BS EN 60068-1:2014

BSI Standards Publication

# Environmental testing

## Part 1: General and guidance

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## National foreword

This British Standard is the UK implementation of EN 60068-1:2014. It is identical to IEC 60068-1:2013. It supersedes BS EN 60068-1:1995, which will be withdrawn on 11 November 2016.

The UK participation in its preparation was entrusted to Technical Committee GEL/104, Environmental conditions, classification and testing.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.


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**Compliance with a British Standard cannot confer immunity from legal obligations.**

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EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

# EN 60068-1

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English version

## Environmental testing - Part 1: General and guidance
(IEC 60068-1:2013)

Essais d'environnement -
Partie 1: Généralités et lignes directrices
(CEI 60068-1:2013)

Umgebungseinflüsse -
Teil 1: Allgemeines und Leitfaden
(IEC 60068-1:2013)

This European Standard was approved by CENELEC on 2013-11-11. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

**CEN-CENELEC Management Centre: Avenue Marnix 17, B - 1000 Brussels**

## Foreword

The text of document 104/618/FDIS, future edition 7 of IEC 60068-1, prepared by IEC/TC 104 "Environmental conditions, classification and methods of test" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 60068-1:2014.

The following dates are fixed:

| | | |
|---|---|---|
| – latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement | (dop) | 2014-09-21 |
| – latest date by which the national standards conflicting with the document have to be withdrawn | (dow) | 2016-11-11 |

This document supersedes EN 60068-1:1994.

EN 60068-1:2014 includes the following significant technical changes with respect to EN 60068-1:1994:

– updated normative reference list;

– indication of normative and informative annexes;

– new informative Annex C, *Environmental test tailoring*.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

## Endorsement notice

The text of the International Standard IEC 60068-1:2013 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

| | | |
|---|---|---|
| IEC 60068-2-14 | NOTE | Harmonized as EN 60068-2-14. |
| IEC 60068-2-20 | NOTE | Harmonized as EN 60068-2-20. |
| IEC 60068-2-27 | NOTE | Harmonized as EN 60068-2-27. |
| IEC 60068-2-38 | NOTE | Harmonized as EN 60068-2-38. |
| IEC 60068-3-1 | NOTE | Harmonized as EN 60068-3-1. |
| IEC 60529 | NOTE | Harmonized as EN 60529. |
| IEC 60721 | NOTE | Harmonized in EN 60721 series (not modified). |

# Annex ZA
(normative)

## Normative references to international publications with their corresponding European publications

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

| Publication | Year | Title | EN/HD | Year |
|---|---|---|---|---|
| IEC 60068-2 | series | Environmental testing<br>Part 2: Tests | EN 60068-2 | series |

## CONTENTS

# INTRODUCTION

The IEC 60068 series contains fundamental information on environmental testing procedures and severities of tests. In addition, this Part 1 contains information on atmospheric conditions for measurement and testing.

It is intended to be used in those cases where a relevant specification for a certain type of product (electrical, electromechanical or electronic equipment and devices, their subassemblies and constituent parts and components), hereinafter referred to as the "specimen", is to be prepared, so as to achieve uniformity and reproducibility in the environmental testing of this product.

NOTE 1 Although primarily intended for electrotechnical products, many of the environmental testing procedures in Part 2 of this series are equally applicable to other industrial products.

The expression "environmental conditioning" or "environmental testing" covers the natural and artificial environments to which specimens may be subjected and exposed to in practice so that an assessment can be made of their performance under conditions of storage, transportation, installation and use.

The requirements for the performance of specimens subjected to environmental conditioning are not covered by this standard. The relevant specification for the specimen under test defines the allowed performance limits during and after environmental testing.

When drafting a relevant specification or purchasing contract, only those tests should be specified that are necessary for the relevant specimen, taking into account the technical and economic aspects.

The IEC 60068 series consists of:

a) this first part, IEC 60068-1 – *General and guidance*, which deals with generalities;
b) the second part, IEC 60068-2 – *Tests* – which publishes particular tests separately for different applications;
c) the third part, IEC 60068-3 – *Supporting documentation and guidance*, which deals with background information on a family of tests.

The families of tests comprising Part 2 of the IEC 60068 series are designated by the following upper-case letters:

A: Cold
B: Dry heat
C: Damp heat (steady-state)
D: Damp heat (cyclic)
E: Impact (for example shock and rough handling shocks)
F: Vibration
G: Acceleration (steady state)
H: (Awaiting allocation)

NOTE 2 Originally allotted to storage tests.

J: Mould growth
K: Corrosive atmospheres (for example salt mist)
L: Dust and sand
M: Air pressure (high or low)
N: Change of temperature

P: (Awaiting allocation)

NOTE 3 Originally allotted to “flammability”.

Q: Sealing (including panel sealing, container sealing and protection against ingress and leakage of fluid)

R: Water (for example rain, dripping water)

S: Radiation (for example solar, but excluding electromagnetic)

T: Soldering (including resistance to heat from soldering)

U: Robustness of terminations (of components)

V: (Awaiting allocation)

NOTE 4 Originally allocated to “acoustic noise” but “vibration, acoustically induced” will now be Test Fg, one of the “vibration” family of tests.

W: (Awaiting allocation)

Y: (Awaiting allocation)

The letter X is used as a prefix together with a second lower-case letter providing for extension of the list of families of tests, e.g. Test Xa: Immersion in cleaning solvents. The letter Z is used to denote combined tests and composite tests as follows: Z is followed by a solidus (slash) and a group of lower-case letters relating to the combined or composite stresses, for example Test Z/am: Combined cold and low air pressure tests.

If appropriate, a test may be designated as “primarily intended for components” or “primarily intended for equipment”.

To provide for future expansion within a family of tests and to maintain consistency of presentation, each family of tests may be subdivided. The subdivisions are identified by the addition of a (lower-case) second letter, for example:

U: Robustness of terminations and integral mounting devices

Test Ua: Subdivided as Test $Ua_1$: Tensile; and Test $Ua_2$: Thrust

Test Ub: Bending

Test Uc: Torsion

Test Ud: Torque

This subdivision is made even though only one test is published and no further tests are immediately contemplated in the relevant family.

In order to avoid confusion with numbers, the letters i, I, o and O are not used.

# ENVIRONMENTAL TESTING –

# Part 1: General and guidance

## 1 Scope

The IEC 60068 series includes a series of methods for environmental testing along with their appropriate severities, and prescribes various atmospheric conditions for measurements and tests designed to assess the ability of specimens to perform under expected conditions of transportation, storage and all aspects of operational use.

Although primarily intended for electrotechnical products, this standard is not restricted to them and may be used in other fields where desired.

Other methods of environmental testing, specific to the individual types of specimen, may be included in the relevant specifications.

The framework of environmental test tailoring process is given in order to assist the production of test specifications with appropriate tests and test severities.

The IEC 60068 series provides a series of uniform and reproducible environmental, climatic, dynamic and combined tests, performed and measured under standard atmospheric conditions, for those preparing specifications and those engaged in the testing of products.

These test methods are based upon available international engineering experience and judgement and are primarily designed to provide information on the following properties of specimens:

a) the ability to operate within specified limits of temperature, pressure, humidity, mechanical stress or other environmental conditions and combinations of these conditions;
b) the ability to withstand conditions of transportation, storage and installation.

NOTE 1 The IEC 60721 series provides a system for classification of environmental conditions and gives relevant definitions.

The tests in this standard permit the comparison of the performance of sample products. To assess the quality or useful life of a given production lot, the test methods should be applied in accordance with a suitable sampling plan and may be supplemented by appropriate additional tests, if necessary.

NOTE 2 ISO defines “quality” as the degree to which a set of inherent characteristics fulfils requirements..

NOTE 3 "Useful life": under given conditions, the time interval beginning, at a given instant of time, and ending when the failure intensity becomes unacceptable or when the item is considered unrepairable as a result of a fault.

To provide tests appropriate to the different intensities of an environmental condition, some of the test procedures have a number of degrees of severity. These different degrees of severity are obtained by varying the time, temperature, air pressure or some other determining factor, separately or in combination.

As the tests and their degrees of severity should be based on real environmental conditions that a particular specimen might encounter, the framework and the necessary phases for the environmental test tailoring process are provided. The test tailoring process may be used to produce the required relevant test specification for the particular specimen.

## 2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60068-2 (all parts), *Environmental testing – Tests*

## 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

NOTE Tests covered by this standard may, in themselves, consist of a series of operations in order to determine the effect of such a test, or series of tests, on a specimen.

**3.1**
**test**
complete series of operations implied by its title, normally comprising the following operations, if required:

a) pre-conditioning;
b) initial examination and measurements;
c) testing;
d) recovery;
e) final examination and measurements.

Note 1 to entry: Intermediate measurements may be required during conditioning and/or recovery.

Note 2 to entry: When the temperature and humidity for conditioning of a specimen for measurement are the same as those prescribed for pre-conditioning, the pre-conditioning and conditioning may be merged, and the pre-conditioning may be said to take the place of conditioning for measurement.

**3.2**
**pre-conditioning**
treatment of a specimen with the object of removing, or partly counteracting, the effects of its previous history

Note 1 to entry: Where pre-conditioning is called for, it is the first process in the test procedure.

Note 2 to entry: Pre-conditioning may be affected by subjecting the specimen to climatic, electrical, or any other conditions required by the relevant specification in order that the properties of the specimen may be stabilized before measurement and test.

**3.3**
**testing**
**e**xposure of a specimen to environmental conditions in order to determine the effect of such conditions on the specimen

**3.4**
**recovery**
treatment of a specimen, after conditioning, in order that the properties of the specimen may be stabilized before measurement

**3.5**
**specimen**
product designated to be tested in accordance with the procedures of the IEC 60068 series

Note 1 to entry: The term “specimen” includes any auxiliary parts or systems that are integral functional features of the specimen, for example systems for cooling and heating.

**3.6**
**heat-dissipating specimen**
specimen with the hottest point on its surface, measured in free air conditions and under the air pressure as specified in 4.3, more than 5 K above the ambient temperature of the surrounding atmosphere after thermal stability has been reached

Note 1 to entry: Measurements required to prove that a specimen can be classified as either heat-dissipating or non-heat-dissipating can be made under standard atmospheric conditions for measurement and tests if care has been taken that no outside influence (for example draughts or sunlight) affects the measurements. In the case of large or complicated specimens, it may be necessary to make measurements at several points.

**3.7**
**air conditions**
conditions within an infinite space where the movement of the air is affected only by the heat-dissipating specimen itself

**3.8**
**relevant specification**
set of requirements to be satisfied by a specimen, indicating the method(s) necessary to determine whether the requirements given are satisfied

**3.9**
**ambient temperature**
temperature of the air (further defined in 3.9.1 and 3.9.2)

Note 1 to entry: In applying these definitions, guidance should be sought from IEC 60068-3-1.

**3.9.1**
**non-heat-dissipating specimens**
temperature of the air surrounding the specimen

**3.9.2**
**heat-dissipating specimens**
temperature of the air in free air conditions at such a distance from the specimen that the effect of the dissipation is negligible

Note 1 to entry: In practice, the ambient temperature is taken as the average of temperatures measured at a number of points in a horizontal plane situated between 0 mm and 50 mm below the specimen, at half the distance between the specimen and the wall of the chamber, or at 1 m distance from the specimen, whichever is less. Suitable precautions should be taken to avoid heat radiation affecting these measurements.

**3.10**
**surface temperature**
case temperature
temperature measured at one or more specified points on the surface of the specimen

**3.11**
**thermal stability**
state when the temperatures of all parts of the specimen are within 3 K, or as otherwise prescribed by the relevant specification, of their final temperature

Note 1 to entry: For non-heat-dissipating specimens, the final temperature will be the mean (in time) temperature of the chamber in which the specimen is placed. For heat-dissipating specimens, it is necessary to make repeated measurements to determine the interval of time for the temperature to change 3 K, or as otherwise prescribed by the relevant specification. Thermal stability has been reached when the ratio between two consecutive time intervals exceeds 1,7.

Note 2 to entry: Where the thermal time constant of the specimen is short compared with the duration of the exposure to a given temperature, no measurement is needed. Where the thermal time constant of the specimen is of the same order as the duration of the exposure, checks should be made to ascertain that

a) non-heat-dissipating specimens are within the required limit of the mean (in time) ambient temperature,

b) for heat-dissipating specimens the ratio between two consecutive time intervals exceeds 1,7 when repeated measurements are made to determine the interval of time required for the temperature to change by 3 K, or as otherwise prescribed by the relevant specification.

IEC 60068-3-1 gives background information on the testing of specimens with and without heat-dissipation.

Note 3 to entry: In practice, it may not be possible to make direct measurements of the internal temperature of the specimen. A check may then be made by measuring some other parameter which is temperature-dependent and for which the temperature dependence is known.

**3.12**
**chamber**
enclosure or space in some part of which the specified conditions can be achieved

**3.13**
**working space**
part of the chamber in which the specified conditions can be maintained within the specified tolerances

**3.14**
**combined test**
tests during which a specimen is subjected simultaneously to two or more environmental influences

Note 1 to entry: Tests with a simultaneous influence of a) temperature and humidity; b) temperature, humidity and a specific (including chemically active) medium; and c) temperature and solar radiation, are not related to combined tests.

Note 2 to entry: Combined tests, as a rule, are used to provide simultaneous climatic and mechanical influences.

Note 3 to entry: Measurements are usually taken at the start and at the end of the test.

**3.15**
**composite test**
test in which the specimen is exposed to two or more test environments in close succession

Note 1 to entry: The intervals of time between the exposures to different test environments are defined precisely since they may have a significant effect on the specimen.

Note 2 to entry: Pre-conditioning, recovery or stabilization periods are usually not included between each exposure.

Note 3 to entry: Measurements are usually taken prior to the start of the first exposure and at the conclusion of the last exposure.

**3.16**
**sequence of tests**
sequence in which the specimen is exposed successively to two or more test environments

Note 1 to entry: The durations of interval between the exposures to different test environments are such that they normally have no significant effect on the specimen.

Note 2 to entry: Pre-conditioning and recovery periods are usually performed between the different exposures.

Note 3 to entry: Measurements are usually taken before and after each exposure, the final measurement of one test being the initial measurement of the next.

**3.17**
**reference atmosphere**
atmosphere to which values measured under any other conditions are corrected by calculation

**3.18**
**referee measurements**
measurements repeated under closely controlled atmospheric conditions when the correction factors to adjust atmospheric-sensitive parameters to their standard reference atmosphere

values are unknown, and measurements under the recommended range of ambient atmospheric conditions are unsatisfactory

**3.19**
**conditioning (of a specimen for measurement)**
subjection of the specimen to an atmosphere of a specified relative humidity, or complete immersion in water or other liquid, at a specified temperature for a specified period of time

Note 1 to entry: According to circumstances, the space used for conditioning of a specimen for measurement may be a whole laboratory room in which the specified conditions are maintained within the prescribed tolerances, or a special chamber.

**3.20**
**environmental test tailoring**
process of producing testing procedures and test specifications on the basis of actual field conditions encountered by the particular specimen, derived from measurements, literature or other relevant sources and reduced and transformed so that it can be used for a test specification

Note 1 to entry: The environmental test tailoring process described in this standard is given in a general form in order to give a framework for consistent flow of information.

Note 2 to entry: There are various methods and practices for test tailoring and care should be taken to ensure the consistent tailoring process with compatible analysis methods and test procedures.

Note 3 to entry: In practice, it may not be possible to obtain reliable data, e.g. from literature, or to make measurements of the physical parameters of the specimen and its environment. Numerical simulation may be used to determine the environmental conditions and product responses needed to be used for the derivation of the test specifications. In particular, simulation may be valuable for the determination of product subassembly and constituent part and component level environmental conditions.

Note 4 to entry: For the specifications derived from the environmental test tailoring process, the tests and severities of this standard should be used. Other test procedures and test severities may be used only if reliable technical and/or proven economical benefits are found. In this case, the reasoning of the diversion from the standard tests should be included in the specification.

Note 5 to entry: With environmental test tailoring, it is not essential to reproduce the environmental conditions, only the critical failure mechanisms.

Note 6 to entry: If acceleration factors are used, they should always be chosen so as to avoid the introduction of mechanisms of failure which differ from those occurring in service, storage, or transportation.

Note 7 to entry: With environmental test tailoring, checks should be made to ascertain:

a) specimen life cycle profile;

b) critical failure mechanisms;

c) proper acceleration factors;

d) proper specimen modelling.

**3.21**
**quality**
ability of a product or a service to satisfy user's need

**3.22**
**useful life**
under given conditions, the time interval of the beginning, at a given instance of time, and ending when the failure intensity becomes unacceptable or when the item is considered unrepeatable as a result of a fault

## 4 Standard atmospheric conditions

### 4.1 Standard reference atmosphere

– temperature: 20 °C;
– air pressure: 101,3 kPa (1 013 mbar).

NOTE No requirement for relative humidity is given because correction by calculation is generally not possible.

If the parameters to be measured depend on temperature and/or pressure, and the law of dependence is known, the values shall be measured under the conditions specified in 4.3 and, if necessary, corrected by calculation to the standard reference atmosphere above.

### 4.2 Standard atmospheres for referee measurements and tests

If the parameters to be measured depend on temperature, pressure and humidity, and the law of dependence is unknown, the atmospheres to be specified shall be selected from Table 1.

**Table 1 – Standard atmospheres for referee measurements and tests**

| **Temperature** °C | | | **Relative humidity** [a] % | | **Air pressure** [a] | |
|---|---|---|---|---|---|---|
| **Nominal value** | **Close tolerance** | **Wide tolerance** | **Close range** | **Wide range** | kPa | mbar |
| 20 | ±1 | ±2 | 63 to 67 | 60 to 70 | 86 to 106 | (860 to 1 060) |
| 23 | ±1 | ±2 | 48 to 52 | 45 to 55 | 86 to 106 | (860 to 1 060) |
| 25 | ±1 | ±2 | 48 to 52 | 45 to 55 | 86 to 106 | (860 to 1 060) |
| 27 | ±1 | ±2 | 63 to 67 | 60 to 70 | 86 to 106 | (860 to 1 060) |

NOTE 1 The above values include those published in this standard as well as those given in ISO 554 and ISO 3205.

NOTE 2 The value of 25 °C is included primarily because of its interest for the testing of semiconductor devices and integrated circuits (It does not appear in ISO 554 and ISO 3205).

NOTE 3 The close tolerances may be used for the referee measurements. The wider tolerances may be used only when allowed by the relevant specification.

NOTE 4 The relative humidity may be disregarded when it has no influence on the test results.

[a] Inclusive values.

### 4.3 Standard atmospheric conditions for measurements and tests

The standard range of atmospheric conditions for carrying out measurements and tests is shown in Table 2.

**Table 2 – Standard atmospheres for measurements and tests**

| Temperature [a] °C | Relative humidity [a] % | Air pressure [a] |
|---|---|---|
| 15 to 35 | 25 to 75 | 86 kPa to 106 kPa (860 mbar to 1 060 mbar) |
| [a] Inclusive values. | | |

Variations in temperature and humidity should be kept to a minimum during a series of measurements carried out as a part of one test on one specimen.

NOTE 1 For large specimens or in test chambers where it is difficult to maintain the temperature within the limits specified above, the range may be extended beyond these limits either down to 10 °C or up to 40 °C, when allowed by the relevant specification. Absolute humidity should not exceed 22 g/m$^3$.

Where the relevant specification recognizes that it is impracticable to carry out measurements in standard atmospheric conditions, a note stating the actual conditions shall be added to the test report.

NOTE 2 The relative humidity may be disregarded when it has no influence on the results of the test.

## 4.4 Recovery conditions

### 4.4.1 General

After the conditioning period and before making the final measurements, the specimens should be allowed to stabilize at the ambient temperature. Measurements shall be made after stabilization.

The “controlled recovery conditions” shall be applied if the electrical parameters to be measured are affected by absorbed humidity or by surface conditions of the specimens and if such parameters change rapidly, for example if the insulation resistance rises considerably within approximately 2 h after removal of the specimens from a humidity chamber.

If the electrical parameters of the specimens affected by absorbed humidity or surface conditions do not vary rapidly, recovery may be carried out in the conditions of standard atmospheric conditions for tests and measurements.

If recovery and measurements are performed in separate chambers, the combination of temperature and humidity conditions shall be such that condensation on the surface of the specimens does not occur when the specimen is transferred to the measurement chamber.

Most of the tests of IEC 60068-2 give the appropriate recovery conditions and duration. These conditions shall apply, unless otherwise prescribed by the relevant specification.

### 4.4.2 Controlled recovery conditions

NOTE 1 Controlled recovery conditions are also referred to as "standard recovery conditions".

The controlled recovery conditions are as follows:

– temperature: actual laboratory temperature ± 1 °C provided that it is within the limits specified in 4.3, between +15 °C and +35 °C;
– relative humidity: between 73 % and 77 %;
– air pressure: between 86 kPa and 106 kPa (860 mbar and 1 060 mbar);
– recovery period: to be stated in the relevant specification if different from that given in the appropriate method of test of IEC 60068-2.

If, for specific cases, different recovery conditions are necessary, they shall be prescribed by the relevant specification.

NOTE 2 These controlled recovery conditions may also be used for pre-conditioning.

#### 4.4.3 Recovery procedure

The specimen shall be placed in the recovery chamber (if a separate chamber is necessary) within 10 min of the completion of conditioning. Where the relevant specification requires measurements to be made immediately after the recovery period, these measurements shall be completed within 30 min of removal from the recovery chamber. Those characteristics which are expected to change most rapidly after the specimen is removed from the recovery atmosphere shall be measured first.

In order to prevent moisture being absorbed or lost by the specimen when removed from the recovery chamber, the temperature of the recovery chamber shall not deviate from the laboratory ambient temperature by more than 1 °C. This necessitates the use of a chamber having good thermal conductivity in which the relative humidity can be closely controlled.

### 4.5 Standard conditions for assisted drying

Where assisted drying is required before commencing a series of measurements, the conditions in Table 3 shall be used for 6 h, unless otherwise prescribed by the relevant specification.

**Table 3 – Standard conditions for assisted drying**

| **Temperature**<br>°C | **Relative humidity**<br>% | **Air pressure** [a] |
|---|---|---|
| 55 ± 2 | Not exceeding 20 | 86 kPa to 106 kPa<br>(860 mbar to 1 060 mbar) |
| [a] Inclusive values. | | |

If it is impracticable to carry out assisted drying under the standard conditions for assisted drying, a note stating the actual conditions shall be added to the test report.

When the specified temperature for the dry heat test is lower than 55 °C, the assisted drying shall be carried out at that lower temperature.

## 5 Use of test methods

As prescribed by the relevant specification test methods may be used for type approval, qualification, quality conformance or any related purposes.

## 6 Climatic sequence

In order to have available for use when required a sequence of climatic tests primarily intended for components, the cold, dry heat, low air pressure and damp heat cyclic conditioning are regarded as interdependent and are referred to as the “climatic sequence”. The order in which these conditionings shall be carried out is as follows:

– dry heat;
– damp heat, cyclic (first cycle of test Db with the upper temperature of 55 °C);
– cold;
– low air pressure (if required);

– damp heat, cyclic (remaining cycles of test Db with the upper temperature of 55 °C).

An interval of not more than three days is permitted between any two of these conditionings except for the interval between the first cycle of the damp heat cyclic conditioning and the cold conditioning when the interval shall be not more than 2 h, including recovery. Measurements are normally made only at the commencement and conclusion of the climatic sequence, except when prescribed during conditioning.

## 7 Component climatic category

Where it is desired to adopt a system of component climatic classification, it shall be based on the general principles contained in Annex A. The common part of all systems shall be the climatic categories.

## 8 Application of tests

General guidance on environmental testing is given in Annex B.

The relevant specification shall prescribe whether tests are to be carried out on specimens in the “energized” or “non-energized” condition. The relevant specification may also, when applicable, prescribe that testing shall be carried out on “packed” specimens if a transport case is considered to be a part of the specimen.

When the sizes and/or weights of specimens are such that testing of the complete specimens is not justified or practicable, the necessary information may be obtained by testing major subassemblies separately. Details of the procedures to be followed shall be given in the relevant specification.

NOTE This procedure is applicable only to those cases where the subassemblies are not subject to mutual influence(s) unless such influences are taken into account.

## 9 Significance of the numerical value of a quantity

### 9.1 General

The numerical values of quantities for the various parameters (temperature, humidity, stress, duration, etc.) given in IEC 60068-2 are expressed in different ways according to the needs of each individual test.

The two cases which most frequently arise are

a) the quantity is expressed as a nominal value with a tolerance,
b) the quantity is expressed as a range of values.

For these two cases, the significance of the numerical value is discussed below.

### 9.2 Quantity expressed as nominal value with tolerance

Examples of two forms of presentation:

a) $(40 \pm 2)$ °C
   $(2 \pm 0,5)$ s
b) $(93^{+2}_{-3})$ % RH

The expression of a quantity as a numerical value indicates the intention that the test should be carried out at the stated value. The object of stating tolerances is to take account of, in particular, the following factors:

– difficulties in adjusting some regulating devices and of their drift (undesired slow variation) during the test;
– instrumental errors;
– non-uniformity of environmental parameters, for which no specific tolerances are given, in the working space in which the specimens under test are located.

These tolerances are not intended to allow latitude in the adjustment of the values of the parameters within the test space. Hence, when a quantity is expressed by a nominal value with a tolerance, the test apparatus shall be adjusted so as to obtain this nominal value making allowance for instrumental errors.

In principle, the test apparatus shall not be adjusted to maintain a limiting value of the tolerance zone, even if its inaccuracy is so small as to ensure that this limiting value would not be exceeded.

If the quantity is expressed numerically as 100 ± 5, the test apparatus should be adjusted to maintain a target value of 100, making allowance for instrumental errors and should in no case be adjusted to maintain a target value of 95 or 105.

In order to avoid exceeding any limiting value applicable to the specimen during the carrying out of the test, it may be necessary in some cases to set test apparatus near to one tolerance limit.

In the particular case where the quantity is expressed by a nominal value with a unilateral tolerance (which is generally deprecated unless justified by special conditions, for example a non-linear response), the test apparatus should be set as close as possible to the nominal value (which is also a tolerance limit) taking into account the inaccuracy of measurement, which depends on the apparatus used for the test (including the instruments used to measure the values of the parameters).

If the quantity is expressed numerically as $100\,^{0}_{-5}$ and the test apparatus is capable of an overall inaccuracy in the control of the parameter of ±1, then the test apparatus should be adjusted to maintain a target value of 99. If, on the other hand, the overall inaccuracy is ±2,5, then the adjustment should be to maintain a target value of 97,5.

### 9.3 Quantity expressed as a range of values

EXAMPLE

– from 15 °C to 35 °C;
– relative humidity from 80 % to 100 %;
– from 1 h to 2 h.

NOTE The use of words in expressing a range may lead to ambiguity, for example “from 80 % to 100 %” may, for some readers, exclude the values 80 and 100 whilst for others they may be included.

The use of symbols, for example “>80” or “≥80” is generally less likely to be ambiguous and is therefore to be preferred.

The expression of a quantity as a range of values indicates that the value to which the test apparatus is adjusted has only a small influence on the result of the test.

Where the inaccuracy of the control of the parameter (including instrumental errors) permits, any desired value within the given range may be chosen. For example, if it is stated that the temperature shall be from 15 °C to 35 °C, any value within this range can be used (but it is not intended that the temperature should be programmed to vary over the range). In fact, the writer of the test intends that it should be carried out at normal ambient temperature.

# Annex A
(normative)

## Component climatic category

The very large number of possible combinations of tests and severities may be reduced by the selection of a few standard groupings in the relevant specification.

To provide a reasonable basic code which will indicate generally the climatic conditions for which components are suitable, the following is recommended.

The category is indicated by a series of three groups of digits separated by oblique strokes corresponding respectively to the temperature in the cold test and that in the dry heat test, and the number of days of exposure to damp heat (steady state) the components will withstand, as follows:

– First set: two digits denoting the minimum ambient temperature of operation (cold test). Where the temperature requires the use of only one digit, it shall be prefixed by the figure "0" for a negative temperature or the symbol "+" for a positive temperature to make up the two-character group.
– Second set: three digits denoting the maximum ambient temperature of operation (dry heat test). Where the temperature requires the use of only two digits, they shall be prefixed by the figure "0" to make up the three-digit group.
– Third set: two digits denoting the number of days of the damp heat, steady-state test (Test Ca). Where the duration requires the use of only one digit, it shall be prefixed by the figure "0" to make up the two-digit group. The figures "00" shall be used to indicate that the component is not required to be exposed to damp heat (steady state).

In order to belong to a given category, components shall comply with the requirements of the relevant specification when subjected to the whole set of tests prescribed for their category.

To belong to the category 55/100/56, a component shall comply with the requirements of at least a), b) and c):

| | |
|---|---|
| a) Cold | –55 °C |
| b) Dry heat | +100 °C |
| c) Damp heat (steady state) | 56 days |

To belong to the category 25/085/04, a component shall comply with the requirements of at least d), e) and f):

| | |
|---|---|
| d) Cold | –25 °C |
| e) Dry heat | +85 °C |
| f) Damp heat (steady state) | 4 days |

To belong to the category 10/070/21, a component shall comply with the requirements of at least g), h) and i):

| | |
|---|---|
| g) Cold | –10 °C |
| h) Dry heat | +70 °C |
| i) Damp heat (steady state) | 21 days |

To belong to the category +5/055/00, a component shall at least comply with the requirements of j) and k):

| | |
|---|---|
| j) Cold | +5 °C |
| k) Dry heat | +55 °C |
| l) Damp heat (steady state) | No requirement |

# Annex B
(informative)

# General guidance

## B.1 General

Environmental testing is intended to demonstrate, with some degree of assurance, that a specimen will survive and perform under specified environmental conditions, either by simulating the real environmental conditions or by reproducing their effects.

The test methods of IEC 60068-2 have the following aims:

– to determine the suitability of a specimen for storage, transportation and operation under specific environmental conditions, taking account of its expected useful life;
– to provide information about the quality of a design or a tested product.

The selection from IEC 60068-2 of the severity of a method of test, or even, in part, the choice of the test itself, that will correspond with a given environmental stress can be difficult. Although it is not possible to give a rule universally valid for all specimens relating test conditions to real environmental conditions, it is nevertheless possible, in most cases, to establish such relations.

Consequently, IEC 60068-1 is restricted to an enumeration of the essential points which need to be taken into consideration when choosing a test and test severities. It should be stressed that the order or sequence in which tests are carried out on a specimen can be important.

For some tests, specific guidance is to be found in the individual standards of IEC 60068-2.

## B.2 Basic considerations

When there is a requirement for environmental testing, the test methods of IEC 60068-2 should always be used, unless there is no appropriate test available. The reasons are the following:

a) Full compliance with a test method of IEC 60068-2 is necessary to achieve the intended repeatability and reproducibility defined in the International Electrotechnical Vocabulary.
b) The tests of IEC 60068-2 are liable to be applied to very varied specimens. They have consequently been designed so as to be independent, as far as possible, of the kind of specimen tested. The specimen need not be an electrotechnical product.
c) The results obtained by different laboratories may be compared.
d) The proliferation of slightly differing methods of test and apparatus can be avoided.
e) The continued employment of the same test enables the results to be related to the results of earlier tests on specimens for which information about the performance in service is available.

As far as possible, the tests are specified in terms of the test parameters and not by a description of the test facilities. However, for some tests, it has been necessary to specify the test apparatus.

In choosing the method of test to be applied, the specification writer should always take into account the economic aspects, particularly where two different methods of test exist, both capable of providing the same specific information.

When the separate successive application of two or more environmental parameters does not provide the desired information, recourse should be had to combined or composite tests. The most significant combined and composite tests are in IEC 60068-2.

In some cases, other combinations of environmental parameters may be chosen, provided that the information obtained will be clearly better than that from the application of a sequence of tests. Account should then be taken of the possible difficulties:

– in describing and carrying out the tests;
– in interpreting the results.

## B.3 Relation between test conditions and real environmental conditions

In order to describe the test, the precise nature of the environmental conditions to which the specimens are to be subjected should first be defined. However, on the one hand it is scarcely possible to reproduce the real environmental conditions, which follow ill-defined laws, and, on the other hand, testing would probably take as long as the life expectancy of the specimen.

NOTE The IEC 60721 series gives information that may be of value in defining the environmental conditions that may be encountered in practice. The guidance to some individual tests in IEC 60068-2 gives advice on the selection of suitable severities.

Moreover, the conditions of operational use are not always defined. For these reasons, environmental tests are generally accelerated tests with, in the majority of cases, the real stresses increased to give a quicker result.

The acceleration factor for a test will depend upon the specimen to which it is to be applied. For this reason, and because the relation between the required reduction in testing time and the appropriate intensification of stress is not always known, it is difficult to give a figure for the acceleration factor, and this has not been attempted.

Acceleration factors should always be chosen to avoid the introduction of mechanisms of failure which differ from those occurring in service.

The process of environmental test tailoring given in this standard may be used to derive test specifications, reproducing the critical environmental stresses with appropriate acceleration factors based on systematic engineering evaluation.

## B.4 Principal effects of environmental parameters

The principal effects on a specimen of environmental parameters include: corrosion, cracking, embrittlement, moisture absorption or adsorption and oxidation. These may result in a change in the physical and/or chemical properties of materials.

The principal effects of some single environmental parameters and of resulting typical failures are listed in Table B.3. Nuclear radiation and mould growths are examples of environmental parameters which are not listed.

## B.5 Difference between tests for components and for other specimens

### B.5.1 Testing of components

In general, the precise environment in which the given component may have to operate is not known at the time of its design. Also, the component may be used in a variety of products where the environmental conditions differ from those in which the products are themselves subjected.

Components are frequently available in sufficient quantities to permit different tests to be applied to several samples from different lots. The number of specimens tested may allow statistical analysis of the results. It is often possible for destructive testing to be adopted.

### B.5.2 Testing of other specimens

Specimens for testing are often available only in small numbers because of their cost. Very often, for complex equipment and other products, there is only one specimen, either complete or as part of an assembly, available for testing. Destructive testing is not, therefore, usually possible and the sequence of the tests is of particular importance. In certain cases, information from tests on components, assemblies of components and subassemblies may allow the testing otherwise required to be reduced.

## B.6 Sequence of tests

### B.6.1 Introductory remark

When the effect of one environmental parameter on the specimen depends on the previous conditions to which the specimen has been exposed, it is necessary that it be exposed to the different tests in a specified order.

In a sequence of tests, the intervals of time between the exposures to different environmental parameters are such that they normally have no significant effect on the specimen. If the interval does have an influence, recourse should be had to a composite test, in which the intervals of time between the exposures to different environmental parameters are defined precisely because they have a significant effect on the specimen.

EXAMPLE

a) Composite test: Test Z/AD (IEC 60068-2-38)

b) Sequence of tests: Test T (IEC 60068-2-20)

followed by Test Na (IEC 60068-2-14)

followed by Test Ea (IEC 60068-2-27).

### B.6.2 Choice of a sequence of tests

The choice of a sequence of tests as a function of the intended objectives depends upon considerations which may sometimes be contradictory. These objectives and appropriate applications are discussed in Table B.1.

**Table B.1 – Choice of tests as a function of objectives and applications**

| | Objectives | Principal applications |
|---|---|---|
| a) | Obtain information about failure tendencies from the early part of the test sequence, i.e. by starting with the most severe tests. However, tests which result in the inability of the specimen to resist further testing are placed at the end of the sequence | Development testing: generally used as part of the investigations into the capabilities of prototypes |
| b) | Obtain as much information as possible before the specimen is damaged, i.e. by starting with the least severe tests, for example non-destructive tests | Development testing: generally used as part of the investigations into the capabilities of prototypes, especially when a limited number of specimens is available |
| c) | Use a sequence of tests which will give the most significant effects; in particular, certain tests may reveal damage caused by previous tests | Standardized type approval testing of components and equipment |
| d) | Use a sequence of tests which simulates the sequence of environmental parameters most likely to occur in practice | Type approval testing of equipment and complete systems where the conditions of use are known |

### B.6.3 Sequence of tests for components

Because of the difficulty of standardizing a general sequence of tests applicable to all types of components, appropriate sequences should be given in the relevant specifications.

However, when choosing a sequence, the following considerations should be taken into account:

a) A test with a rapid change of temperature should come at the start of the sequence.

b) Tests for robustness of terminations and soldering (including resistance to heat from soldering) should be placed early in the sequence of tests.

c) All or part of the mechanical tests should then be performed, so as to accentuate the faults likely to have been produced by rapid temperature changes and to provoke new faults, such as cracks or leaks. Such faults are easily detected by climatic tests carried out at the end of the sequence. Unless otherwise specified, these climatic tests should be those prescribed for the “Climatic sequence” in Clause 6.

d) The cold and dry heat phases should be applied early in the sequence of climatic tests so that the short-term effects of temperature can be recognized. The damp heat cyclic phase will introduce moisture into any cracks and the effects of this will be accentuated by the cold phase, and possibly by a low air pressure phase. The application of a further damp heat cyclic phase will introduce more moisture into any cracks present and, after recovery, this may be demonstrated by changes in the electrical parameters measured.

e) In some cases, sealing tests may be used for the rapid detection of cracks or leaks.

f) A damp heat, steady-state test is often applied at the end of the whole sequence of tests or, where not included in the sequence, on separate specimens in order to determine the long-term behaviour of the component in a humid atmosphere.

g) Tests such as corrosion drop and topple and solar radiation are not normally included in a sequence of tests and should, if they are required, be made on separate samples.

### B.6.4 Sequence of tests for other specimens

#### B.6.4.1 Choice of sequence

Whenever possible, the sequence of tests should be determined on the basis of information about the conditions in service.

When this information is not available, it is recommended that a sequence giving the most significant effect be used. A sequence suitable for most types of specimen is described below. It is, however, stressed that only those tests which are significant in relation to the intended use should be applied.

#### B.6.4.2 General sequence of tests to give the most significant effects

An example of a general sequence of tests, as referred to above, suitable for most types of equipment, is shown in Table B.2.

**Table B.2 – General sequence of tests**

| Test | | Comment |
|---|---|---|
| A | Cold | May cause mechanical stress which may make the specimen more sensitive to later tests |
| B | Dry heat | |
| N | Rapid change of temperature | |
| E | Impact [a] | Cause mechanical stresses which may make the specimen fail immediately or make it more sensitive to later tests |
| F | Vibration [a] | |
| M | Air pressure | Application of these tests will reveal the effects of the preceding thermal and mechanical stress tests |
| Db | Damp heat, cyclic (12 h + 12 h cycle) | |
| C | Damp heat (steady state) [b] | Application of these tests may aggravate the effects of the preceding thermal and mechanical stress tests |
| K | Corrosion [b] | |
| L | Dust and sand | |
| Ingress of solid bodies<br>Ingress of water, for example rain | | The tests of IEC 60529 should be used pending the completion of work on Test L and Test R in 60068-2 |

[a] The order of application of tests E and F may be reversed.

[b] Tests for damp heat (steady state) and corrosion should be made on different samples whenever possible.

### B.6.4.3 Tests for special applications

The following tests should be specified only for special applications where products are likely to be affected by such environmental parameters in service:

– G Acceleration, steady state
– J Mould growth
– S Solar radiation
  Ozone [1]
  Icing [1]

Tests for mould growth should be made on different samples whenever possible.

[1] No test method under study for IEC 60068-2.

**Table B.3 – Principal effects of single environmental parameters**

| Environmental parameters | Principal effects | Typical failure resulting |
|---|---|---|
| High temperature | Thermal ageing: oxidation, cracking and chemical reactions; softening; melting; sublimation; viscosity reduction; evaporation; expansion | Insulation failure, mechanical failure, increased mechanical stress, increased wear on moving parts due to expansion or loss of lubricant properties |
| Low temperature | Embrittlement; ice formation; increased viscosity and solidification; loss of mechanical strength; physical contraction | Insulation failure, cracking, mechanical failure, increased wear on moving parts due to contraction or loss of lubricant properties, seal and gasket failure |
| High relative humidity | Moisture absorption and adsorption; swelling; loss of mechanical strength; chemical reactions: corrosion and electrolysis; increased conductivity of insulators | Physical breakdown, insulation failure, mechanical failure |
| Low relative humidity | Desiccation; embrittlement; loss of mechanical strength; shrinkage; increase of abrasion between moving contacts | Mechanical failure, cracking |
| High pressure | Compression, deformation | Mechanical failure, leaks (failure of sealing) |
| Low pressure | Expansion; reduced electric strength of air; corona and ozone formation; reduced cooling | Mechanical failure, leaks (failure of sealing), flashover, overheating |
| Solar radiation | Chemical, physical and photochemical reactions; surface deterioration; embrittlement; discolouration, ozone formation; heating; differential heating and mechanical stresses | Insulation failure<br>See also “High temperature” |
| Dust and sand | Abrasion and erosion; seizure and clogging; reduced thermal conductivity; electrostatic effects | Increased wear, electrical failure, mechanical failure, overheating |
| Corrosive atmospheres | Chemical reactions: corrosion and electrolysis; surface deterioration; increased conductivity; increased contact resistance | Increased wear, mechanical failure, electrical failure |
| Wind | Force application; fatigue; deposition of materials; clogging; erosion; induced vibration | Structural collapse, mechanical failure<br>See also “dust and sand” and "corrosive atmospheres” |
| Rain | Water absorption; temperature shock; erosion and corrosion | Electrical failure; cracking; leaks; surface deterioration |
| Hail | Erosion; temperature shock; mechanical deformation | Structural collapse, surface damage |
| Snow or ice | Mechanical loading; water absorption; temperature shock | Structural collapse;<br>See also “Rain” |
| Rapid change of temperature | Temperature shock; differential heating | Mechanical failure; cracking; seal damage; leaks |
| Ozone | Rapid oxidation; embrittlement (especially rubber); reduced electric strength of air | Electrical failure, mechanical failure, crazing, cracking |
| Acceleration (steady state); vibration; bump or shock | Mechanical stress; fatigue; resonance | Mechanical failure; increased wear of moving parts; structural collapse |

# Annex C
(informative)

# Environmental test tailoring

## C.1 General

The process of producing realistic testing procedures on the basis of actual field conditions is often called environmental test tailoring. The idea is not to reproduce the environmental conditions but their effects on a specimen. This process is used if there is uncertainty in the occurring environmental stresses and their level of severities.

In this standard a general framework for environmental test tailoring process is presented. The general approach is chosen as there are numerous tools and methods for test tailoring for different environmental factors and their combinations. The test tailoring process may be quite complicated and the parties involved should understand the basic assumptions and goals of the conducted work. The given framework provides a common process with the essential main phases ensuring a unified engineering approach and proper flow of information with the commonly agreed terminology.

## C.2 Basic considerations

A general simplified process for the environmental test tailoring is given. The process may be applied at system or subsystem level for any environmental factor.

The critical environmental stresses shall be reproduced with the developed test specifications, using appropriate acceleration factors and test combinations based on systematic engineering evaluation.

The principles of dealing with uncertainties of the product life cycle profile, environmental conditions, product physical properties and number of tested specimens should be stated.

Environmental testing is intended to demonstrate, with some degree of assurance, that a specimen will survive and perform under specified environmental conditions. The test tailoring process can be used to produce information for the degree of assurance, e.g. for the evaluation of the acceleration factor.

When there is a requirement for environmental testing, the test methods of IEC 60068-2 should always be used, unless there is no appropriate test available.

The given environmental test tailoring process is not obligatory and another tailoring process with somewhat different phases and terminology may be used. However, the main phases presented in this standard should be considered and the listed output documentation should ensure the right evaluation of the critical factors for a successful test tailoring process.

## C.3 Environmental test tailoring process

### C.3.1 General process

The main phases of the environmental test tailoring process are presented in Figure C.1. In practice, each phase of the process is further divided into more detailed steps. This final, more detailed process will depend on each set of goals, applications and available knowledge of the particular specimen.

In an ideal situation, the tailoring work is carried out with the co-operation of product developers, end customers, subcontractors, consultants and test laboratories. The content and responsibilities of each phase of the tailoring process are agreed within the parties involved. The results are documented and saved for future use and development. The documents should be updated when new information becomes available. The goal is to have a flexible and iterative work process, with the documentation providing the reasoning behind the work carried out. An example of the information flow and the corresponding activities within the main phases is given in Table C.1.

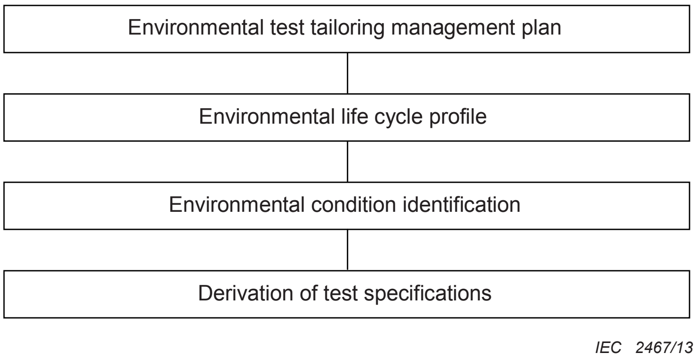


**Figure C.1 – Environmental test tailoring process**

**Table C.1 – Test tailoring process with information flow and the corresponding activities**

| Input | Activity | Output |
|---|---|---|
| **1. Environmental test tailoring management plan** | | |
| ***Background***<br>Need, market possibility, technical and economical circumstances.<br>New or updated requirements.<br>System or subsystem level.<br>Test tailoring standards and handbooks | ***Planning***<br>Goal, strategy, participants, responsibilities, resources, timetable and financing.<br>System and subsystem level.<br>Boundary conditions, limitations. Level of tailoring: difficulty, costs.<br>Technological and financial risk | ***Environmental test tailoring management plan (ETTMP)***<br>- overview; goal and strategy<br>- deliverables |
| **2. Environmental life cycle profile** | | |
| ***Existing knowledge of life cycle profile and environments***<br>Experience, customers, literature, standards, handbooks and databases. Life cycle, duty cycle. Internal and external environments. Self-generated influences | ***Data collection and development***<br>Basic information of all possible environments and their characteristics and statistics. The existence and influence of environments: co-existence, parallel or in series.<br>Possible failure modes. Evaluation of the the critical environmental factors and corresponding failure modes.<br>Teamwork of all participants | ***Environmental life cycle profile (ELCP)***<br>- baseline document<br>- clear technical information<br>- state-of-the-art information<br>- critical environments<br>- critical failure modes<br>- updated when necessary |
| **3. Environmental condition identification** | | |
| ***Environmental life cycle profile (ELCP)***<br>Existing knowledge of critical environmental conditions<br><br>***Product characteristics***<br>System and subsystem behaviour.<br>Product, mounting system and platform information. Physical properties: material, geometry, etc.<br>Critical functional properties | ***Data collection, field and laboratory measurement, computer simulation***<br>Detailed information of environments.<br>Product properties and behaviour.<br>Interaction phenomena.<br><br>***Determination of critical failure modes and mechanisms***<br>The controlling physical laws and equations for corresponding failure mechanisms. Interaction phenomena.<br>Test acceleration laws. Combined environmental factors | ***Critical environment descriptions (CED)***<br>- detailed information of collected critical environments<br><br>***Critical failure modes and mechanisms (CFMM)***<br>- failure modes and mechanisms<br>- the controlling physical laws for failure control and test specification determination |
| **4. Derivation of test specifications** | | |
| ***Environmental test tailoring management plan (ETTMP)***<br><br>***Environmental life cycle profile (ELCP)***<br><br>***Critical environmental descriptions (CED)***<br><br>***Cfrtical failure modes and mechanisms (CFMM)***<br><br>***Data for verification***<br>Test requirements and the corresponding technical data from all test tailoring process phases.<br>State of art knowledge | ***Derivation of testing conditions***<br>Raw environmental data, combination of environments, events, statistics.<br>Reliability considerations. System and subassembly. Test acceleration.<br>Financial and technical factors.<br>Resources and facilities.<br><br>**Verification of realistic testing**<br>Comparison to existing requirements and specifications.<br>Comparison of different testing levels and time duration.<br>System level and subsystem level testing and simulation.<br>Failure identification: means and results<br>Failure mechanism controlling laws.<br>Collection of field feedback from real environmental conditions | ***Test specifications (TS)***<br>- format according to the ETTMP<br>- test program<br>- system and subsystem level<br>- raw environmental data<br>- test type and purpose<br><br>***Test specification verification (TSV)***<br>- existing test requirements<br>– at different test loads<br>– at different test durations<br>- critical failure modes and mechanisms<br>- field feedback<br>- feedback from testing<br>- recommendations for long term verification plan<br>- recommendations for test updating |

### C.3.2 Environmental test tailoring management plan

The development and documentation of the environmental test tailoring management plan (ETTMP) is the first phase in the test tailoring process. ETTMP is used to achieve an overview and agreement on the general framework of the environmental test tailoring process. The tasks and points to be considered here are, e.g.

– need and overview,

- system and subsystem evaluation,
- restrictions and boundaries of the tailoring programme,
- goal, methods, budget, resources and timetable (people, time, money),
- participants and their responsibilities (resources, financing),
- level of tailoring: level of uncertainty and reliability, difficulty and costs,
- risks, and
- deliverables and outcomes (reporting, documentation, database, quality management).

### C.3.3 Environmental life cycle profile (ELCP)

The environmental life cycle profile (ELCP) determination and documentation is important due to both administrative (schedule, budget) and technical (reliability, usability) reasons. The environmental conditions of each life cycle phase should be determined and included in the ELCP. The emphasis is on the most critical life cycle phases. In the tailoring process, the ELCP may be determined for the system or subsystem level with the same basic steps.

The environmental life cycle profile can be described as follows:

a) all phases and environments of a product's life, e.g.
   - manufacturing, distribution and end user profiles,

     NOTE 1 Typical main parts of a product life cycle.
   - maintenance, disassembly, re-use, withdraw from service,
   - all environmental factors (vibration, temperature, pressure etc.),
   - different platforms,

     NOTE 2 Any vehicle, surface, or medium where the product is attached or loaded on.
   - character, sequence, co-existence, correlation of events and environments, and
   - statistic information: e.g. probabilities, extreme and mean values.

b) research and development tool, e.g.
   - integrated information of environmental conditions,
   - current state-of-art situation, level of knowledge,
   - cost-effective approach for design and testing, and
   - risk management (load/durability).

c) useful documentation, e.g.
   - important product characterization baseline,
   - the same baseline for design and testing, and
   - administrative tools,

d) teamwork with all parties ensures the best results.

ELCP is an evolving document and may be updated during design, test tailoring, or later, e.g. with feedback from the end users. Thus, it may be connected closely to product documentation (e.g. quality management). ELCP does not give the answer as to what to do or how to deal with a particular situation, but serves as a document and baseline for further considerations. It should be a document simple enough to be understood by all parties on all project management levels. The production of ELCP is critical as exclusion of important events or inclusion of unrealistic situations may cause significant costs and unreliable results.

### C.3.4 Environmental condition identification

During the phase of environmental condition identification, the environmental conditions of the most critical life cycle phases are determined in more detail. The critical environmental influences should be determined as realistically and in as detailed a manner as possible. In studying these influences, e.g. the platform, where the product is installed, the product properties and critical failure modes should be taken into account. One should also note if a packed or unpacked specimen is studied.

Information can be gathered from, e.g. literature, field measurements, computer simulation and database systems. In addition, common sense and information from end users should be applied. Not only environmental conditions are studied; the critical properties of relevant specimens are also considered. Specimen properties are important due to the possible interaction with the environment and in order to have a proper description of the environment for the critical failure mechanisms. The results are presented in two documents:

– critical environment descriptions (CED);
– critical failure modes and mechanisms (CFMM).

The main results should be used to update ELCP.

### C.3.5 Derivation of the test specifications

The previous steps of the tailoring process give the environment-specific life cycle information. The test specifications (TS) should be derived on the basis of the obtained results. In addition, one should adjust the tests, and test levels, according to the desired level of reliability.

To carry out the test, the following information is necessary:

– environmental life cycle;
– environmental conditions;
– critical failure modes;
– cause and effect relationships and acceleration laws.

For the test severity determination, an important question is the combination of different encountered events. In addition, environmental factors may not only co-exist but have combined effects which should be taken into account. Furthermore, time compression and test acceleration are typical objectives for more efficient test development. The challenge is to be able to accelerate the correct failure modes with realistic testing methods and severity.

### C.3.6 Derivation of testing conditions

For each environmental factor there exists various methodologies for the derivation of testing severity and conditions. The danger is that, even with the same input data, variations in test severity may result if different methodologies are used. This may be a question of different strategy and test purpose, but may also be due to variation in the accuracy of the analysis procedure or in the wanted level of reliability of the final product. Therefore, this phase in test tailoring is very critical and needs special emphasis.

One has to be careful to have a clear strategy and to fully understand the tailoring process. The purpose of testing as well as its application area should be well established. Important issues in the derivation of testing conditions are, e.g. the combination of events and environments, evaluation of the interaction phenomena, the level of reliability and the statistical methodologies used. It is interesting to note that the tailoring process offers a natural bridge between the traditionally more separate environmental testing procedures and the reliability testing procedures.

To establish test severity, it is necessary to identify properly the target levels of structural and operational reliability. The target probability of failure is basically product dependent: e.g. high reliability equipment (space, medical, military etc.) need higher margins for uncertainty. In addition, the number of test specimens submitted has an influence on the defined test severity.

NOTE See IEC/TR 62130 and the IEC/TR 62131 series for information on environmental data.

### C.3.7 Verification

After developing the test specifications, it is necessary to ensure that the obtained results are realistic. This step is documented in the test specification verification (TSV) report. The tests should simulate the effects of the true environmental conditions. Thus, the effects and failures of tests should correspond to the feedback from the actual field use. This information is critical to time reduction, where one has to ensure successful acceleration of the relevant failure modes.

On the basis of test verification results, one can further optimize acceleration, e.g. by increasing or decreasing the test levels. The test tailoring process enables the modification of test specifications according to the best available data. With the use of more conservative test levels, the need for updating is reduced, but then the tests are not as optimized and efficient.

# Bibliography

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

IEC 60068-2-20, *Environmental testing – Part 2-20: Tests – Test T: Test methods for solderability and resistance to soldering heat of devices with leads*

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

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

IEC 60068-3-1, *Environmental testing – Part 3-1: Supporting documentation and guidance – Cold and dry heat tests*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 60721 (all parts), *Classification of environmental conditions*

IEC 62130, *Climatic field data including validation*

IEC 62131 (all parts), *Environmental conditions – Vibration and shock of electrotechnical equipment*

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

ISO 3205, *Preferred test temperatures*

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