

Classification of environmental conditions —

**Part 4-1: Guidance for the correlation
and transformation of environmental
condition classes of IEC 60721-3 to the
environmental tests of IEC 60068 —
Storage**

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 4-1:

**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 –
Stockage**

Classification of environmental conditions –

Part 4-1:

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



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

CLASSIFICATION OF ENVIRONMENTAL CONDITIONS –

**Part 4-1: Guidance for the correlation and transformation
of environmental condition classes of IEC 60721-3
to the environmental tests of IEC 60068 – Storage**

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 60721-4-1, 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
104/57/CDV	104/107/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.

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

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.

INTRODUCTION

It is essential to emphasize 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 60721-3-1 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 60721-3-1 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 4-1: Guidance for the correlation and transformation of environmental condition classes of IEC 60721-3 to the environmental tests of IEC 60068 – Storage

1 Scope and object

This part of IEC 60721 is a technical report dealing with the correlation and transformation of the condition given in IEC 60721-3-1 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 60068-2-29:1987, *Environmental testing – Part 2: Tests – Test Eb and guidance: Bump*

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

IEC 60721-3-0:1984, *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Introduction*

IEC 60721-3-1:1997, *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 1: Storage*

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 2234:2000, *Packaging – Complete, filled transport packages and unit loads – Stacking tests using static load*

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

ISO 12048:1994, *Packaging – Complete, filled transport packages – Compression and stacking tests using a compression tester*

3 Overview

3.1 General remarks concerning IEC 60721

IEC 60721-3-1 establishes classes of groups of environmental parameters with their associated environmental conditions to which products may be exposed during storage. 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.

3.3 Severities

IEC 60721-3-1 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.

¹⁾ To be published.

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 storage classes

IEC 60721-3-1 classifies groups of environmental parameters and their severities to which products together with their packaging, if any, are subjected when stored. Transfer during storage is not included in the classification.

If possible, the products should be tested in the state in which it is normally stored. For example, if the product is in a packaged state, then it should be tested in its packaging. If the product is stored both with and without its packaging, it may be necessary to perform tests for both configurations. For some tests and products, the test may be more severe for the packaged rather than the unpackaged product. For example, for products in a sealed package, the change of temperature test may produce condensation.

Environmental conditions created by co-located products within an enclosure are not included in this class.

3.6 Test durations

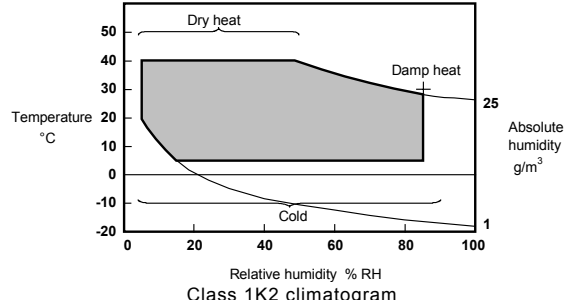
The durations recommended in tables 1 to 8 are selected on the basis that experience has shown them to be sufficient to demonstrate the effect of the condition on most products. However, the user may change these values if experience of a specific application warrants it. To assist the user, the notes 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 atmospheric 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 60721-3-1 – Class 1K2
(temperature-controlled enclosed locations, humidity not controlled)

IEC 60721-3-1 – Climatic conditions		IEC 60068-2 – Climatic tests				
Environmental parameter	Class 1K2	Nearest IEC 60068-2		Recommended test		Note No.
		Test method	Severity	Test method	Severity	
 Class 1K2 climatogram				x) Dry heat 60068-2-2: Bb/Bd y) Cold 60068-2-1: Ab/Ad z) Damp heat 60068-2-56: Cb	+40 °C, 16 h +5 °C, 16 h +30 °C, 85 % RH, 96 h	1), 2) 1), 3) 1), 4)
a) Low air temperature	+5 °C	As recommended test		See above		
b) High air temperature	+40 °C	As recommended test		See above		
c) Low relative humidity	5 %	As recommended test		See above		
d) High relative humidity	85 %	As recommended test		See above		
e) Low absolute humidity	1 g/m³	As recommended test		See above		
f) High absolute humidity	25 g/m³	As recommended test		See above		
g) Rate of change of temperature	0,5 °C/min	60068-2-14: Nb	+5 °C to ambient two cycles 1 °C/min $t_1 = 3\text{ h}$	Test normally not required – See note 5)		5)
h) Low air pressure	70 kPa	60068-2-13: M	70 kPa, 30 min	Test normally not required – See note 6)		6)
i) High air pressure	106 kPa	No IEC 60068-2 test		Test normally not required – See note 7)		7)
j) Solar radiation	700 W/m²	60068-2-5: Sa Procedure C	1 120 W/m², 72 h, 40 °C	Add 10 °C to the dry heat test and evaluate materials for photochemical reactions		8)
k) Heat radiation User selection from 1Z1 or 1Z2		No IEC 60068-2 test		Test normally not required – See note 9)		9)
l) Movement of surrounding air 1 m/s or user selection from 1Z3 or 1Z4		No IEC 60068-2 test		Test normally not required – See note 10)		10)
m) Condensation	No					
n) Precipitation (rain, snow, hail, etc.)	No					
o) Rain intensity	No					
p) Low rain temperature	No					
q) Water from sources other than rain	No					
r) Formation of ice and frost	No					

NOTE "No" in the class column means that no IEC 60721-3-1 condition is specified.

NOTE "No" in the class column means that no IEC 60721-3-1 condition is specified.

Explanatory notes for table 1 – Class 1K2

- 1) A climatogram is shown for information only in order to describe the climatic conditions and associated choice of test. IEC 60721-3-1 does not contain such a climatogram. To test products against the conditions of the climatogram, only three tests are normally used:
 - dry heat test, where the relative humidity shall not exceed 50 % but is not specifically controlled;
 - cold test, where humidity is not controlled;
 - damp heat test steady state, where both temperature and humidity are controlled.

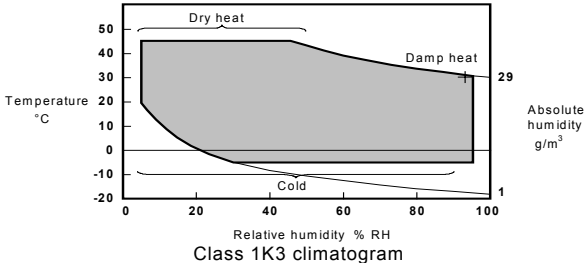
These are shown as tests x, y and z in the table. Other boundary conditions of the climatogram are not required to be tested, and there are no suitable IEC 60068-2 tests available.
- 2) The test temperature is equivalent to the environmental parameter of IEC 60721-3-1 for this class. The choice of the duration of 16 h is considered to be sufficient for most products to demonstrate that its design is adequately tolerated to survive this temperature. Where the thermal effects of solar radiation or heat radiation are to be evaluated (see note 8) below), extend the duration to 72 h for IEC 60068-2-2.
- 3) The test temperature is equivalent to the environmental parameter of IEC 60721-3-1 for this class. Because there are rarely chemical or physical changes in material once low-temperature stabilization has been achieved, the recommended duration of 16 h is considered to be more than adequate for low-temperature testing and this may be reduced to 2 h for small products with low thermal mass.
- 4) These severities are the nearest preferred values in IEC 60068-2, and the minor differences in both temperature and humidity conditions are considered to be insignificant and within normal measurement tolerances. The duration of 96 h is considered to be sufficient to demonstrate that the product's design is adequately tolerated to survive this humidity.
- 5) The change of temperature test is normally used to check design tolerancing and the range is not important. However, in this class, the temperature range is small and condensation is unlikely to occur so it is recommended that, with the possible exception of hermetically sealed products, this test should be omitted.

- 6) For sealed products or for products containing/processing liquids, the 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.
- 7) There is no IEC 60068-2 test method for this condition, which is within the standard range of atmospheric conditions as defined in IEC 60068-1 and is therefore considered benign for most products. No test is recommended.
- 8) 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 Sa test condition contained in IEC 60068-2-5 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 60741-4-0.

- 9) No test is recommended. No value is available in IEC 60721-3-1 for heat radiation and the effect is normally included in the dry heat test. For products mounted near sources of high heat radiation, special precautions such as heat shields or insulation may be necessary or an additional elevated temperature test may be required, the degree of elevation being dependant on the severity of the heat source.
- 10) No test is recommended. No suitable IEC 60068-2 test exists and the condition is considered to be benign for most products. Precautions should be taken, especially for large products, if a special condition (1Z3 or 1Z4) is chosen, and the user may have to develop his own methodology if the condition is to be evaluated.

Table 2 – Recommended tests for IEC 60721-3-1 – Class 1K3
(enclosed locations having neither temperature nor humidity control)

IEC 60721-3-1 – Climatic conditions		IEC 60068-2 – Climatic tests				
Environmental parameter	Class 1K3	Nearest IEC 60068-2		Recommended test		Note No.
		Test method	Severity	Test method	Severity	
 Class 1K3 climatogram		x) Dry heat 60068-2-2: Bb/Bd y) Cold 60068-2-1: Ab/Ad z) Damp heat 60068-2-56: Cb	+40 °C, 16 h –5 °C, 16 h +30 °C, 93 % RH, 96 h	x) Dry heat 60068-2-2: Bb/Bd y) Cold 60068-2-1: Ab/Ad z) Damp heat 60068-2-56: Cb	+45 °C, 16 h –5 °C, 16 h +30 °C, 93 % RH, 96 h	1), 2) 1), 3) 1), 4)
a) Low air temperature	–5 °C	See above		See above		
b) High air temperature	+45 °C	See above		See above		
c) Low relative humidity	5 %	See above		See above		
d) High relative humidity	95 %	See above		See above		
e) Low absolute humidity	1 g/m ³	See above		See above		
f) High absolute humidity	29 g/m ³	See above		See above		
g) Rate of change of temperature	0,5 °C/min	60068-2-14: Nb	+5 °C to ambient two cycles 1 °C/min $t_1 = 3 \text{ h}$	Test normally not required – See note 5)		5)
h) Low air pressure	70 kPa	60068-2-13: M	70 kPa, 30 min	Test normally not required – See note 6)		6)
i) High air pressure	106 kPa	No IEC 60068-2 test		Test normally not required – See note 7)		7)
j) 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		8)
k) Heat radiation User selection from 1Z1 or 1Z2		No IEC 60068-2 test		Test normally not required – See note 9)		9)
l) Movement of surrounding air 1 m/s or user selection from 1Z3 or 1Z4		No IEC 60068-2 test		Test normally not required – See note 10)		10)
m) Condensation	Yes	No IEC 60068-2 test		60068-2-30: Db Variant 2	+40 °C, 90 % to 100 % RH One cycle	11)
n) Precipitation (rain, snow, hail, etc.)	No					
o) Rain intensity	No					
p) Low rain temperature	No					
q) Water from sources other than rain User selection from 1Z5, 1Z6 and 1Z7		No IEC 60068-2 test		60068-2-18:Rb	See note 12)	12)
r) Formation of ice and frost	Yes	No IEC 60068-2 test		Test normally not required – See note 13)		13)
NOTE "No" in the class column means that no IEC 60721-3-1 condition is specified.						

Explanatory notes for table 2 – Class 1K3

- 1) A climatogram is shown for information only in order to describe the climatic conditions and associated choice of test. IEC 60721-3-1 does not contain such a climatogram. To test products against the conditions of the climatogram, only three tests are normally used:
 - Dry heat test, where the relative humidity shall not exceed 50 % but is not specifically controlled;
 - Cold test, where humidity is not controlled;
 - Damp heat test steady state, where both temperature and humidity are controlled.

These are shown as tests x, y and z in the table. Other boundary conditions of the climatogram are not required to be tested, and there are no suitable IEC 60068-2 tests available.

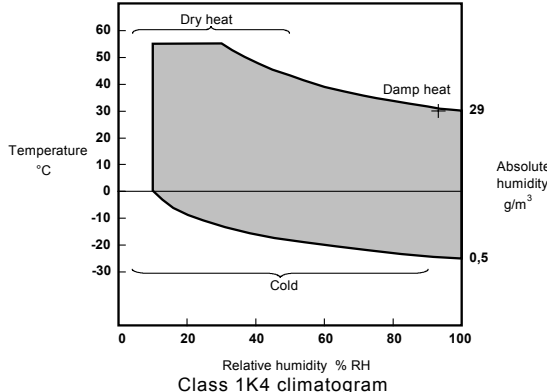
- 2) The test temperature is the nearest preferred value in IEC 60068-2-2. However, it is recommended that the test temperature is increased to +45 °C so as to reflect the conditions of IEC 60721-3-1 for this class. The choice of the duration of 16 h is considered to be sufficient for most products to demonstrate that their design is adequately toleranced to survive this temperature. Where the thermal effects of solar radiation or heat radiation are to be evaluated (see note 8 below), extend the duration to 72 h for IEC 60068-2-2.
- 3) The test temperature is equivalent to the environmental parameter of IEC 60721-3-1 for this class. Because there are rarely chemical or physical changes in material once low-temperature stabilization has been achieved, the recommended duration of 16 h is considered to be more than adequate for low-temperature testing, and this may be reduced to 2 h for small products with low thermal mass.
- 4) These severities are the nearest preferred values in IEC 60068-2, and the minor differences in both temperature and humidity conditions are considered to be insignificant and within normal measurement tolerances. The duration of 96 h is considered to be sufficient to demonstrate that the product's design is adequately toleranced to survive this humidity.
- 5) 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 crosses the 0 °C boundary in order to allow condensation to form for low heat-dissipating products. The specified IEC 60721-3-1 value of rate of change is 0,5 °C/min; however, the lowest preferred value in IEC 60068-2-14 is 1 °C/min which is recommended for products in this class.
- 6) For sealed products or for products containing/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.
- 7) There is no IEC 60068-2 test method for this condition, which is within the standard range of atmospheric conditions as defined in IEC 60068-1 and is therefore considered benign for most products. No test is recommended.

- 8) 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 Sa test condition contained in IEC 60068-2-5 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.

- 9) No test is recommended. No value is available in IEC 60721-3-1 for heat radiation and the effect is normally included in the dry heat test. For products mounted near sources of high heat radiation, special precautions such as heat shields or insulation may be necessary or an additional elevated temperature test may be required, the degree of elevation being dependant on the severity of the heat source.
- 10) No test is recommended. No suitable IEC 60068-2 test exists and the condition is considered as benign for most products. Precautions should be taken, especially for large products if a special condition (1Z3 or 1Z4) is chosen, and the user may have to develop his own methodology if the condition is to be evaluated.
- 11) The recommended test severities are chosen to replicate the effects of typical storage locations. See also note 12).
- 12) If suitable data exists, the user is encouraged to select a condition from 1Z5, 1Z6 and 1Z7. The user will then 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 is likely to be exposed to falling drops from condensation or leakage from upper surfaces, IEC 60068-2-18: Ra 2 – drip box with 2 m drop height, tilt angle 0°, and 1 h duration – is the preferred method.
 - b) Spraying water: if the product is likely to be exposed to water from sprinkler systems or 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 max. – 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: tests Ra or Rb to demonstrate that the product is designed to function under these conditions.
- 13) No suitable test exists in IEC 60068-2 other than the cold test (test Ab/Ad); however, this condition should be considered when designing products for this class.

Table 3 – Recommended tests for IEC 60721-3-1 – Class 1K4
(locations which may have openings directly to the open air, partially weatherprotected)

IEC 60721-3-1 – Climatic conditions		IEC 60068-2 – Climatic tests				
Environmental parameter	Class 1K4	Nearest IEC 60068-2		Recommended test		Note No.
		Test method	Severity	Test method	Severity	
 Class 1K4 climatogram				x) Dry heat 60068-2-2: Bb/Bd y) Cold 60068-2-1: Ab/Ad z) Damp heat 60068-2-56: Cb	+55 °C, 16 h -25 °C, 16 h +30 °C, 93 % RH, 96 h	1), 2) 1), 3) 1), 4)
a) Low air temperature	-25 °C	As recommended test		See above		
b) High air temperature	+55 °C	As recommended test		See above		
c) Low relative humidity	10 %	As recommended test		See above		
d) High relative humidity	100 %	As recommended test		See above		
e) Low absolute humidity	0,5 g/m ³	As recommended test		See above		
f) High absolute humidity	29 g/m ³	As recommended test		See above		
g) Rate of change of temperature	0,5 °C/min	60068-2-14: Nb	-5 °C to ambient two cycles 1 °C/min <i>t</i> ₁ = 3 h	60068-2-14: Nb	-33 °C to ambient two cycles 1 °C/min <i>t</i> ₁ = 3 h	5)
h) Low air pressure	70 kPa	60068-2-13: M	70 kPa, 30 min	Test normally not required – See note 6)		6)
i) High air pressure	106 kPa	No IEC 60068-2 test		Test normally not required – See note 7)		7)
j) Solar radiation	1 120 W/m ²	60068-2-5: Sa Procedure C	1 120 W/m ² , 72 h, 40 °C	Add 15 °C to the dry heat test and evaluate materials for photochemical reactions		8)
k) Heat radiation User selection from 1Z1 or 1Z2		No IEC 60068-2 test		Test normally not required – See note 9)		9)
l) Movement of surrounding air 1 m/s or user selection from 1Z3 or 1Z4		No IEC 60068-2 test		Test normally not required – See note 10)		10)
m) Condensation	Yes	No IEC 60068-2 test		60068-2-30: Db Variant 2	+40 °C, 90 % to 100 % RH One cycle	11)
n) Precipitation (rain, snow, hail, etc.)	Yes	No IEC 60068-2 test		Test normally not required – See note 12)		12)
o) Rain intensity	No					
p) Low rain temperature	No					
q) Water from sources other than rain User selection from 1Z5, 1Z6 and 1Z7		No IEC 60068-2 test		60068-2-18: Rb	See note 13)	13)
r) Formation of ice and frost	Yes	No IEC 60068-2 test		Test normally not required – See note 14)		14)
NOTE "No" in the class column means that no IEC 60721-3-1 condition is specified.						