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Environmental testing – Part 3-14: Supporting documentation and guidance – Developing a climatic sequential test

Essais d'environnement – Partie 3-14: Documentation d'accompagnement et recommandations – Élaboration d'un essai climatique séquentiel

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CONTENTS

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Environmental testing - Part 3-14: Supporting documentation and guidance - Developing a climatic sequential test

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IEC 60068-3-14 has been prepared by IEC technical committee 104: Environmental conditions, classification and methods of test. It is an International Standard.

The text of this International Standard is based on the following documents:

Draft	Report on voting
104/1100/FDIS	104/1124/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 60068 series, published under the general title *Environmental testing*, can be found on the IEC website

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

– reconfirmed,
– withdrawn, or
– revised.

INTRODUCTION

The IEC 60068-2 series includes a variety of single and combined climatic condition tests. Some of these tests can give cumulative effects or hysteretic effects, causing the unit-under-test to deteriorate, and making it more vulnerable to subsequent tests. Thus, determining the sequence of tests has a significant influence on the conclusion of a composite test.

This subpart of IEC 60068-3 provides guidance for developing a climatic sequential test for a certain type of product (electrical, electromechanical or electronic equipment and devices, as well as their subassemblies, constituent parts and components). It is written for technicians, engineers and managers in environment testing, and for those who need to understand the results of climatic sequential tests.

With the increasing importance of the IEC Quality Assessment System for Electronic Components (IECQ), it has become necessary to define the test sequence more precisely than it could be done in IEC 60068-1:2013, Clause 7, in order to provide a satisfactory reproducibility of the test. This document describes in detail a composite test specifying a "climatic sequence" for product specimens. It includes guidance in informative annexes for specification writers and those performing the test.

1 Scope

This part of IEC 60068 describes a generic process for developing a climatic sequential test programme by sequencing test methods selected from the IEC 60068-2 series.

This generic process comprises a systematic approach to the development of a sequential environmental test programme.

A climatic sequential test is applicable to electrical, electromechanical or electronic equipment and devices, as well as their subassemblies, constituent parts and components. It can be customized according to specific product requirements and applications.

The process is designed for use by product designers, manufacturers and users.

The process is particularly relevant to electrical products which include components or materials that have the potential to degrade, as a consequence of environmental exposures.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

– IEC Electropedia: available at http://www.electropedia.org/

– ISO Online browsing platform: available at http://www.iso.org/obp

3.1
cumulative effects
permanently remained consequences of environmental conditions imposed on a product after the environmental exposures are removed

3.2
hysteretic effects
gradually attenuated consequences of an environmental condition after the environmental exposure are removed

3.3
life cycle environmental profile
LCEP
design and test decision baseline document outlining real-world environmental conditions that a product or component will experience during usage-related events from its release/ manufacturing to the end of its useful life

Note 1 to entry: Examples of usage-related events are transportation, storage, operational usage and maintenance.

4 Background

4.1 Environmental exposure sequence in life cycle

When exposed to environmental conditions, products can be influenced by the surrounding environment. The influence is related to the environmental severity, the mechanism of environmental effect on products and the initial state.

To provide confidence that a product is capable of surviving and operating in environmental conditions which it encounter during its life cycle, it is necessary to evaluate the product against those conditions.

As far as practicable, such evaluations should consider all environmental conditions and their sequence the product can experience during its life cycle. An environmental test programme should, as far as practicable, replicate the usage environment and expose the product to the environmental conditions so that the product can experience them from the point of manufacture to the end of its life. The environmental conditions that exist during storage, transportation, handling and operation should be considered.

NOTE See IEC 60721-1, the IEC 60721-2 series and the IEC 60721-3 series for the classification of environmental conditions.

4.2 Failure mechanism under a sequential test

The environmental worthiness assessment of products is generally conducted by serial laboratory environmental tests according to a specified environmental test programme.

NOTE See the IEC 60721-4 series for guidance for the correlation and transformation of environmental condition classes to the environmental tests.

While a specimen is exposed to one environmental test, its state changes somehow. The changes can be some permanent damages due to the previous environment to which the specimen exposes, or some remaining effects, which will disappear gradually in a long duration, by the previous environmental exposure.

When an environmental test programme is to be specified for a particular product, the sequence in which tests are carried out is important. That is because damage or effect, initiated by the previous environmental test, is not probably become apparent or significant, until another is applied. Specifically, a product can survive from an environmental test programme if the test is carried out in one particular order but fail if executed in another order.

Therefore, the order in which environmental tests are undertaken should ideally reflect the order in which they appear in the life cycle of product. In practice, it is usually not possible to exactly reproduce every aspect of a product life cycle, as environmental exposure varies, especially during operational conditions.

5 Introduction to the process

5.1 General

The process to develop a climatic environmental test sequence, as set out in this document, consists of three stages:

a) stage 1: reviewing environmental requirements of products and compiling a provisional sequence;

b) stage 2: establishing critical environments based upon knowledge and refining sequence;

c) stage 3: preparing a technically reliable, cost-effective sequential test programme.

5.2 Stage 1: reviewing environmental requirements and compiling a provisional test sequence

Stage 1 of the process considers the product usage requirements to establish a provisional environmental sequence.

Generally, the requirements of specific concerns are

– the product life cycle distinguished by several phases including transportation, storage, installation, operation and maintenance, as well as

– the product environmental requirements, usually consisting of a set of environmental characteristics representing each phase of the product life cycle.

Together these are used to generate a provisional list of environmental requirements and sequence.

At this stage, the environmental sequence comprises a list of environmental conditions arising from each phase of the product life cycle. This provisional environmental sequence will be extensive, with many similar environmental conditions appearing within a number of different phases, of the life cycle.

5.3 Stage 2: establishing critical environments and refining sequence

Stage 2 of the process refines the provisional environmental sequence to eliminate unnecessary repetition of environmental conditions, as well as consider the effects of the sequence and of potential product failure modes. The elimination of unnecessary repetition of environmental conditions is achieved by considering the operational state. For example, the environmental conditions occurring when the product is packaged and non-operational have the potential to be merged.

It is possible for concurrent environmental conditions to have an effect on the product, which is greater than the case if they are applied separately. In such cases, the concurrent environmental conditions sometimes have a synergistic effect. If the synergistic effect is likely to be significant for a particular product, consideration shall be given to undertake combined environmental testing.

In parallel, consideration of the potential failure modes of the product should allow a sequential order of the environmental conditions to be established. For example, if temperature variation testing degrades seals and joints, allowing moisture around to pass through these seals and joints when the product is exposed to a damp heat condition, the temperature variation test should be done before the humidity test. Conversely, when moisture penetrates into electrical box during the humidity test, a following low temperature test can cause the test sample to condense or freeze inside.

It is for this reason that the recursive and iterative philosophy to refine test sequence is generally the keyword throughout the whole process to develop a test programme.

Stage 2 of the process also distinguishes the environmental conditions which should be considered as part of a sequential programme and those that can be considered separately, as non-sequential tests.

5.4 Stage 3: preparing sequential test programme

Stage 3 of the process considers the environmental sequence generated by the preceding stages and then generates a technically reliable, cost-effective test programme.

Having identified the appropriate sequences of environments, these can be converted into a test programme.

This shall also consider the need to include appropriate functional testing of the product before, during and after the testing, as well as the need for any post-test destructive or non-destructive inspection.

In certain cases, greater technical credibility and cost effectiveness can be achieved by modifying the sequence, to allow more effective use and time.

Although, such modifications should not override the order identified in stage 2, some adjustments can still be achieved.

5.5 Overall process

The overall process is illustrated in Table 1 and is discussed in detail hereinafter.

Table 1 – Process to develop an environmental test sequence

Stage	Task	Sub-task
1	Reviewing requirements and compiling a provisional test sequence	Evaluating life cycle
		Evaluating environmental requirements
		Compiling provisional lists of critical environments
2	Establishing critical environments based upon knowledge of product and refining test sequence	Consideration of the operational state of the product
		Identification of potential failure modes
		Reviewing sensitivity of the product to sequential environmental conditions
		Identifying need for combined testing, and refine test programme
		Consideration of sequential and non-sequential testing
3	Preparing a sequential test programme	Reviewing programme for technical credibility and cost effectiveness

6 Stage 1: reviewing requirements and compiling provisional test sequence

6.1 Evaluating product life cycle

Consideration of the product life cycle should have occurred as part of the exercise to generate the environmental requirements document. The environmental requirements document should reflect the predominant phases of the life cycle. However, a product life cycle can contain multiple iterations of some events; for instance, the product has the potential to be transported several times in its entire life. As a consequence, even a well-constructed environmental requirements document should be considered alongside the life cycle, when identifying all the sequential conditions the particular equipment experiences.

The product life cycle can also be used to identify whether changes in logistics and operational usage will occur in the future. For example, one type of transport vehicle can be replaced by another. Even when information of future potential environmental conditions is not known, identifying the possibility permits the management of potential consequences. It is also necessary to consider a worst-case usage to future proof against unknown usage requirements.

6.2 Evaluating environmental requirements

6.2.1 Identifying major phases

The information in the environmental requirements document can be presented in several ways. Whichever approach is used, the logistical and operational requirements should be broken down into their major phases. The phases can differ for each type of product, but typically consist of the following, which reflect the layout used in other parts of this document.

a) Delivery: This phase should encompass the types of transportation to be used and the associated worldwide regions, from which the product is delivered. The most common form of transportation is by road, but air, rail and water transportation are sometimes also required. Delivery is usually undertaken with the product packaged. Handling of ISO shall be addressed.

b) Storage: The main environments of concern during long term storage are climate along with some potential for contamination. Storage can be within conditioned or non-conditioned buildings. Handling using forklift trucks and also manhandling, for low mass product, shall be considered.

c) Transportation to depot: This phase should encompass the types of transportation to be used, along with the associated worldwide regions, in which the product is transported. The most common forms of transportation are by road, rail, air and sea. Transportation to the depot is usually undertaken, with the packaged. Handling using forklift trucks and cranes shall be considered.

d) Transportation beyond the depot: The environments experienced during delivery beyond the depot can be more severe than those during delivery to the depot. In addition to road, air and sea transportation, the product can experience off-road transportation and poor-quality handling.

e) Short term storage: The main environments of concern during short term storage are climate and contamination. Storage can be within conditioned or non-conditioned buildings, partially protected (open sided) buildings, under temporary covers such as a tarpaulin or fully exposed to climatic conditions. Poor quality handling products or manual handling can be chosen for handling products. Packaging can be the same as for the situation of transporting to the depot. Alternatively, it involves degraded packaging or no packaging.

f) Operation: The environmental conditions during operation, can be severe and also unique. They can occur in conjunction with those of installation/operation. The product is likely to be required to operate during this phase.

g) Return: In some cases, products can be returned to the depot or country of origin for storage, repair, upgrade or disposal, etc. Returned products are possible to have been "broken out" of its packaging during earlier phases and consequently have become contaminated.

h) Product disposal: There can be no control over the storage and transportation environmental conditions imposed on product during the disposal phase.

6.2.2 Determining typical environmental conditions

For each phase of the logistical and operational requirements identified for particular product, the individual environmental conditions should be specified in detail. Typical environmental conditions, which should be encompassed, are indicated below. In each case, the information should provide the conditions causing the environment (especially for self-induced environments), a description of the environment and quantifiable values.

NOTE See the IEC 60721-2 series and the IEC 60721-3 series for more detailed information.

a) Mechanical environments: These environments include acceleration, vibration and shock as well as acoustic noise, impact (drop and crane swing) and bounce, etc. The environments can also include the mechanical loading environments, associated with handling packaged.

b) Climatic environments: These environments include temperature, humidity, solar radiation, pressure and maybe rapid or explosive decompression, icing, thermal shock, winds, freeze-thaw and snow load etc.

c) Chemical, biological and contamination environments: These environments include fungal growth, salt, acid corrosion, dust and sand, mist and fog, driving rain, driving snow and immersion, etc. as well as a whole range of potential chemical and biological contaminants.

d) Electrical environments: Electrical and related environments also should be considered.

e) Combined environments: For each environment, it is necessary to indicate whether it occur in conjunction with other environments and if appropriate, the probability of their joint occurrence.

6.3 Compiling provisional list of critical environments

The provisional environmental sequence can be deduced from the environmental requirement and the product life cycle. At this stage, the environmental sequence will comprise a list of groups of environmental conditions, arising from each and every phase of the product life cycle. This list comprises provisional environmental conditions and sequence and will be extensive, with many environmental conditions appearing, within a number of different phases of the life cycle. The purpose of the subsequent stages is to refine this sequence and reduce any unnecessary repetition of the environmental conditions within the test programme.

7 Stage 2: establishing critical environments and refining sequence

7.1 Consideration of the operational state of the product

To eliminate unnecessary repetition of environmental conditions in the provisional environmental sequence, the preliminary step takes the various operational states of the product into consideration. If the product is in the same operational state, the potential exists to merge similar environmental conditions. Through considering in this way, a significant reduction in the provisional environmental test sequence is usually possible. For example, many transportation phases take place on similar platforms and are likely to occur with the product in the same operational state (packaged and non-operating).

Similar environmental conditions, but with the product in a different operational state, cannot usually be accumulated, unless it is shown that the environmental conditions have a similar effect on the product.

For most products, the relevant states are likely to be: "packaged and non-operating", "unpackaged and non-operating", "unpackaged and operating" and "re-packaged and non-operating". Some products can have intermediate levels of packaging. This includes situations when the product is unpackaged, but still has limited protection. Similarly, some products can have different levels of operation/function, for example, a standby and fully operational state. "Re-packaged and non-operating" products have been specifically included here, because the re-packaging process can occur under poor conditions and the products can return to their package (or another package) in a contaminated or incomplete state.

Generally, if product is non-operating, it will be expected to operate after the applicable environmental conditions but not during. However, if product is operating, it will be expected to meet its operational requirements, during the applicable environmental conditions as well as after. An exception to these categories is the case of abnormal environmental conditions (e.g. extreme normal or accidental conditions). Products that are exposed to abnormal environmental conditions usually have specific requirements which only a few shall be considered as part of the environmental sequential test programme. Others are considered as potential non-sequential tests, which will be addressed later.

7.2 Identification of potential failure modes

Identifying potential failure modes of product is undertaken to allow a sequential order of the priority of environmental conditions to be established.