For most products, this condition is not as severe as the rapid temperature change (see table line e)) and so, if the rapid change of temperature test is performed, this test can be omitted.
- 5) The specified IEC 60721 value of rate of change is 10 °C/min; however, the highest preferred value in IEC 60068-2-14 is 5 °C/min; it is recommended that the test value of 10 °C/min be used, according to the environmental parameter.
- 6) No specified IEC 60068-2 test exists. The effect of rapid temperature change which is experienced by products when it either rains or snows in a warm location is partially covered by the change of temperature air/air (test Na), and therefore no additional testing is recommended.
- 7) These severities are the nearest preferred values in IEC 60068-2-5 and the minor change in humidity is considered to be insignificant and within normal measurement tolerances. The duration of 96 h is considered to be sufficient for most heat-dissipating products to demonstrate that their design is adequately tolerated to function at this humidity.
- 8) This condition cannot be practically tested due to constraints of physics. However, it may be approximated by conducting a composite test with the steady-state humidity test followed immediately by the rapid change-in-temperature test, with the pre- and post-conditioning periods omitted between the two tests. By conducting a composite test in this way, the effects of the condition are considered to be adequately demonstrated. If this composite test is performed, the user may decide that the individual tests (see table line e) and k)) may be omitted. This would be particularly recommended if the product is monitored throughout the test.

Explanatory notes for table 1 – Class 5K2 (continued)

- 9) This is the maximum preferred damp heat cyclic test condition and it is considered to be adequate to demonstrate the effects of this condition (the test condition absolute humidity being higher and the temperature lower). The duration of two cycles (48 h) is considered adequate for most products. Variant 2 of test Db is chosen since it adequately tests the condition and is simpler to perform than variant 1.
- 10) No suitable IEC test available in IEC 60068-2 series. The main effects of low relative humidity are embrittlement, shrinking, impairment of mechanical strength, increase in wearing of contact surfaces and development of electrostatic charge. Typical faults caused by drying are mechanical faults of non-metallic parts, cracking and electrical faults. Low relative humidity may attract dust particles, which cause, for example, wearing of contact surfaces. This effect has to be considered when selecting materials and components for products for this class.
- 11) For sealed products or for products containing or processing liquids, test M of IEC 60068-2-13 is recommended. For normal applications where the effect of air pressure is evaluated at the component level, no test is recommended.
- 12) No suitable test exists in IEC 60068-2; however, special precautions should be taken, especially for large products, and the user may have to develop his own methodology if the condition is to be evaluated.
- 13) The IEC 60068-2-5 procedure C test for simulating the effects of solar radiation at ground level is chosen since it produces continuous irradiation, thus allowing assessment of photo-degradation effects. Although the severity of this class is 700 W/m², the only test condition contained in IEC 60068-2-5: Sa is for a solar radiation value of 1 120 W/m².

Solar tests are not considered satisfactory, since it is difficult to replicate the actual radiation experienced in practice. It is recommended that this condition should be evaluated by increasing the temperature of the dry heat test by 10 °C and evaluating materials and components for photochemical reactions. For more information, see IEC 60721-4-0.

Products may be protected against the effect of solar radiation, for example, by the fitting of efficient heat shields, in which case the elevated temperature for the dry heat test can be omitted or reduced in severity depending on the effectiveness of the precautions. It should be normal practice to model such precautions in order to give confidence in the ability of the product to resist the effect of solar radiation.

With this level of solar radiation, surface temperatures may be as high as 25 °C above ambient. Surface temperature can also fall at night due to heat irradiation (see IEC 60721-2-4). These effects should be taken into account when selecting materials and a reduced temperature test should be considered for the low temperature test (test Ab/Ad).

- 14) No test is recommended. There is no IEC 60068-2 test method for this condition. This effect is considered to be included in the dry heat test (see table line c) or d)). For products mounted near sources of high heat radiation, special precautions may be necessary or an additional elevated temperature test may be required.
- 15) The source of water is not given in IEC 60721-3-5. The user will have to select the appropriate test together with the duration and test severity from IEC 60068-2-18. As a guide, the following may assist the user in the selection of a suitable test:
 - a) Dripping water: If the product is normally protected from rain, but likely to be exposed to falling drops from condensation or leakage from upper surfaces, IEC 60068-2-18: Ra 2 – drip box – with a 2 m drop height, a tilt angle of 0°, and a 1 h duration is the preferred method.
 - b) Spraying water: If the product is likely to be exposed to water spray from wheels, IEC 60068-2-18 tests Rb 2.1 – oscillating tube – or Rb 2.2 – hand-held shower – 1 min/m², 30 min maximum, are the preferred methods.
 - c) Splashing water: If the product is likely to be exposed to flushing or sluicing water, IEC 60068-2-18: Rb 3 – hosing – is the preferred method.
 - d) Water jets: If jets of water are likely to strike the product, choose from either IEC 60068-2-18: Ra or Rb test to demonstrate that the product is designed to function under these conditions.
- 16) No test is recommended, no value is available in IEC 60721-3-5 for wet surfaces. The effect of wet surfaces is partially produced by several other tests in this class (see, for example, table line s) rain test) and should be taken into account when selecting materials. It is not possible to give any values to wet surfaces. The effect can be more severe than the effect of rain because it may be continuous, and the oxygen concentration difference increases the corrosion in a surface which is in contact with another surface. This can accelerate electrochemical corrosion reactions, especially if the two surfaces are of different metals.

Table 2 – Recommended tests for IEC 60721-3-5 – Class 5K3
(cold temperate open-air climate. It covers vehicles used in unventilated compartment)

IEC 60721-3-5 – Climatic conditions		IEC 60068-2 – Climatic tests				
Environmental parameter ^a	Class 5K3	Nearest IEC 60068-2		Recommended test		Note No.
		Test method	Severity	Test method	Severity	
a) Low air temperature	–40 °C	As recommended test		60068-2-1: Ab	–45 °C, 16 h	1)
b) High temperature, air in ventilated compartments (except engine compartments) or outdoor air	+40 °C	As recommended test		60068-2-2: Bb	+40 °C, 16 h	2)
c) High temperature, air in unventilated compartments except engine compartments	+70 °C	As recommended test		60068-2-2: Bb	+70 °C, 16 h	2)
d) High temperature, air in engine compartments	+70 °C	As recommended test		60068-2-2: Bb	+70 °C, 16 h	2)
e) Change of temperature: air/air	–40 °C +30 °C	As recommended test		60068-2-14: Na	–40 °C to ambient, five cycles $t_1 = 3 \text{ h}$ $t_2 < 3 \text{ min}$	3)
f) Gradual change of temperature, air/air, except engine compartments	–40 °C +30 °C 5 °C/min	60068-2-14: Nb	–40 °C to +30 °C, two cycles 5 °C/min $t_1 = 3 \text{ h}$	Test normally not required – See note 4)		4)
g) Gradual change of temperature, air/air, in engine compartments	–40 °C +70 °C 10 °C/min	60068-2-14: Nb	–40 °C to +70 °C, two cycles 5 °C/min $t_1 = 3 \text{ h}$	60068-2-14: Nb	–40 °C to +70 °C, two cycles 10 °C/min $t_1 = 3 \text{ h}$	5)
h) Change of temperature, air/water, except in engine compartments	+40 °C +5 °C	No IEC 60068-2 test		Test normally not required – See note 6)		6)
i) Change of temperature, air/water, in engine compartments	+70 °C +5 °C	No IEC 60068-2 test		Test normally not required – See note 6)		6)
j) Change of temperature, air/snow, in engine compartments	+70 °C –5 °C	No IEC 60068-2 test		Test normally not required – See note 6)		6)
k) Relative humidity, not combined with rapid temperature changes, except in engine compartment of vehicles powered by internal combustion engines	95 % +45 °C	As recommended test		60068-2-56: Cb	+40 °C, 93 % RH, 96 h	7)
l) Relative humidity, not combined with rapid temperature changes, in engine compartment of vehicles powered by internal combustion engines	95 % +70 °C	As recommended test		60068-2-56: Cb	+55 °C, 93 % RH, 96 h	8)
m) Relative humidity, combined with rapid temperature changes: air/air at high relative humidities. Not in close proximity to refrigerated air conditioning systems	95 % –40 °C +30 °C	As recommended test		Damp heat, steady-state test (test Cb in this table) followed immediately by the rapid change-of-temperature test (test Na)		9)
n) Relative humidity, combined with rapid temperature changes: air/air at high relative humidities. In close proximity to refrigerated air conditioning systems	95 % +10 °C +70 °C	As recommended test		Damp heat, steady-state test (test Cb in this table) followed immediately by the rapid change-of-temperature test (test Na)		9)