IEC 60068-2-14

Edition 7.0 2023-07
REDLINE VERSION

INTERNATIONAL STANDARD

Environmental testing –
Part 2-14: Tests – Test N: Change of temperature

IEC 60068-2-14:2023-07 RLV(en)

IEC Secretariat
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications
The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, …). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch
Discover our powerful search engine and read freely all the publications previews. With a subscription you will always have access to up to date content tailored to your needs.

Electropedia - www.electropedia.org
The world's leading online dictionary on electrotechnology, containing more than 22 300 terminological entries in English and French, with equivalent terms in 19 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC 60068-2-14

Edition 7.0 2023-07
REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

Environmental testing –
Part 2-14: Tests – Test N: Change of temperature

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 19.040

ISBN 978-2-8322-7338-8

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

____

ENVIRONMENTAL TESTING –

Part 2-14: Tests – Test N: Change of temperature

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at https://patents.iec.ch or www.iso.org/patents. IEC shall not be held responsible for identifying any or all such patent rights.

This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC 60068-2-14:2009. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

IEC 60068-2-14 has been prepared by IEC technical committee 104: Environmental conditions, classification and methods of test. It is an International Standard.

This seventh edition cancels and replaces the sixth edition published in 2009. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) updating of the figures for clarification purposes;
b) updating of specimen temperature(s) and severities as well as tolerances for change of temperature tests;
c) revision of standardized requirements for test reports for Tests Na and Nb.

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

Draft	Report on voting
104/991/FDIS	104/1016/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,
- replaced by a revised edition, or
- amended.

IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

A change of temperature test is intended to determine the effect on the specimen of a change of temperature or a succession of changes of temperature.

It is not intended to show effects that are ~~due only to high or low temperatures~~ caused by low or high temperature exposure. For these effects, the cold test or the dry heat test, as specified in IEC 60068-2-1 and IEC 60068-2-2, should be used.

The effect of ~~such~~ change of temperature tests is determined by

– values of high and low conditioning temperature between which the change is to be ~~effected~~ affected,
– the conditioning times for which the test specimen is kept at these temperatures,
– the rate of change between these temperatures,
– the number of cycles of conditioning,
– the amount of heat transfer into or from the specimen,
– the thermal conductivity and the materials of the specimen,
– the rate of change of the specimen's temperature on its surface (respectively in relevant positions) or in its core.

Guidance on the choice of suitable test parameters for inclusion in the detail specification is given throughout this document.

ENVIRONMENTAL TESTING –

Part 2-14: Tests – Test N: Change of temperature

1 Scope

~~This part of IEC 60068 provides a test to determine the ability of components, equipment or other articles to withstand rapid changes of ambient temperature. The exposure times adequate to accomplish this will depend upon the nature of the specimen.~~

This document provides tests with specified ambient temperature changes to analyse their impacts on specimens.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

~~IEC 60068 (all parts), *Environmental testing*~~

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

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

~~IEC 60068-2-17, *Environmental testing – Part 2-17: Tests – Test Q: Sealing*~~

~~IEC Guide 104, *The preparation of safety publications and the use of basic safety publications and group safety publications*~~

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60068-2-1 and IEC 60068-2-2 apply.

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

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

4 Symbols

D	temperature difference between high conditioning temperature T_B and low conditioning temperature T_A
T_A	low conditioning temperature
T_{Ad}	decreased low conditioning temperature
T_B	high conditioning temperature
T_{Bi}	increased high conditioning temperature
T_{STD}	temperature of standard atmospheric conditions for measurement and tests (15 °C to 35 °C)
ΔT_s	temperature difference between the specimen and the test medium (e.g. air)
dT_R	temperature change rate (Test Nb)
t_s	stabilization time of specimen temperature
t_{s*}	stabilization time of specimen temperature during the first cycle, starting from laboratory air temperature
t_1	exposure time of the specimen to each conditioning temperature
t_2	transfer time of the specimen from one test chamber to another (two-chamber test method)
$\pm\sigma_T$	applicable temperature tolerance of the medium temperature during temperature transition (Test Nb)
$\pm\sigma_{Tconst}$	applicable temperature tolerance of the medium temperature during the constant conditioning

5 General

5.1 Field conditions of changing temperature

It is common in electronic equipment and components that changes of temperature occur. Parts inside equipment undergo slower changes of temperature than those on an external surface when the equipment is not switched on.

Rapid changes of temperature ~~may~~ can be expected

- when equipment is transported from warm indoor into cold outdoor environments ~~into cold open air conditions~~ or vice versa,
- when equipment is suddenly cooled by rainfall or immersion in cold water,
- when equipment is attached or in close proximity to components leading to high thermal stress (e.g. combustion engines, central processing units),
- when equipment is artificially cooled or heated,
- in externally mounted airborne equipment or when equipment is located in unheated aircraft or cargo holds,
- under certain conditions of transportation and storage.

Components will undergo stresses due to changing temperature when high temperature gradients build up in an equipment after being switched on, for example in the ~~neighbourhood~~ proximity of high ~~wattage~~ power resistors, radiation can cause rise of the surface temperature ~~in neighbouring~~ on close components while other portionsremain cold.

Artificially cooled components ~~may~~ can be subjected to rapid temperature changes when the cooling system is switched on. Rapid changes of temperature in components ~~may~~ can also be induced during manufacturing processes or the transportation of equipment. Both the number and amplitude of temperature changes, the time interval between them and the thermal responsiveness of the equipment (or specimen) are important.

~~4 General~~

5.2 Design of ~~change of temperature~~ tests with temperature change

Change of temperature Tests Na, Nb and Nc comprise alternate periods at a high and ~~at~~ a low temperature with well-defined transfers from one temperature to the other. The conditioning run from the laboratory ambient temperature to the first conditioning temperature, then to the second conditioning temperature, then back to the laboratory ambient temperature is considered as one test cycle.

5.3 Test parameters

~~Test parameters comprise the following:~~

- ~~laboratory ambient;~~
- ~~high temperature;~~
- ~~low temperature;~~
- ~~duration of exposure;~~
- ~~transfer time or rate of change;~~
- ~~number of test cycles.~~

~~The high and low temperatures are understood to be ambient temperatures which will be reached by most specimens with a certain time-lag.~~

~~*Only in exceptional cases* may they be specified outside the normal storage or operating temperature range of the object under test.~~

Test parameters comprise the following:

- laboratory ambient conditions (mainly temperature and humidity);
- high conditioning temperature T_B;
- increased high conditioning temperature T_{Bi}, if applicable;
- low conditioning temperature T_A;
- decreased low conditioning temperature T_{Ad}, if applicable;
- exposure time t_1 of the specimen to each conditioning temperature;
- transfer time t_2 or temperature change rate dT_R;
- number of test cycles.

As these tests are intended to validate the effects of temperature changes on the specimen, the specimen’s characteristics should always be taken into consideration (if not specified otherwise):

- thermal responsiveness of the specimen in affected areas or the core;

  - thermal conductivity;
  - specific heat capacity;
- density;
- geometry;
- mass.

The experimental determination of these characteristics is recommended, if unknown and not specified otherwise.

The test is accelerated because the number of severe changes of temperature in a given period is greater than that which will occur under field conditions.

The high and low conditioning temperatures are understood to be ambient temperatures which will be reached by most specimens with a certain time lag. It is recommended to consider the specimen's characteristics when specifying the test. Annex A gives further information on potential consequences of improper severities of tests.

Only in exceptional cases should these temperatures be specified outside the normal storage or operating temperature range of the object under test.

NOTE If the specimen's characteristics (mass, density, geometry) prevent the specified rate of change, the temperatures can be specified outside the normal storage or operating temperatures to increase the severity of the intended test, if not specified otherwise.

5.4 Purpose and choice of the tests

Change of temperature testing is recommended in the following cases:

- evaluation of electrical performance after a specified number of rapid changes of temperature, Test Na or Test Nc;
- evaluation of the suitability of mechanical components, and of materials and combinations of materials to withstand rapid changes of temperature, Test Na or Test Nc;
- evaluation of the suitability of construction of components to withstand artificial stressing, Test Na or Test Nc;
- evaluation of electrical performance ~~during~~ as a consequence of a change of temperature, Test Nb;
- evaluation of mechanical performance ~~during~~ as a consequence of a change of temperature, Test Nb.

The change of temperature tests specified in the IEC 60068 series is not intended to evaluate the difference in material constants or electrical performance when operating under ~~temperature stability at the two extremes of temperature~~ the conditioning temperatures T_A and T_B.

5.5 Choice of ~~the duration of~~ the exposure time to each conditioning temperature

The duration of the exposure should be based on the requirements stated in 7.2.3, 8.2.3 or 9.2.2, or as stated in the relevant specification, keeping in mind the following points:

a) The exposure begins as soon as the specimen is in the new environment.

b) Stabilization occurs when the temperature difference ~~(ΔT)~~ between the specimen and the test medium (ΔT_s) is within ~~3 K to~~ 5 K, or as stated in the test specification. The stabilization ~~period, (~~time of specimen temperature t_s~~),~~ is from the start of exposure until the ~~time~~ moment when the temperature is within the specified difference. A representative point (or points) on the specimen ~~may~~ can be used for this measurement.

c) ~~The test duration, t_1, shall be longer than the specimen stabilization time, t_s.~~ The exposure time t_1 of the specimen to each conditioning temperature shall be longer than the stabilization time of the specimen temperature t_s. Figure 1 provides a graphical representation of the process. ~~This may~~ It is possible that this will not be appropriate for heat generating specimens.

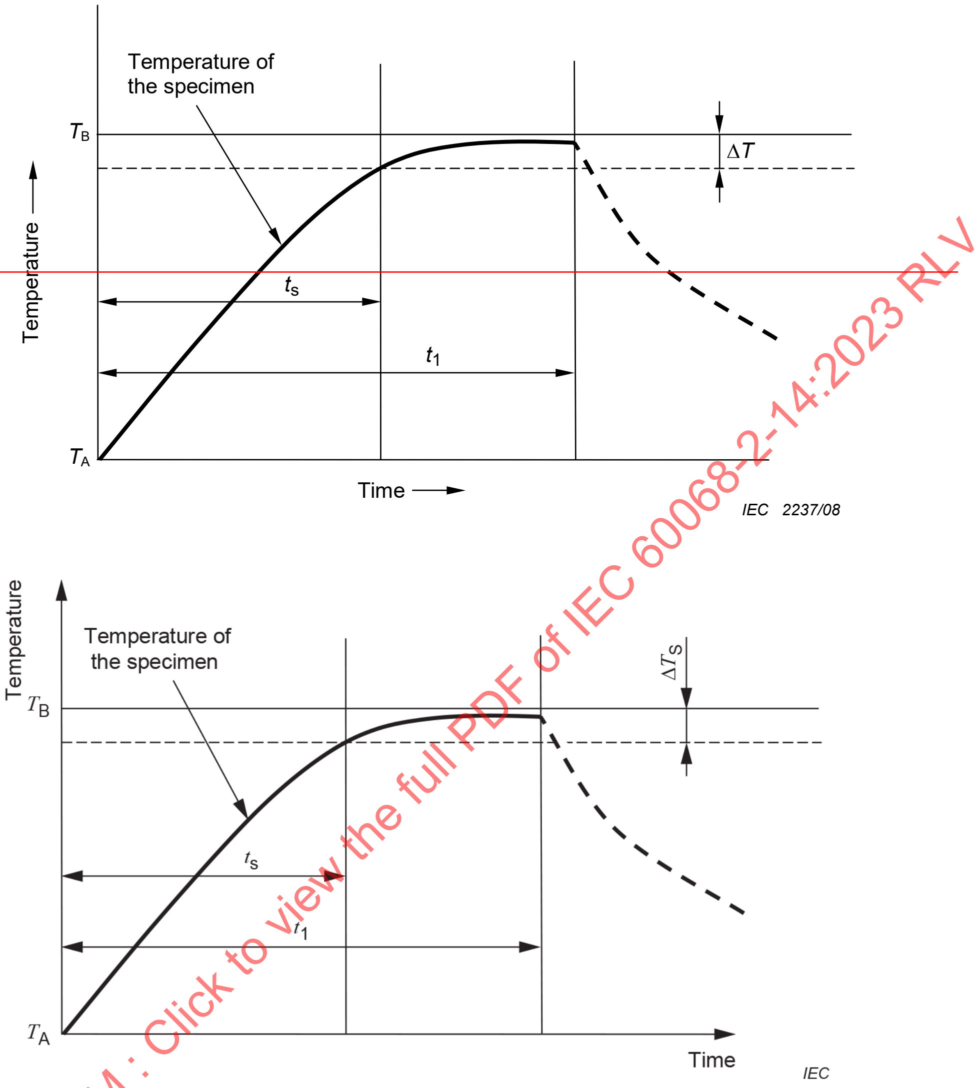


Figure 1 – Determination of ~~test duration time (t_1)~~ the exposure time t_1 of the specimen to each conditioning temperature

5.6 Choice of the duration of the transfer time t_2

~~If, in the case of the two-chamber method, because of the large size of the specimens the transfer time cannot be made in 3 min, the transfer time may be increased without an appreciable influence on the test results as follows:~~

$$t_2 \leq 0{,}05\ t_s$$

~~where~~

~~t_2 is the duration of the transfer time;~~

~~t_s is the stabilisation period of the specimen.~~

If, for example owing to the large size of the specimens, the transfer time t_2 cannot be kept within 3 min, the transfer time can be increased with a negligible influence on the test results as follows:

$$t_2 \leq 0{,}05\ t_s$$

This applies for the two-chamber test (see 7.2.1) method only. When using the one-chamber test method, period t_2 is not applicable.

5.7 Applicability limits of change of temperature tests

Inside a specimen, the temperature change rate depends on the heat conduction of its materials, the spatial distribution of its heat capacity as well as on its dimensions and surface area. A representative point (or points) on (or inside) the specimen can be used for the measurement of the temperature change rates.

NOTE 1 The rate of temperature change of specimens made of the same material and mass can vary if their surfaces differ from each other.

The change of temperature at one point on the surface of a specimen follows approximately an exponential law. Inside large specimens, such alternate exponential rises and decreases ~~may~~ can lead to periodic and approximately sinusoidal changes of temperature with much lower amplitudes than the applied temperature swing. Annex B gives further information on the thermal responsiveness of different materials and geometries.

The mechanism of heat transfer between the test specimen and the conditioning medium in the chamber or bath should be ~~taken into account~~ considered. Liquid in motion leads to very high rates of change of temperature on the surface of the specimens and still air to very low rates.

NOTE 2 If more than one specimen is tested in the same test chamber, a uniform incoming airflow can be disturbed. For further information on the relation of airflow and specimen temperature, IEC 60068-3-1 can be helpful.

The two-bath method with water as a conditioning medium (Test Nc) should be restricted to specimens which are either sealed or are by their nature insensitive to water, since their performance and properties ~~may~~ can deteriorate by immersion.

In particular cases, such as with specimens sensitive to water, a test with liquid other than water ~~may need to~~ should be specified. When designing such a test, the characteristics of heat transfer of the liquid, which ~~may~~ can differ from those of water, shall be ~~taken into account~~ considered.

NOTE 3 To assess the applicability of the two-bath method, evaluations from Test Q: Sealing (IEC 60068-2-17) ~~may~~ can be helpful.

~~5 Guidance for the selection of the kind of test~~

~~The severity of the test will increase with the increase in the temperature difference, the increase in rate of temperature change, and the heat transfer to the specimen.~~

The application of Tests N is preferred as part of a sequence of tests. It is possible that some types of damage ~~may~~ will not become apparent by the final measurements of a Test N but ~~may~~ will appear only during subsequent tests ~~(e.g. Test Q: Sealing, Test F: Vibration or Test D: Accelerated damp heat)~~.

An exemplary sequence of tests can be IEC 60068-2-17 Test Q: Sealing, IEC 60068-2-6 Test Fc: Vibration (sinusoidal), IEC 60068-2-30 Test Db: Damp heat, cyclic (12 h + 12 h cycle) or IEC 60068-2-67 Test Cy: Damp heat.

The change of temperature Test Nc (Two-bath method) should not be used as an alternative to Test Q (Sealing).

When specifying a change of temperature test, the properties of the objects under test which are affected by conditions of changing temperature, and their possible failure mechanisms, should be kept in mind. The initial and the final measurements should be specified accordingly.

6 Initial and final measurements

6.1 General

Tests Na, Nb and Nc all use the same initial and final measurements.

6.2 Initial measurements

The specimen shall be visually examined and electrically and mechanically checked, as required by the relevant specification.

6.3 Final measurements

The specimen shall be visually examined and electrically and mechanically checked, as required by the relevant specification.

7 Test Na: Rapid change of temperature ~~with prescribed time of transfer~~

7.1 General description of the test

This test determines the ability of components, equipment or other articles to withstand rapid changes of ambient temperature. The exposure times adequate to accomplish this will depend upon the nature of the specimen. The specimen shall be either in the unpacked, switched-off, ready for use state, or as otherwise specified in the relevant specification. The specimen is exposed to rapid changes of temperature in air, or in a suitable inert gas, by alternating exposure to a low ~~temperature~~ ~~and~~ ~~to~~ a high conditioning temperature.

7.2 Testing procedure

7.2.1 Testing chamber

Two separate chambers (two-chamber method, see Figure 2) or one rapid temperature change rate chamber (one-chamber method, see Figure 3) ~~may~~ can be used. If two chambers are used, one for the low temperature and one for the high temperature, the location shall be such as to allow transfer of the specimen from one chamber to the other within the ~~prescribed~~ specified time. Either manual or automatic transfer methods ~~may~~ can be used.

~~The chambers shall be capable of maintaining the atmosphere at the appropriate temperature for the test in any region where the specimen is placed.~~

~~After insertion of the test specimens, the air temperature shall be within the specified tolerance after a time of not more than 10 % of the exposure time.~~

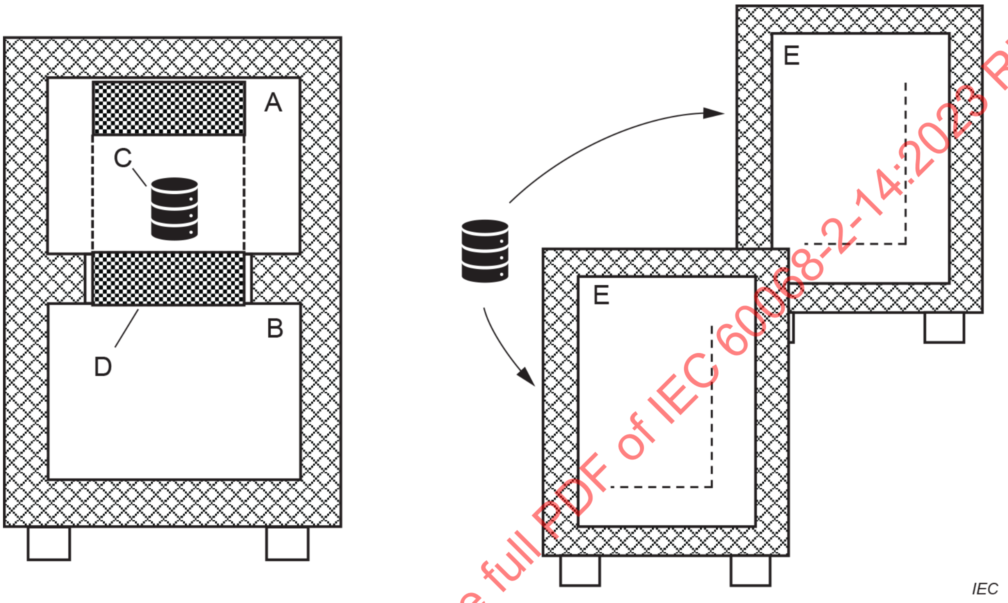
Some two-chamber method systems are known as thermal shock test cabinets. These systems combine characteristics of two separate test chambers and are equipped with a mobile lifting cage (applies for horizontal shock test chambers as well) for the automatic transfer of the specimens from one chamber to another (see Figure 2).

Damper shock test cabinets are another embodiment of a one-chamber test system. These systems contain two conditioning and one test chamber. The test chamber is alternately exposed to conditioned air from a hot respectively cold conditioning chamber via air flaps (see

Figure 3). No physical transfer is required and the transfer time t_2 is not applicable, when using this kind of test systems.

Damper shock test cabinets with a stationary test chamber, a hot chamber and a cold chamber are commonly capable of two-zone tests with hot respectively cold exposure. Some are capable of three-zone tests, including exposure to ambient air.

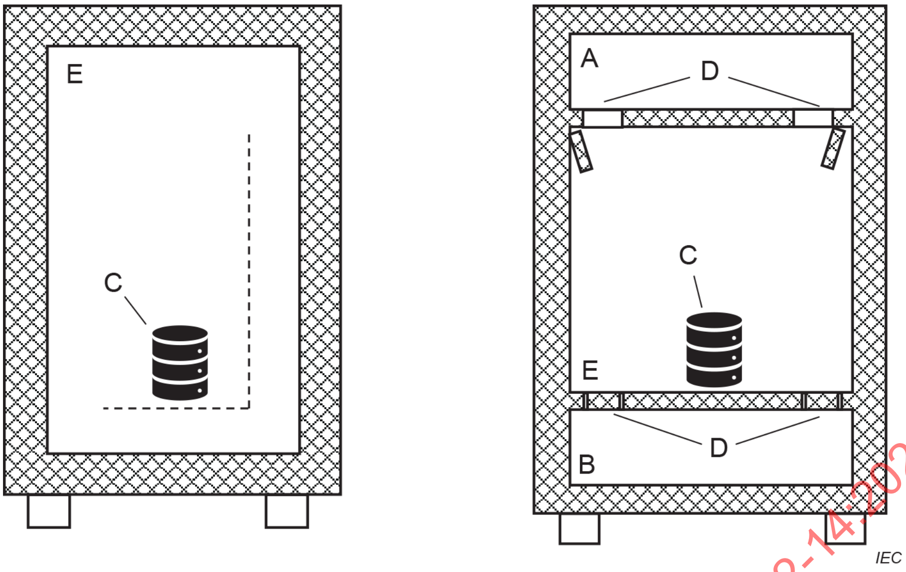
NOTE 1 Damper and basket-type test cabinets are often used for Test Na. Depending on the performance, two separate chambers or one rapid temperature change rate chamber are often used for Test Na as well. One rapid temperature change rate chamber is often used for Test Nb.



Key

A	hot chamber	**B**	cold chamber	**C**	specimen
D	mobile cage	**E**	stationary test space		

Figure 2 – Schematic representation of examples of thermal test cabinets and test procedure with two separate test chambers



Key

A	hot chamber	**B**	cold chamber	**C**	specimen
D	air flaps	**E**	stationary test space		

Figure 3 – Schematic representation of examples of thermal test cabinets with one test chamber

The chambers should be capable of maintaining the working space at the required temperatures.

After insertion of the test specimens, the temperature of the test medium shall be within the specified tolerance after a time of not more than 10 % of the exposure time t_1 of the specimen to each conditioning temperature. The temperature of the test medium refers to the control sensor of the test chamber, if not specified otherwise.

Owing to the specimen's lower rate of temperature change, its temperature can fall below the dew point temperature when bringing the specimens in the hot test environment (see Figure 4) or exposing them to ambient laboratory air (see Figure 5). During the rapid change to the high temperature T_B or when transferring the specimens from the cold chamber to the hot chamber, condensation of ambient air humidity should always be taken into consideration.

NOTE 2 Depending on the heat capacity and mass of the specimen, this phenomenon can be more or less pronounced.

Dehumidification during heating phases or compressed air dryers can be used to prevent condensation on the specimen's surface, if necessary.

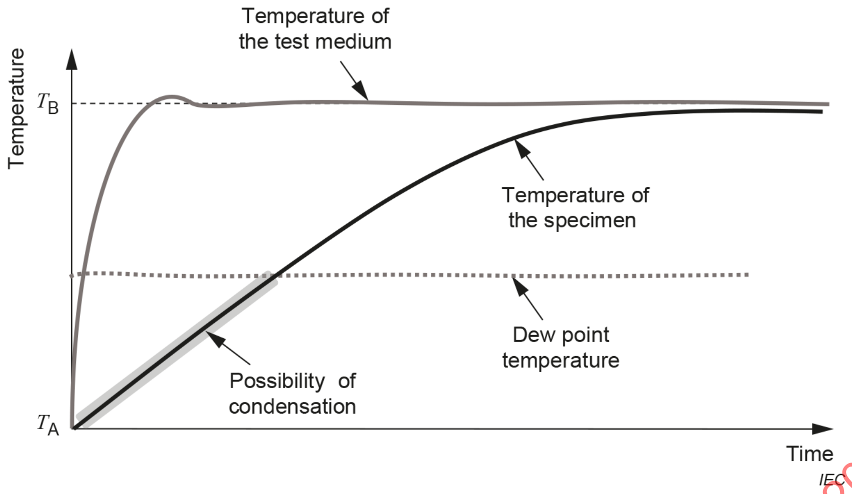


Figure 4 – Possibility of condensation during rapid temperature change

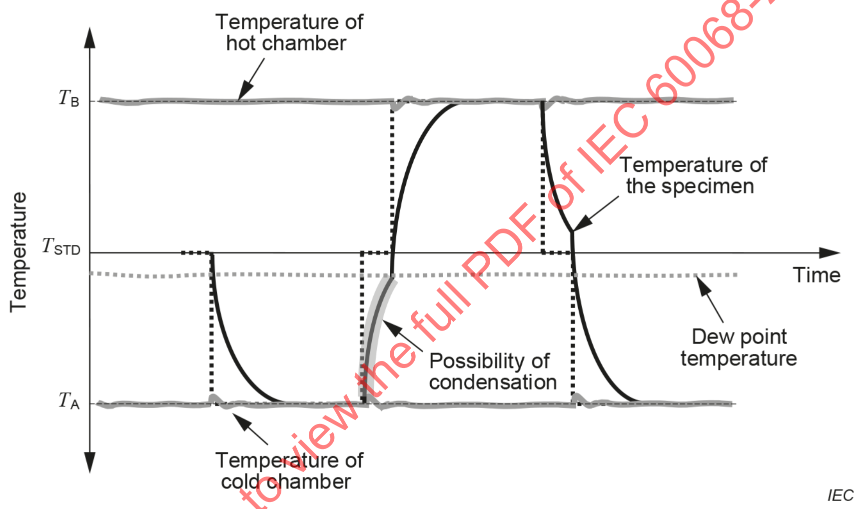


Figure 5 – Possibility of condensation during transfer of the specimen

7.2.2 Mounting or supporting of the test specimen

The thermal conduction of the mounting or supports shall be low, such that for practical purposes the specimen is thermally isolated, if not specified otherwise. When testing several specimens simultaneously they shall be so placed that free circulation shall be provided between specimens, and between specimens and chamber surfaces.

7.2.3 Severities

The severity of the test is defined by the combination of the two temperatures, the transfer time, the exposure time of the specimen and the number of cycles.

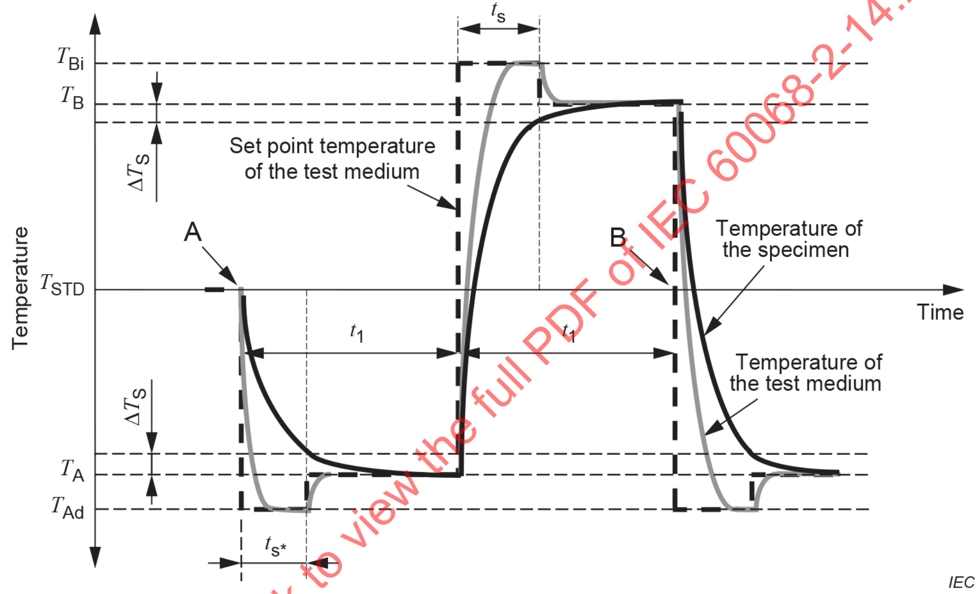
The ~~lower~~ low conditioning temperature T_A shall be specified in the relevant specification and ~~should~~ shall be chosen from the test temperatures of either IEC 60068-2-1 ~~and~~ or IEC 60068-2-2 or both, if not specified otherwise.

The ~~higher~~ high conditioning temperature T_B shall be specified in the relevant specification and ~~should~~ shall be chosen from the test temperatures of either IEC 60068-2-1 ~~and~~ or IEC 60068-2-2 or both, if not specified otherwise.

The exposure time t_1 ~~of~~ to each of the two conditioning temperatures depends on the heat capacity of the specimen. It ~~may~~ can be 3 h, 2 h, 1 h, 30 min or 10 min, or as specified in the relevant specification. Where no exposure period is specified in the relevant specification, it is understood to be 3 h.

NOTE The 10 min exposure time often applies to the testing of small specimens that achieve temperature stabilization without a significant time lag.

If temperature stabilization of the specimens cannot be achieved within the chosen exposure time, for example owing to a high heat capacity of the specimens, the severity of the test can be temporarily increased. The severity shall only be increased until temperature stabilization is achieved. A representative point (or points) on (or inside) the specimen can be used for this measurement. A higher severity of the test is achieved by increasing the temperature difference between the low conditioning temperature T_A and the high conditioning temperature T_B. Figure 6 provides a graphical representation of an increased severity.



Key

A start of first cycle

B end of first cycle and start of second cycle

Figure 6 – Increased severity of Test Na

The decreased low conditioning temperature T_{Ad} and the increased high conditioning temperature T_{Bi} should be chosen from the test temperatures of either IEC 60068-2-1 or IEC 60068-2-2 or both, if not specified otherwise.

When choosing the increased high conditioning temperature T_{Bi} and the decreased low conditioning temperature T_{Ad} the temperature limits of the specimen should be respected to avoid possible damage caused by the chosen temperature differences, if not specified otherwise. The chosen conditioning temperatures shall be given in the test report.

The preferred number of test cycles is 5, unless otherwise specified in the relevant specification.

~~NOTE The 10 min exposure time applies to the testing of small specimens.~~

7.2.4 Conditioning Preconditioning

The specimen and the temperature in the test chamber shall be at the ambient temperature of the laboratory, +25 °C ± 5 K standard atmospheric conditions for measurement and test T_{STD}, 15 °C to 35 °C. If required by the relevant specification, the specimen shall be brought into operating conditions.

7.2.5 Test cycle

The test specimen shall be exposed to the cold temperature, T_A.

The temperature, T_A, shall be maintained for the specified period t_1. t_1 includes an initial time, not longer than 0,1 t_1 for temperature stabilization of the air temperature in the chamber (see 7.2.1).

NOTE 1 The exposure time is measured from the moment of insertion of the specimen into the chamber.

The specimen shall then be exposed to the hot temperature, T_B, in a period, t_2, which should not be more than 3 min.

t_2 shall include the time need for the removal from one chamber and the insertion into the second chamber as well as any dwell time at the ambient temperature of the laboratory.

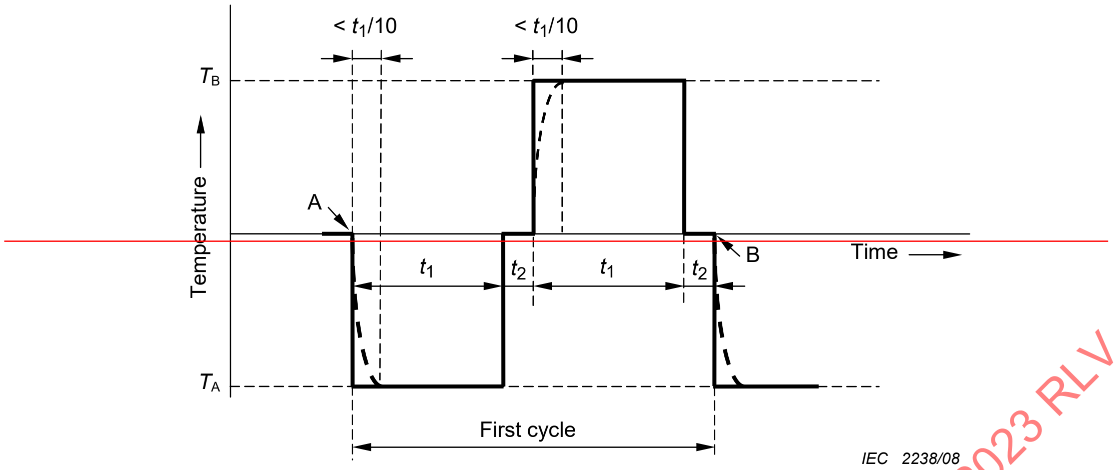
NOTE 2 For specimens with a large mass, the transfer time from one chamber to another may be increased as specified in the relevant standard or specification.

T_B shall be maintained for the specified period, t_1. t_1 includes an initial time, not longer than 0,1 t_1 for temperature stabilization of the air temperature in the chamber (see 7.2.1).

NOTE 3 The exposure time is measured from the moment of insertion of the specimen into the chamber.

For the next cycle the specimen shall be exposed to the cold temperature, T_A, in a transfer time, t_2, which shall not be more than 3 min.

The first cycle comprises the two exposure times, t_1, and the two transfer times, t_2 (see Figure 2).



~~**Key**~~

~~A start of first cycle~~
~~B end of first cycle and start of second cycle~~

~~NOTE The dotted curve is explained above.~~

~~**Figure 2 – Na test cycle**~~

~~At the end of the last cycle the specimen shall be subjected to the recovery procedures~~

a) One-chamber test method

The specimen shall be brought into the test chamber and be exposed to the temperature change to the low conditioning temperature T_A (see Figure 7).

The low conditioning temperature T_A shall be maintained for the specified exposure time t_1 (see 5.5). t_1 includes an initial time, not longer than 0,1 t_1 for temperature stabilization of the test medium.

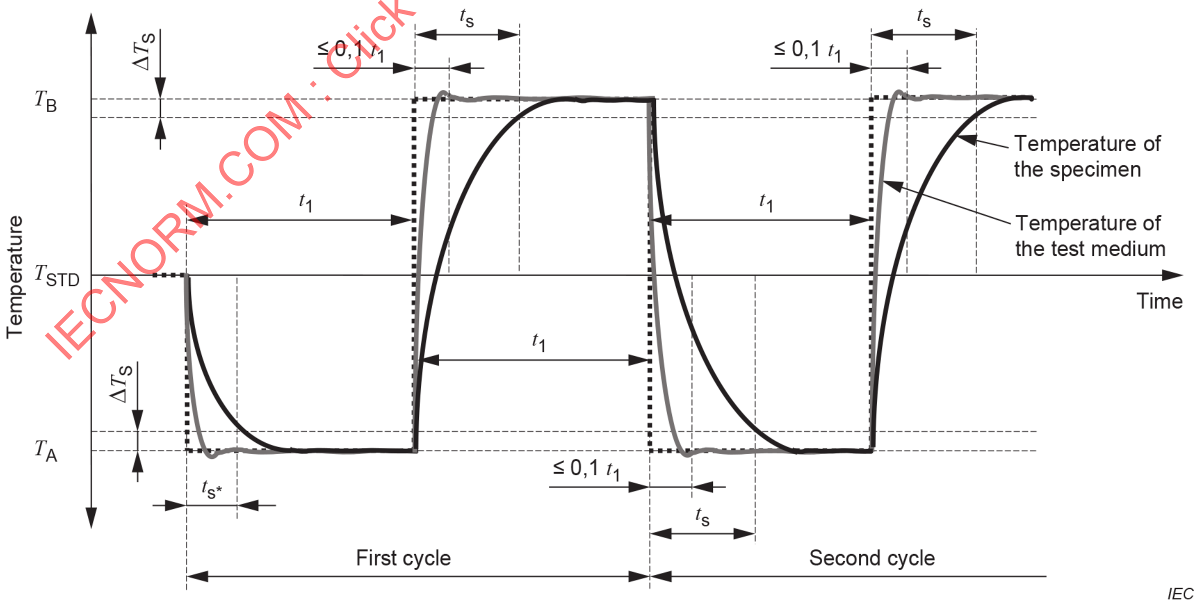


Figure 7 – Na test cycle, one-chamber method

NOTE 1 The exposure time is measured from the beginning of change of temperature within the chamber.

Temperature stabilization of the specimen (ΔT_s) can be achieved in the specified period t_1 (see Figure 7), if not specified otherwise. The time required for this is indicated with t_s.

NOTE 2 In some cases it can become necessary to extend t_1 to promote temperature equalization of the specimen or to initiate a certain relaxation process.

The specimen shall then be exposed to the temperature change to the high conditioning temperature T_B.

The high conditioning temperature T_B shall be maintained for the specified exposure time t_1. t_1 includes an initial time, not longer than 0,1 t_1 for temperature stabilization of the test medium.

Temperature stabilization of the specimen (ΔT_s) can be achieved in the specified period t_1 (see Figure 7), if not specified otherwise. The time required for this is indicated with t_s.

NOTE 3 In some cases it can become necessary to extend t_1 to promote temperature equalization of the specimen or to initiate a certain relaxation process.

For the next cycle the specimen shall be exposed to the low conditioning temperature T_A.

One cycle comprises the exposure time t_1 to both conditioning temperatures. At the end of the last cycle, the specimen shall be subjected to the recovery procedure (see 7.3).

NOTE 4 There are no transfer times required for the one-chamber test method.

b) Two-chamber test method

The test specimen shall be brought into the cold chamber and be exposed to the low conditioning temperature T_A.

The low conditioning temperature T_A shall be maintained for the specified exposure time t_1 (see 5.5). t_1 includes an initial time, not longer than 0,1 t_1, for temperature stabilization of the air temperature in the chamber (see Figure 8).

NOTE 5 The exposure time is measured from the moment of insertion of the specimen into the chamber.

Temperature stabilization of the specimen (ΔT_s) can be achieved in the specified period t_1 (see Figure 8), if not specified otherwise. The time required for this is indicated with t_s.

NOTE 6 In some cases it can become necessary to extend t_1 to promote temperature equalization of the specimen or to initiate a certain relaxation process.

The specimen shall then be brought into the hot chamber in a transfer time t_2, which should not be more than 3 min, and be exposed to the high conditioning temperature T_B.

The transfer time t_2 shall include the time needed for the removal from one chamber and the insertion into the second chamber as well as any dwell time at the ambient temperature of the laboratory.

NOTE 7 For specimens with a large mass or geometry, the transfer time from one chamber to another can be increased as specified in the relevant standard or specification (see 5.6).

The high conditioning temperature T_B shall be maintained for the specified exposure time t_1. t_1 includes an initial time, not longer than 0,1 t_1, for temperature stabilization of the air temperature in the chamber.

NOTE 8 The exposure time is measured from the moment of insertion of the specimen into the chamber.

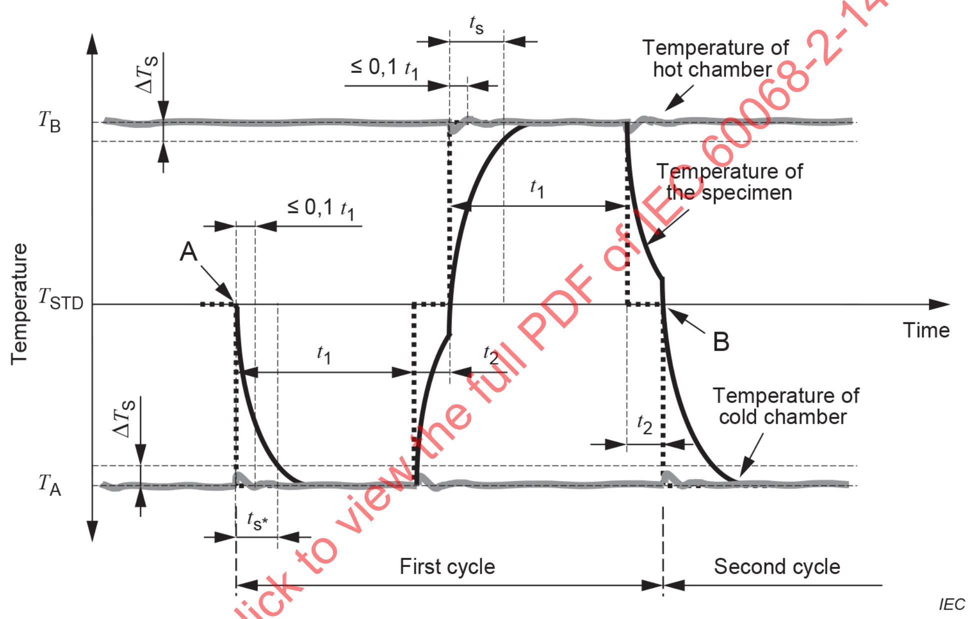
Temperature stabilization of the specimen (ΔT_s) can be achieved in the specified period t_1 (see Figure 8), if not specified otherwise. The time required for this is indicated with t_s.

NOTE 9 In some cases it can become necessary to extend t_1 to promote temperature equalization of the specimen or to initiate a certain relaxation process.

For the next cycle the specimen shall be brought into the cold chamber in a transfer time t_2, which should not be more than 3 min, and be exposed to the low conditioning temperature T_A.

NOTE 10 For specimens with a large mass or geometry, the transfer time from one chamber to another can be increased as specified in the relevant standard or specification (see 5.6).

One cycle comprises the exposure time t_1 to both conditioning temperatures and the two transfer times t_2 (see Figure 8). At the end of the last cycle, the specimen shall be subjected to the recovery procedure (see 7.3).



Key

A start of first cycle

B end of first cycle and start of second cycle

Figure 8 – Na test cycle, two-chamber method

7.3 Recovery

~~At the end of the test cycle, the specimen shall remain in standard atmospheric conditions for testing for a period adequate for the attainment of temperature stability.~~

~~The relevant specification may prescribe a specific recovery period for a given type of specimen.~~

At the end of the test cycle, the specimen shall be brought to the temperature of standard atmospheric conditions for measurement and test T_{STD}, 15 °C to 35 °C. It is recommended that the specimen be brought to this temperature within the specified period t_1, if not specified otherwise.

If this is not possible or specified otherwise, the temperature in the test chamber shall be lowered to the temperature of standard atmospheric conditions for measurement and test T_{STD}, 15 °C to 35 °C. It is recommended that the temperature be lowered to that of standard atmospheric conditions within the specified period t_1, if not specified otherwise.

NOTE Keeping the specimen exposed to the high conditioning temperature for an extended time after completion of the test can be seen as temperature storage, which can cause unintended damages to the specimen.

The specimen shall remain at the temperature of standard atmospheric conditions for measurement and test T_{STD}, 15 °C to 35 °C, for testing for a period adequate for the attainment of temperature stability. The relevant specification should specify a specific recovery period for a given type of specimen.

~~7.4 Information to be given in the relevant specification~~

~~When this test is included in the relevant specification, the following details shall be given as far as they are applicable:~~

~~a) Type of test~~

~~b) Preconditioning~~

~~c) Initial measurements~~

~~d) Details of mounting and supports~~

~~e) Low temperature T_A~~

~~– High temperature T_B~~

~~f) Duration of exposure t_1~~

~~g) Number of cycles~~

~~h) Measurements and/or loading during conditioning~~

~~i) Recovery~~

~~j) Final measurements~~

~~k) Any deviation in procedure as agreed upon between customer and supplier~~

8 Test Nb: Change of temperature with specified rate of change

8.1 General description of the test

This test determines the ability of components, equipment, or other articles to withstand ~~and/~~or function, or both, during changes of ambient temperature.

The specimen shall be either in the unpacked, switched-off, ready for use state, or as otherwise specified in the relevant specification.

The specimen is exposed to changes of temperature in air by exposure in a chamber to ~~prescribed~~ specified temperatures varied at a controlled rate. During this exposure the performance of the specimen ~~may~~ should be monitored.

8.2 Testing procedure

8.2.1 Testing chamber

The chamber for this test shall be designed so that in the working space, where the specimen under test is placed, a temperature cycle can be performed in such a manner that

a) the low temperature required for the test can be maintained,

b) the high temperature required for the test can be maintained,

c) the temperature change ~~rate~~ required for the test from low temperature to high temperature or vice versa can be performed at the required rate of change.

8.2.2 Mounting or supporting structure of the test specimen

Unless otherwise specified in the relevant specification, The thermal conduction of the mounting or supporting structure shall be low, such that for practical purposes the specimen is thermally isolated, if not specified otherwise. When testing several specimens simultaneously they shall be so placed that free circulation is provided between the specimens, and between the specimens and chamber surfaces.

8.2.3 Severities

The severity of the test is defined by the combination of the two temperatures, the rate of temperature change, the exposure time of the specimen and the number of cycles. The severity of the test will increase with an increase in the temperature difference, the increase in rate of temperature change, and the heat transfer to the specimen.

The lower low conditioning temperature T_A shall be specified in the relevant specification and should be chosen from the test temperatures of IEC 60068-2-1 and IEC 60068-2-2.

The higher high conditioning temperature T_B shall be specified in the relevant specification and should be chosen from the test temperatures of IEC 60068-2-1 and IEC 60068-2-2.

The air temperature shall be lowered or raised between 90 % and 10 % of D = T_B - T_A within a tolerance of 20 % of the temperature change rate. Preferred values are

(1 ± 0,2) K/min,

(3 ± 0,6) K/min,

(5 ± 1) K/min,

(10 ± 2) K/min, or

(15 ± 3) K/min,

unless otherwise specified in the relevant specification.

The rate of temperature change rate dT_R shall be specified in the relevant specification. Example rates are as follows, if not specified otherwise:

– 1 K/min,
– 3 K/min,
– 5 K/min,
– 10 K/min,
– 15 K/min,
– 20 K/min,
– 25 K/min.

NOTE Temperature change rates > 15 K/min can result in severe testing conditions.

The exposure time to each of the two temperatures t_1 depends upon the heat capacity and the mass of the specimen. It may can be 3 h, 2 h, 1 h, 30 min, or 10 min, or as specified in the relevant specification. Where no exposure period is prescribed specified in the relevant specification it is understood to be 3 h.

The specimen shall be subjected to two consecutive cycles, unless otherwise specified in the relevant specification.

8.2.4 Tolerance

Tolerances shall be specified in the relevant specification. If there are no tolerances specified, the following tolerances shall apply.

The calculation of the applicable temperature tolerance $\pm\sigma_T$ during the temperature transition depends on the temperature change rate dT_R and temperature difference D.

The applicable temperature tolerance of the medium temperature during temperature transition $\pm\sigma_T$ shall be selected from the larger of the two calculated values $\pm\sigma_{T,1}$ and $\pm\sigma_{T,2}$, if not specified otherwise. The value $\pm\sigma_{T,1}$ shall be calculated by using the temperature difference D multiplied with an adjustment factor of 0,075. The value $\pm\sigma_{T,2}$ shall be calculated by using the temperature change rate dT_R multiplied with a time constant of ±1 min.

The following applies:

$$\pm\sigma_T = \pm\sigma_{T,1} = \pm D \times 0{,}075 \qquad \text{for } \pm\sigma_{T,1} > \pm\sigma_{T,2} \qquad \text{or}$$

$$\pm\sigma_T = \pm\sigma_{T,2} = \pm dT_R \times (1\ \text{min}) \qquad \text{for } \pm\sigma_{T,1} < \pm\sigma_{T,2}$$

Annex C shows an auxiliary table with temperature tolerances for preferred combinations of high and low conditioning temperatures and rates of temperature change.

The applicable temperature tolerance $\pm\sigma_{Tconst}$ of the medium temperature during the constant conditioning shall respectively be taken from IEC 60068-2-1 and IEC 60068-2-2, if not specified otherwise.

NOTE 1 The constant conditioning temperature periods can be seen as phases of temperature storage.

NOTE 2 For large test chambers the tolerances $\pm\sigma_{Tconst}$ during the constant conditioning can differ, refer to IEC 60068-2-1 and IEC 60068-2-2.

The relevant specification can call for tighter tolerances under special circumstances, if necessary.

The tolerance $\pm\sigma_T$ is applied during transition starting from 10 % to 90 % of the temperature difference D. The tolerance $\pm\sigma_{Tconst}$ is applied after 0,1 t_1 but at least 5 min and at most 15 min from the start of the constant temperature conditioning period.

For the period 0,1 t_1 at the beginning of each constant temperature conditioning as well as at the beginning and end of each transition no tolerance is specified, as indicated by the hatched areas in Figure 9. For better understanding of the periods with and without applicable tolerance, see Figure 9. The tolerances apply to the temperature as measured by the chamber control sensor.

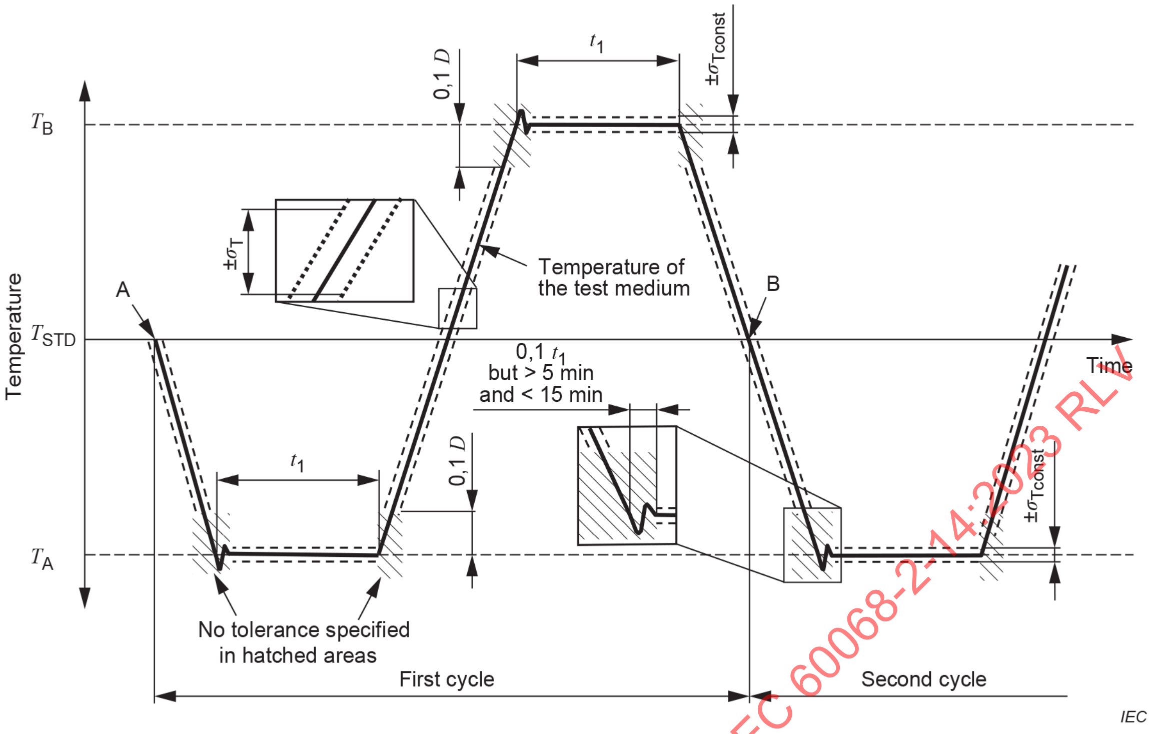


Figure 9 – Tolerance for fluctuation of test temperatures

8.2.5 ~~Conditioning~~ Preconditioning

The specimen and the temperature in the test chamber shall be at the ~~ambient~~ temperature of ~~the laboratory, +25 °C ±5 K~~ standard atmospheric conditions for measurement and test T_{STD}, 15 °C to 35 °C. If required by the relevant specification the specimen shall be brought into operating conditions.

8.3 Test cycle

The air temperature in the chamber shall then be lowered to the ~~specified~~ low conditioning temperature T_A at the specified rate dT_R (see Figure 10).

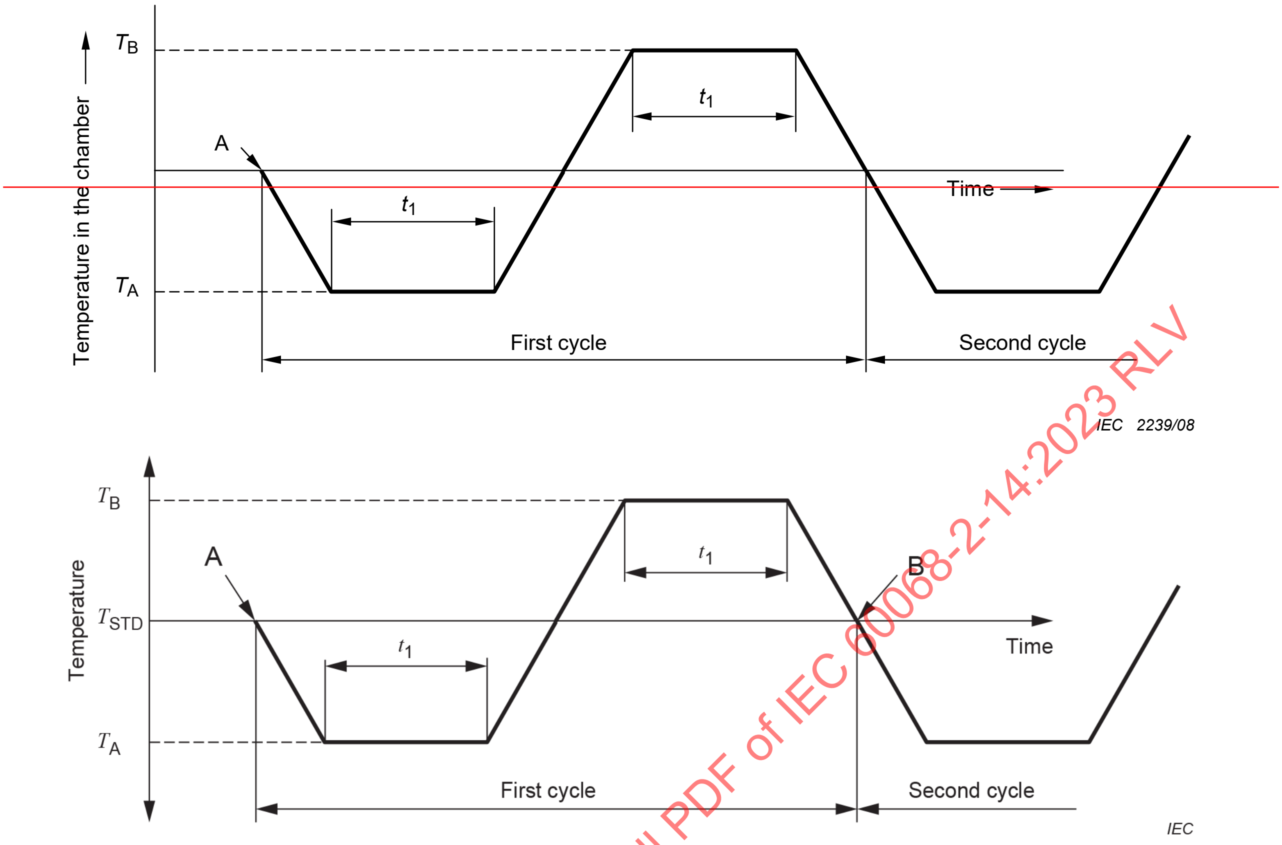
After temperature stability in the chamber has been reached, the specimen shall be exposed to ~~the low temperature condition for the specified period, t_1~~ the temperature T_A for the specified exposure time t_1.

The air temperature in the chamber shall then be raised to the ~~specified~~ high conditioning temperature T_B at the specified rate dT_R ~~(see Figure 3)~~.

After temperature stability in the chamber has been reached, the specimen shall be exposed to ~~the high temperature condition for the specified period, t_1~~ the temperature T_B for the specified exposure time t_1.

The air temperature in the chamber shall then be lowered to ~~the value of the laboratory ambient temperature, +25 °C ±5 K, at the specified rate (see Figure 3)~~ the temperature of standard atmospheric conditions for measurement and test T_{STD}, 15 °C to 35 °C, at the specified rate dT_R.

This procedure constitutes one cycle.



Key

A start of first cycle

B end of first cycle and start of second cycle

Figure 10 – Nb test cycle

To limit the impact of the heat generating specimen on the test severity it is recommended to perform functional checks only during constant temperature phases of each test, if not specified otherwise. Continuous operation of specimen can prevent temperature equalization of the inner parts of these specimens during cooling. The designated time frames are shown in Figure 11, they should be limited to 90 % of the exposure time t_1, if not specified otherwise. The designated time frame for functional tests should start after 0,1 t_1 but at least 5 min and at most 15 min from the start of the constant temperature conditioning period, for temperature stabilization of the medium temperature in the chamber, if not specified otherwise.

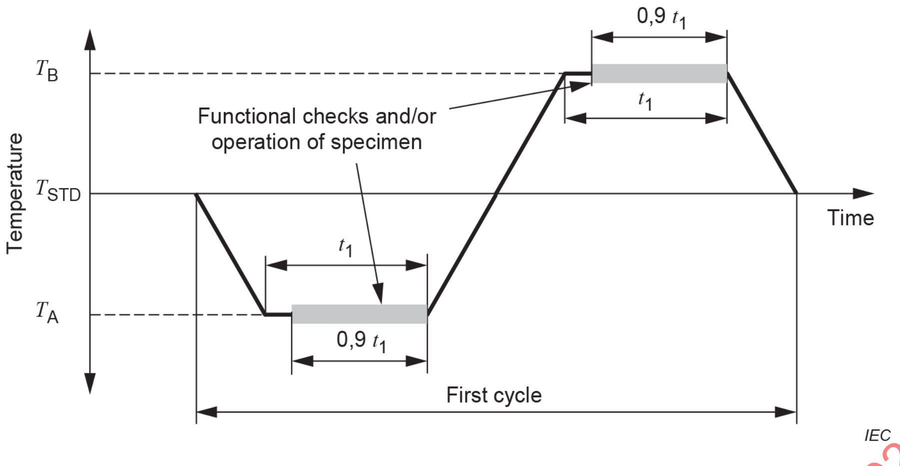


Figure 11 – Test times for intermediate operation of specimens

8.4 Recovery

At the end of the test cycle, the specimen shall remain ~~in~~ at the temperature of standard atmospheric conditions for measurement and test T_{STD}, 15 °C to 35 °C, for testing for a period adequate for the attainment of temperature stability.

The relevant specification ~~may prescribe~~ should specify a specific recovery period for a given type of specimen.

~~8.4 Information to be given in the relevant specification~~

~~When this test is included in the relevant specification, the following details shall be given as far as they are applicable:~~

~~a) Type of test~~

~~b) Preconditioning~~

~~c) Initial measurements~~

~~d) Details of mounting and supports~~

~~e) Low temperature T_A~~

~~High temperature T_B~~

~~f) Duration of exposure t_1~~

~~g) Rate of change of temperature~~

~~h) Number of cycles~~

~~i) Measurements and/or loading during conditioning~~

~~j) Recovery~~

~~k) Final measurements~~

~~l) Any deviation in procedure as agreed upon between customer and supplier~~

9 Test Nc: Rapid change of temperature, two-fluid-bath method

9.1 General description of the test

This test determines the ability of components, equipment, or other articles to withstand rapid changes of temperature.

This test procedure results in a severe thermal shock and is applicable to glass-metal seals and similar specimens.

The specimen is immersed alternately in two baths, one filled with liquid at a low temperature T_A and one filled with liquid at a high temperature T_B.

9.2 Testing procedure

9.2.1 Testing equipment

Two baths, one at low temperature and one at high temperature, shall be provided in such a way that the specimen under test can be easily immersed and be quickly transferred from one bath to the other.

The low temperature bath shall contain liquid at the lower low conditioning temperature T_A stated in the relevant specification. If no temperature is stated, the liquid shall have a temperature of 0 °C.

The bath for the high temperature shall contain liquid at the upper temperature T_B as required by the relevant specification. If no temperature is stated, the liquid shall have a temperature of +100 °C.

The baths shall be so constructed that at no moment during the test shall the temperature of the cold bath rise more than 2 K above T_A or the temperature of the warm hot bath fall more than 5 K below T_B.

The liquids used for the test shall be compatible with the materials and finishes used in the manufacture of the specimens.

NOTE The rate of heat transfer will depend upon the liquids used and will affect the severity of the test for a given temperature range. In special cases, the relevant specification should specify the liquids to be used.

9.2.2 Severities

The severity of the test is defined by the specified bath temperatures, the period of transfer time t_2 from one bath to the other, t_2, and the number of cycles. The severity of the test will increase with an increase in the temperature difference, the reduction of the transfer time, and the heat transfer to the specimen.

The relevant specification shall specify the duration parameters to be used and the chosen value of the exposure time t_1 to both conditioning temperatures.

The number of test cycles is 10, unless otherwise specified in the relevant specification.

9.2.3 Conditioning

The specimen shall be subjected to the test in the unpacked condition.

The specimen under test shall not be in operation during immersion. It shall be switched off and its movable parts shall be at rest, if not specified otherwise.

9.3 Test cycle

The specimen under test, while being at the ambient temperature of the laboratory, shall be immersed into the cold bath containing liquid at the low conditioning temperature T_A as stated in the relevant specification.

The specimen shall be maintained immersed in the cold bath for the appropriate period, specified exposure time t_1.

The specimen shall then be removed from the cold bath and immersed in the hot bath containing liquid at the high conditioning temperature T_B as stated in the relevant specification. The transfer time t_2 shall be as stated in the relevant specification.

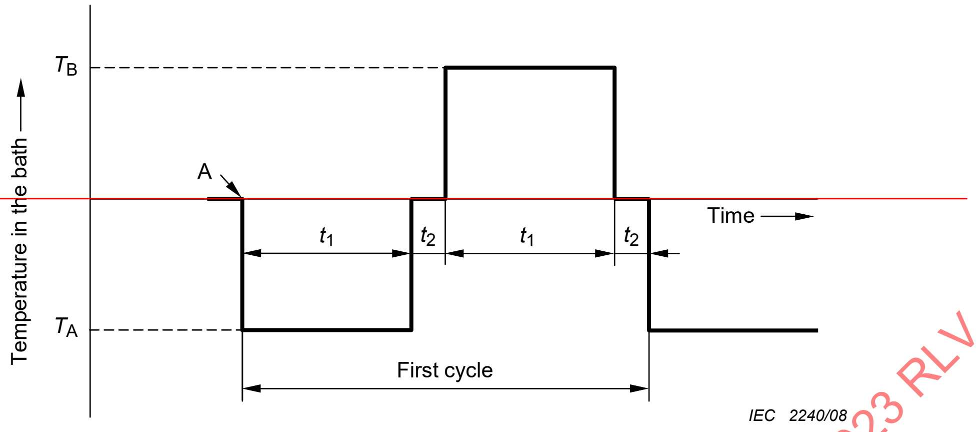
The specimen shall be maintained immersed in the hot bath for the ~~appropriate period,~~ specified exposure time t_1.

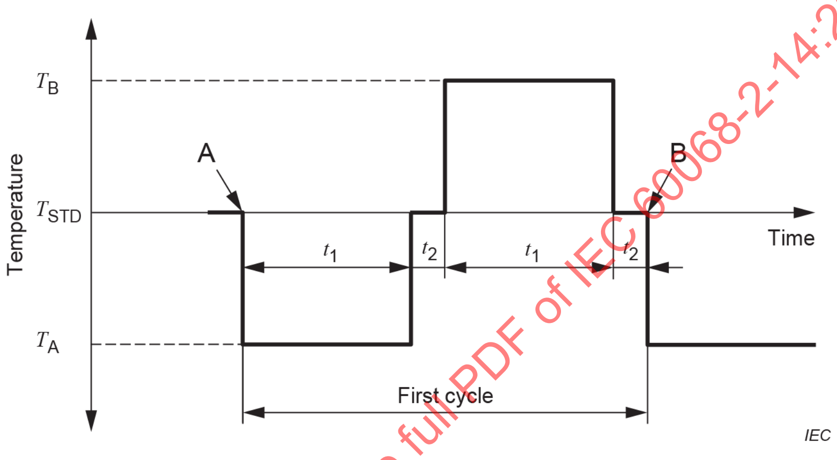
The specimen shall then be removed from the hot bath. The ~~period~~ transfer time t_2 between removal from the hot bath and immersion in the cold bath shall be as specified in the relevant specification.

~~One cycle consists of two immersion times, t_1, and two transfer times, t_2 (see Figure 4).~~

One cycle comprises the exposure times t_1 to both conditioning temperatures and the transfer time t_2 (see Figure 12).

At the end of the last cycle, the specimen shall be subjected to the recovery procedure.





Key

A start of first cycle

B end of first cycle, start of second cycle

Figure 12 – Nc test cycle

9.4 Recovery

At the end of the test cycle, the specimen shall be subjected to ~~laboratory ambient~~ the temperature of standard atmospheric conditions for measurement and test T_{STD}, 15 °C to 35 °C. Droplets of liquid shall be removed. If cleaning is necessary, then the method shall be defined by the relevant specification.

The relevant specification ~~may prescribe~~ should specify a specific recovery period for a given type of specimen.

~~9.5 Information to be given in the relevant specification~~

~~When this test is included in the relevant specification, the following details shall be given as far as they are applicable:~~

~~a) Type of test~~

~~b) Preconditioning~~

~~c) Initial measurements~~

~~d) Details of mounting and supports~~

~~e) Low temperature T_A, cold bath~~

~~High temperature T_B , hot bath~~

f) Duration of exposure t_1

g) Number of cycles

h) Liquids used

i) Measurements and/or loading during conditioning

j) Cleaning methods, if necessary

k) Recovery

l) Final measurements

m) Any deviation in procedure as agreed upon between customer and supplier

10 Information to be given in the test report

As a minimum, the test report shall show the following information:

a)	Customer	(name and address)
b)	Test laboratory	(name and address and details of accreditation - if any)
c)	Test dates	(dates when test was run)
d)	Type of test	(Na, Nb, or Nc)
e)	Purpose of test	(development, qualification, etc.)
f)	Test standard, edition	(IEC 60068-2-14, edition used)
g)	Relevant laboratory test procedure	(code and issue)
h)	Test specimen description	(drawing, photo, quantity build status, etc.).
i)	Test chamber identity	(manufacturer, model number, unique id, etc.)
j)	Performance of test apparatus	(set point temperature control, air flow, etc.)
k)	Air velocity and direction	(air velocity and direction of incident air to the specimen – for Tests Na and Nb only)
l)	Uncertainties of measuring system	(uncertainties data)
m)	Calibration data	(last and next due date)
n)	Initial, intermediate and final measurements	(initial, intermediate and final measurements)
o)	Required severities	(from relevant specification)
p)	Test severities	(measuring points, data etc.)
q)	Performance of test specimens	(results of functional tests etc.)
r)	Observations during testing and actions taken	(any pertinent observations)
s)	Summary of test	(test summary)
t)	Distribution	(distribution list)

a)	Customer	(name and address);
b)	Test laboratory	(name and address and details of accreditation – if any);
c)	Test dates	(dates when test was run);
d)	Type of test	(Na, Nb, Nc);
e)	Test standard, edition	(IEC 60068-2-14, edition used);
f)	Test specimen description	(drawing, photo, quantity build status, etc.);
g)	Test chamber identity	(unique identity of the chamber, e.g. internal Laboratory Identification number/code);
h)	Test set-up	(details of mounting and supports, measuring points, test medium, etc.);
i)	Initial, intermediate and final measurements	(if performed by the test laboratory);
j)	Required severities	(from relevant specification);
k)	Test severities	(preconditioning, temperatures, duration of exposure, data, etc.);
l)	Performance of test specimens	(results of functional tests, etc.);
m)	Observations during testing and actions taken	(any pertinent observations);
n)	Test results	(test summary, e.g. pass/fail decision).

In addition to the mandatory information the test report can include, for example:

o)	Purpose of test	(development, qualification, etc.);
p)	Relevant laboratory test procedure	(code and issue);
q)	Performance of test apparatus	(set point temperature control, air flow, etc.);
r)	Air velocity or direction or both	(air velocity or direction of incident air to the specimen or both);
s)	Uncertainties of chamber independent measuring system	(uncertainties data);
t)	Calibration data	(last and next due date);
u)	Measurements or loading during conditioning or both;	
v)	Any deviation in procedure as agreed between customer and supplier	(test set-up, applicable severities, etc.).

A test log should be written for the testing which can be attached to the report.

Annex A
(informative)

Potential consequences of improper severities

Accelerated temperature stress tests are an important aspect to evaluate the reliability of products and components over their entire life cycle. Complex geometries and differing materials cause mechanical stress within the specimens during cyclic temperature tests.

To guarantee the reliability of the test results, the intended change of temperature of the specimens should be ensured.

The change of temperature of a specimen follows an approximately exponential law. Inside large specimens or specimens with low thermal conductivity, such alternate exponential rises and decreases can lead to periodic and approximately sinusoidal changes of temperature with much lower amplitudes than the applied temperature swing. It is possible that the intended peak temperatures will not be reached in accelerated temperature tests. Figure A.1 gives a graphical display of this process.

NOTE It is common practice to examine the sample in advance to identify those parts that affect the slow temperature change of the sample. The results of the analysis can then be considered in the stabilization time of the sample.

For this reason, the monitoring of the temperature of the specimens at a representative point (or points) is recommended.

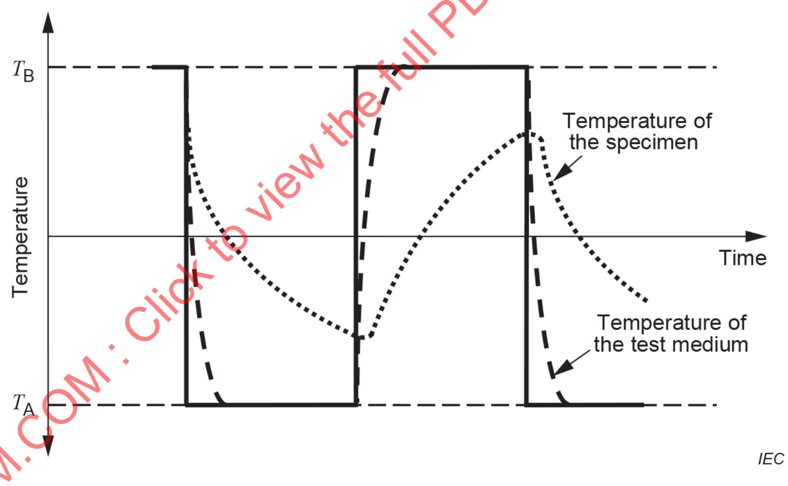


Figure A.1 – Delayed temperature change of the specimen

Annex B
(informative)

Thermal responsiveness of different materials and geometries

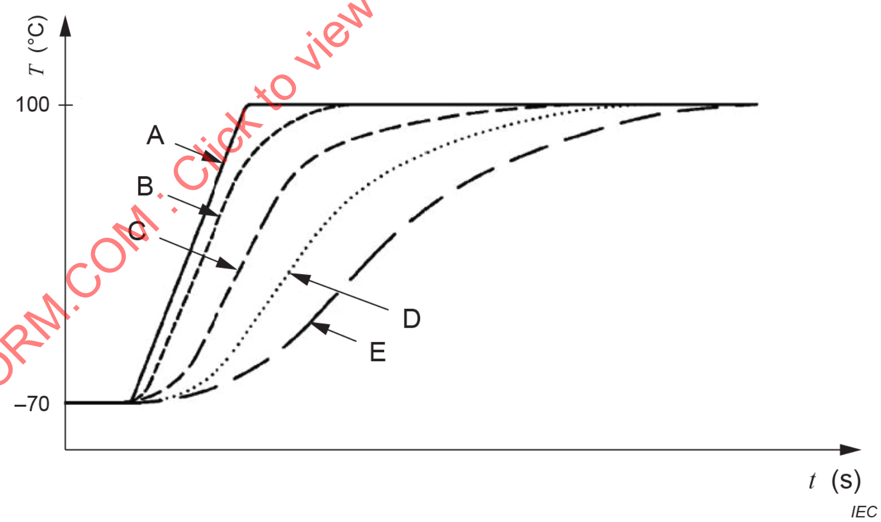
The specimen's characteristics, such as its thermal conductivity, its specific heat capacity as well as its mass and geometry can have a significant effect on the thermal responsiveness of the specimen. The rate of temperature change of the specimen during temperature stress tests is highly affected by its thermal responsiveness.

Small specimens with low specific heat capacity, as well as specimen with a proportionally large surface, will quickly respond to temperature changes of the ambient medium. Big specimens with higher specific heat capacity, as well as specimens with a rather small surface will respond with a significant time lag and lower rates of changes. Figure B.1 gives a graphical representation of the process described above. The figure shows exemplary temperature profiles of specimens with differing thermal responsiveness (C to E).

The specimen with high thermal responsiveness (C) responds almost immediately to the rise of ambient air temperature (B), whereas both specimens with lower thermal responsiveness (D and E) show an increasing time lag.

Furthermore, low thermal conductivities can lead to non-uniform temperature changes within the specimens as seen within the cylindric specimen made of plastic. These can prevent the specimen's core temperature from temperature equalization. This effect can be amplified in specimens with high masses.

These characteristics shall be taken into consideration when specifying any test parameters. If these characteristics are unknown, their experimental determination is recommended. For further information on the thermal responsiveness of specimens IEC 60068-3-1 can be helpful.



A set point test temperature

B air temperature within test chamber

C specimen with high thermal responsiveness

D specimen with medium thermal responsiveness

E specimen with low thermal responsiveness

Figure B.1 – Rate of temperature change of specimen with differing thermal responsiveness

Annex C
(normative)

Auxiliary table with exemplary temperature tolerances ±σT for preferred combinations of high and low conditioning temperatures and rates of temperature change (Test Nb)

Tolerances shall be specified in the relevant specification. If there are no tolerances specified, the following tolerances shall apply.

The calculation of the applicable temperature tolerance $\pm\sigma_T$ during the temperature transition depends on the temperature change rate and temperature difference D.

The applicable temperature tolerance of the medium temperature during temperature transition $\pm\sigma_T$ shall be selected from the larger of the two calculated values $\pm\sigma_{T,1}$ and $\pm\sigma_{T,2}$, if not specified otherwise.

The value $\pm\sigma_{T,1}$ shall be calculated by using the temperature difference D multiplied with an adjustment factor of 0,075. The value $\pm\sigma_{T,2}$ shall be calculated by using the temperature change rate $\mathrm{d}T_R$ multiplied with a time constant of ±1 min.

The following applies:

$$\pm\sigma_T = \pm\sigma_{T,1} = \pm D \times 0{,}075\text{, for } \pm\sigma_{T,1} > \pm\sigma_{T,2} \qquad (C.1)$$

$$\pm\sigma_T = \pm\sigma_{T,2} = \pm\mathrm{d}T_R \times (1\ \text{min})\text{, for } \pm\sigma_{T,1} < \pm\sigma_{T,2} \qquad (C.2)$$

For a better understanding, the following example and Figure C.1 show the applicable tolerance for exemplary test parameters. Additionally, Table C.1 gives an overview of applicable tolerances for preferred combinations of high and low conditioning temperatures as well as rates of temperature change $\mathrm{d}T_R$.

NOTE For large test chambers the tolerances $\pm\sigma_{Tconst}$ during the constant conditioning can differ, refer to IEC 60068-2-1 and IEC 60068-2-2.

EXAMPLE

T_A = −55 °C

T_B = 85 °C

$\mathrm{d}T_R$ = 3 K/min

$$\pm\sigma_{T,1} = \pm D \times 0{,}075 = \pm(85\,°C - (-55\,°C)) \times 0{,}075 = \pm 140\,\text{K} \times 0{,}075 = \pm 10{,}5\,\text{K} \qquad (C.3)$$

$$\pm\sigma_{T,2} = \pm\mathrm{d}T_R \times (1\text{min}) = \pm 3\ \text{K/min} \times (1\text{min}) = \pm 3\ \text{K} \qquad (C.4)$$

$$\pm\sigma_{T,1} > \pm\sigma_{T,2} \quad \rightarrow \pm\sigma_{T} = \pm\sigma_{T,1} = \pm 10{,}5\,K \qquad (C.5)$$

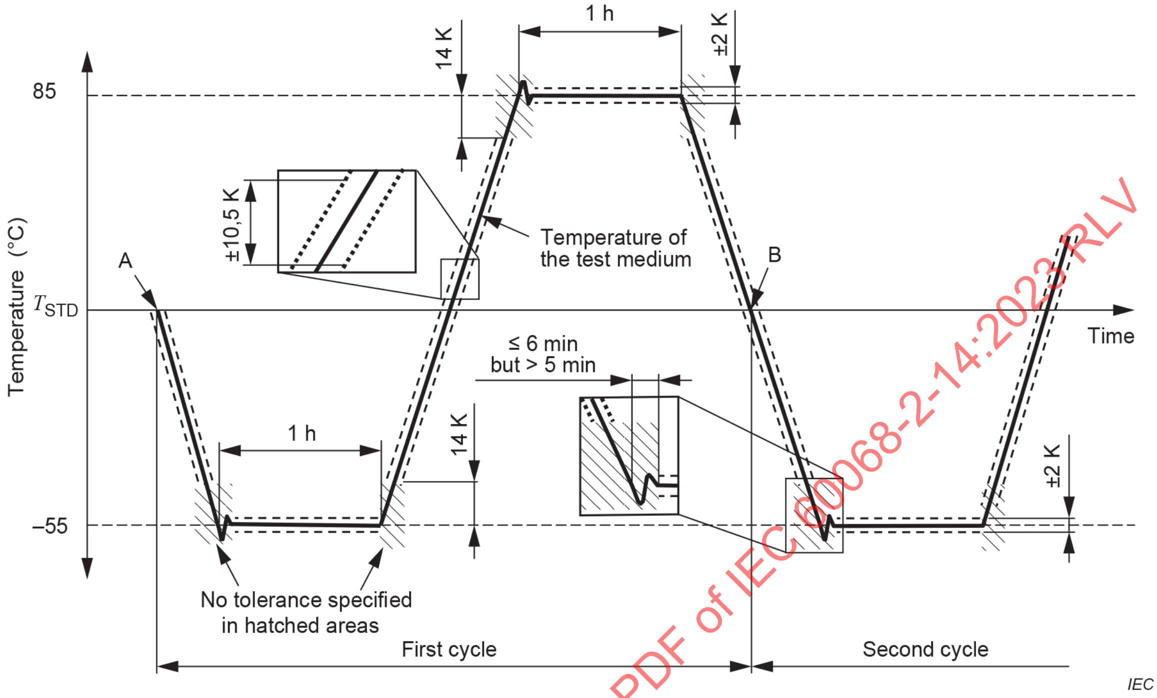


Figure C.1 – Tolerance for fluctuation of test temperatures for exemplary test parameters

Table C.1 – Applicable temperature tolerances $\pm\sigma_T$ in K for preferred combinations of high and low conditioning temperatures and rates of temperature change dT_R

dT_R = 1 K/min		High conditioning temperature T_B														
		30 °C	35 °C	40 °C	45 °C	50 °C	55 °C	60 °C	65 °C	70 °C	85 °C	100 °C	125 °C	155 °C	175 °C	200 °C
Low conditioning temperature T_A	−65 °C	±7,1	±7,5	±7,9	±8,3	±8,6	±9,0	±9,4	±9,8	±10,1	±11,3	±12,4	±14,3	±16,5	±18,0	±19,9
	−55 °C	±6,4	±6,8	±7,1	±7,5	±7,9	±8,3	±8,6	±9,0	±9,4	±10,5	±11,6	±13,5	±15,8	±17,3	±19,1
	−50 °C	±6,0	±6,4	±6,8	±7,1	±7,5	±7,9	±8,3	±8,6	±9,0	±10,1	±11,3	±13,1	±15,4	±16,9	±18,8
	−40 °C	±5,3	±5,6	±6,0	±6,4	±6,8	±7,1	±7,5	±7,9	±8,3	±9,4	±10,5	±12,4	±14,6	±16,1	±18,0
	−33 °C	±4,7	±5,1	±5,5	±5,9	±6,2	±6,6	±7,0	±7,4	±7,7	±8,9	±10,0	±11,9	±14,1	±15,6	±17,5
	−25 °C	±4,1	±4,5	±4,9	±5,3	±5,6	±6,0	±6,4	±6,8	±7,1	±8,3	±9,4	±11,3	±13,5	±15,0	±16,9
	−20 °C	±3,8	±4,1	±4,5	±4,9	±5,3	±5,6	±6,0	±6,4	±6,8	±7,9	±9,0	±10,9	±13,1	±14,6	±16,5
	−10 °C	±3,0	±3,4	±3,8	±4,1	±4,5	±4,9	±5,3	±5,6	±6,0	±7,1	±8,3	±10,1	±12,4	±13,9	±15,8
	−5 °C	±2,6	±3,0	±3,4	±3,8	±4,1	±4,5	±4,9	±5,3	±5,6	±6,8	±7,9	±9,8	±12,0	±13,5	±15,4
	5 °C	±1,9	±2,3	±2,6	±3,0	±3,4	±3,8	±4,1	±4,5	±4,9	±6,0	±7,1	±9,0	±11,3	±12,8	±14,6
dT_R = 3 K/min		High conditioning temperature T_B														
		30 °C	35 °C	40 °C	45 °C	50 °C	55 °C	60 °C	65 °C	70 °C	85 °C	100 °C	125 °C	155 °C	175 °C	200 °C
Low conditioning temperature T_A	−65 °C	±7,1	±7,5	±7,9	±8,3	±8,6	±9,0	±9,4	±9,8	±10,1	±11,3	±12,4	±14,3	±16,5	±18,0	±19,9
	−55 °C	±6,4	±6,8	±7,1	±7,5	±7,9	±8,3	±8,6	±9,0	±9,4	±10,5	±11,6	±13,5	±15,8	±17,3	±19,1
	−50 °C	±6,0	±6,4	±6,8	±7,1	±7,5	±7,9	±8,3	±8,6	±9,0	±10,1	±11,3	±13,1	±15,4	±16,9	±18,8
	−40 °C	±5,3	±5,6	±6,0	±6,4	±6,8	±7,1	±7,5	±7,9	±8,3	±9,4	±10,5	±12,4	±14,6	±16,1	±18,0
	−33 °C	±4,7	±5,1	±5,5	±5,9	±6,2	±6,6	±7,0	±7,4	±7,7	±8,9	±10,0	±11,9	±14,1	±15,6	±17,5
	−25 °C	±4,1	±4,5	±4,9	±5,3	±5,6	±6,0	±6,4	±6,8	±7,1	±8,3	±9,4	±11,3	±13,5	±15,0	±16,9
	−20 °C	±3,8	±4,1	±4,5	±4,9	±5,3	±5,6	±6,0	±6,4	±6,8	±7,9	±9,0	±10,9	±13,1	±14,6	±16,5
	−10 °C	±3,0	±3,4	±3,8	±4,1	±4,5	±4,9	±5,3	±5,6	±6,0	±7,1	±8,3	±10,1	±12,4	±13,9	±15,8
	−5 °C	±3,0	±3,0	±3,4	±3,8	±4,1	±4,5	±4,9	±5,3	±5,6	±6,8	±7,9	±9,8	±12,0	±13,5	±15,4
	5 °C	±3,0	±3,0	±3,0	±3,0	±3,4	±3,8	±4,1	±4,5	±4,9	±6,0	±7,1	±9,0	±11,3	±12,8	±14,6

dT_R = 5 K/min		High conditioning temperature T_B														
		30 °C	35 °C	40 °C	45 °C	50 °C	55 °C	60 °C	65 °C	70 °C	85 °C	100 °C	125 °C	155 °C	175 °C	200 °C
Low conditioning temperature T_A	−65 °C	±7,1	±7,5	±7,9	±8,3	±8,6	±9,0	±9,4	±9,8	±10,1	±11,3	±12,4	±14,3	±16,5	±18,0	±19,9
	−55 °C	±6,4	±6,8	±7,1	±7,5	±7,9	±8,3	±8,6	±9,0	±9,4	±10,5	±11,6	±13,5	±15,8	±17,3	±19,1
	−50 °C	±6,0	±6,4	±6,8	±7,1	±7,5	±7,9	±8,3	±8,6	±9,0	±10,1	±11,3	±13,1	±15,4	±16,9	±18,8
	−40 °C	±5,3	±5,6	±6,0	±6,4	±6,8	±7,1	±7,5	±7,9	±8,3	±9,4	±10,5	±12,4	±14,6	±16,1	±18,0
	−33 °C	±5,0	±5,1	±5,5	±5,9	±6,2	±6,6	±7,0	±7,4	±7,7	±8,9	±10,0	±11,9	±14,1	±15,6	±17,5
	−25 °C	±5,0	±5,0	±5,0	±5,3	±5,6	±6,0	±6,4	±6,8	±7,1	±8,3	±9,4	±11,3	±13,5	±15,0	±16,9
	−20 °C	±5,0	±5,0	±5,0	±5,0	±5,3	±5,6	±6,0	±6,4	±6,8	±7,9	±9,0	±10,9	±13,1	±14,6	±16,5
	−10 °C	±5,0	±5,0	±5,0	±5,0	±5,0	±5,0	±5,3	±5,6	±6,0	±7,1	±8,3	±10,1	±12,4	±13,9	±15,8
	−5 °C	±5,0	±5,0	±5,0	±5,0	±5,0	±5,0	±5,0	±5,3	±5,6	±6,8	±7,9	±9,8	±12,0	±13,5	±15,4
	5 °C	±5,0	±5,0	±5,0	±5,0	±5,0	±5,0	±5,0	±5,0	±5,0	±6,0	±7,1	±9,0	±11,3	±12,8	±14,6

dT_R = 10 K/min		High conditioning temperature T_B														
		30 °C	35 °C	40 °C	45 °C	50 °C	55 °C	60 °C	65 °C	70 °C	85 °C	100 °C	125 °C	155 °C	175 °C	200 °C
Low conditioning temperature T_A	−65 °C	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,1	±11,3	±12,4	±14,3	±16,5	±18,0	±19,9
	−55 °C	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,5	±11,6	±13,5	±15,8	±17,3	±19,1
	−50 °C	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,1	±11,3	±13,1	±15,4	±16,9	±18,8
	−40 °C	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,5	±12,4	±14,6	±16,1	±18,0
	−33 °C	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±11,9	±14,1	±15,6	±17,5
	−25 °C	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±11,3	±13,5	±15,0	±16,9
	−20 °C	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,9	±13,1	±14,6	±16,5
	−10 °C	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,1	±12,4	±13,9	±15,8
	−5 °C	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±12,0	±13,5	±15,4
	5 °C	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±11,3	±12,8	±14,6

dT_R = 15 K/min		High conditioning temperature T_B														
		30 °C	35 °C	40 °C	45 °C	50 °C	55 °C	60 °C	65 °C	70 °C	85 °C	100 °C	125 °C	155 °C	175 °C	200 °C
Low conditioning temperature T_A	−65 °C	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±16,5	±18,0	±19,9
	−55 °C	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,8	±17,3	±19,1
	−50 °C	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,4	±16,9	±18,8
	−40 °C	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±16,1	±18,0
	−33 °C	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,6	±17,5
	−25 °C	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±16,9
	−20 °C	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±16,5
	−10 °C	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,8
	−5 °C	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,4
	5 °C	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0

dT_R = 20 K/min		High conditioning temperature T_B														
		30 °C	35 °C	40 °C	45 °C	50 °C	55 °C	60 °C	65 °C	70 °C	85 °C	100 °C	125 °C	155 °C	175 °C	200 °C
Low conditioning temperature T_A	−65 °C	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0
	−55 °C	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0
	−50 °C	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0
	−40 °C	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0
	−33 °C	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0
	−25 °C	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0
	−20 °C	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0
	−10 °C	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0
	−5 °C	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0
	5 °C	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0

dT_R = 25 K/min		High conditioning temperature T_B														
		30 °C	35 °C	40 °C	45 °C	50 °C	55 °C	60 °C	65 °C	70 °C	85 °C	100 °C	125 °C	155 °C	175 °C	200 °C
Low conditioning temperature T_A	−65 °C	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0
	−55 °C	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0
	−50 °C	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0
	−40 °C	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0
	−33 °C	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0
	−25 °C	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0
	−20 °C	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0
	−10 °C	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0
	−5 °C	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0
	5 °C	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0

Bibliography

IEC 60068 (all parts), *Environmental testing*

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

IEC 60068-2-17, *Environmental testing – Part 2-17: Tests – Test Q: Sealing*

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

IEC 60068-2-67, *Environmental testing – Part 2-67: Tests – Test Cy: Damp heat, steady state, accelerated test primarily intended for components*

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

____

IEC 60068-2-14

Edition 7.0 2023-07

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Environmental testing –
Part 2-14: Tests – Test N: Change of temperature

Essais d'environnement –
Partie 2-14: Essais – Essai N: Variation de température

IEC 60068-2-14:2023-07(en-fr)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

____

ENVIRONMENTAL TESTING –

Part 2-14: Tests – Test N: Change of temperature

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at https://patents.iec.ch or www.iso.org/patents. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 60068-2-14 has been prepared by IEC technical committee 104: Environmental conditions, classification and methods of test. It is an International Standard.

This seventh edition cancels and replaces the sixth edition published in 2009. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) updating of the figures for clarification purposes;
b) updating of specimen temperature(s) and severities as well as tolerances for change of temperature tests;
c) revision of standardized requirements for test reports for Tests Na and Nb.

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

Draft	Report on voting
104/991/FDIS	104/1016/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,
- replaced by a revised edition, or
- amended.

INTRODUCTION

A change of temperature test is intended to determine the effect on the specimen of a change of temperature or a succession of changes of temperature.

It is not intended to show effects that are caused by low or high temperature exposure. For these effects, the cold test or the dry heat test, as specified in IEC 60068-2-1 and IEC 60068-2-2, should be used.

The effect of change of temperature tests is determined by

– values of high and low conditioning temperature between which the change is to be affected,
– the conditioning times for which the test specimen is kept at these temperatures,
– the rate of change between these temperatures,
– the number of cycles of conditioning,
– the amount of heat transfer into or from the specimen,
– the thermal conductivity and the materials of the specimen,
– the rate of change of the specimen’s temperature on its surface (respectively in relevant positions) or in its core.

Guidance on the choice of suitable test parameters for inclusion in the detail specification is given throughout this document.

ENVIRONMENTAL TESTING –

Part 2-14: Tests – Test N: Change of temperature

1 Scope

This document provides tests with specified ambient temperature changes to analyse their impacts on specimens.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60068-2-1 and IEC 60068-2-2 apply.

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

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

4 Symbols

D	temperature difference between high conditioning temperature T_B and low conditioning temperature T_A
T_A	low conditioning temperature
T_{Ad}	decreased low conditioning temperature
T_B	high conditioning temperature
T_{Bi}	increased high conditioning temperature
T_{STD}	temperature of standard atmospheric conditions for measurement and tests (15 °C to 35 °C)
ΔT_s	temperature difference between the specimen and the test medium (e.g. air)
dT_R	temperature change rate (Test Nb)
t_s	stabilization time of specimen temperature
t_{s*}	stabilization time of specimen temperature during the first cycle, starting from laboratory air temperature
t_1	exposure time of the specimen to each conditioning temperature
t_2	transfer time of the specimen from one test chamber to another (two-chamber test method)
$\pm\sigma_T$	applicable temperature tolerance of the medium temperature during temperature transition (Test Nb)
$\pm\sigma_{Tconst}$	applicable temperature tolerance of the medium temperature during the constant conditioning

5 General

5.1 Field conditions of changing temperature

It is common in electronic equipment and components that changes of temperature occur. Parts inside equipment undergo slower changes of temperature than those on an external surface when the equipment is not switched on.

Rapid changes of temperature can be expected

- when equipment is transported from warm indoor into cold outdoor environments or vice versa,
- when equipment is suddenly cooled by rainfall or immersion in cold water,
- when equipment is attached or in close proximity to components leading to high thermal stress (e.g. combustion engines, central processing units),
- when equipment is artificially cooled or heated,
- in externally mounted airborne equipment or when equipment is located in unheated aircraft or cargo holds,
- under certain conditions of transportation and storage.

Components will undergo stresses due to changing temperature when high temperature gradients build up in an equipment after being switched on, for example in the proximity of high power resistors, radiation can cause rise of the surface temperature on close components while other portions remain cold.

Artificially cooled components can be subjected to rapid temperature changes when the cooling system is switched on. Rapid changes of temperature in components can also be induced during manufacturing processes or the transportation of equipment. Both the number and amplitude of temperature changes, the time interval between them and the thermal responsiveness of the equipment (or specimen) are important.

5.2 Design of tests with temperature change

Change of temperature Tests Na, Nb and Nc comprise alternate periods at a high and a low temperature with well-defined transfers from one temperature to the other. The conditioning run from the laboratory ambient temperature to the first conditioning temperature, then to the second conditioning temperature, then back to the laboratory ambient temperature is considered as one test cycle.

5.3 Test parameters

Test parameters comprise the following:

- laboratory ambient conditions (mainly temperature and humidity);
- high conditioning temperature T_B;
- increased high conditioning temperature T_{Bi}, if applicable;
- low conditioning temperature T_A;
- decreased low conditioning temperature T_{Ad}, if applicable;
- exposure time t_1 of the specimen to each conditioning temperature;
- transfer time t_2 or temperature change rate dT_R;
- number of test cycles.

As these tests are intended to validate the effects of temperature changes on the specimen, the specimen's characteristics should always be taken into consideration (if not specified otherwise):

- thermal responsiveness of the specimen in affected areas or the core;
  - thermal conductivity;
  - specific heat capacity;
- density;
- geometry;
- mass.

The experimental determination of these characteristics is recommended, if unknown and not specified otherwise.

The test is accelerated because the number of severe changes of temperature in a given period is greater than that which will occur under field conditions.

The high and low conditioning temperatures are understood to be ambient temperatures which will be reached by most specimens with a certain time lag. It is recommended to consider the specimen's characteristics when specifying the test. Annex A gives further information on potential consequences of improper severities of tests.

Only in exceptional cases should these temperatures be specified outside the normal storage or operating temperature range of the object under test.

NOTE If the specimen's characteristics (mass, density, geometry) prevent the specified rate of change, the temperatures can be specified outside the normal storage or operating temperatures to increase the severity of the intended test, if not specified otherwise.

5.4 Purpose and choice of the tests

Change of temperature testing is recommended in the following cases:

– evaluation of electrical performance after a specified number of rapid changes of temperature, Test Na or Test Nc;

– evaluation of the suitability of mechanical components, and of materials and combinations of materials to withstand rapid changes of temperature, Test Na or Test Nc;

– evaluation of the suitability of construction of components to withstand artificial stressing, Test Na or Test Nc;

– evaluation of electrical performance as a consequence of a change of temperature, Test Nb;

– evaluation of mechanical performance as a consequence of a change of temperature, Test Nb.

The change of temperature tests specified in the IEC 60068 series is not intended to evaluate the difference in material constants or electrical performance when operating under the conditioning temperatures T_A and T_B.

5.5 Choice of the exposure time to each conditioning temperature

The duration of the exposure should be based on the requirements stated in 7.2.3, 8.2.3 or 9.2.2, or as stated in the relevant specification, keeping in mind the following points:

a) The exposure begins as soon as the specimen is in the new environment.

b) Stabilization occurs when the temperature difference between the specimen and the test medium (ΔT_s) is within 5 K, or as stated in the test specification. The stabilization time of specimen temperature t_s is from the start of exposure until the moment when the temperature is within the specified difference. A representative point (or points) on the specimen can be used for this measurement.

c) The exposure time t_1 of the specimen to each conditioning temperature shall be longer than the stabilization time of the specimen temperature t_s. Figure 1 provides a graphical representation of the process. It is possible that this will not be appropriate for heat generating specimens.

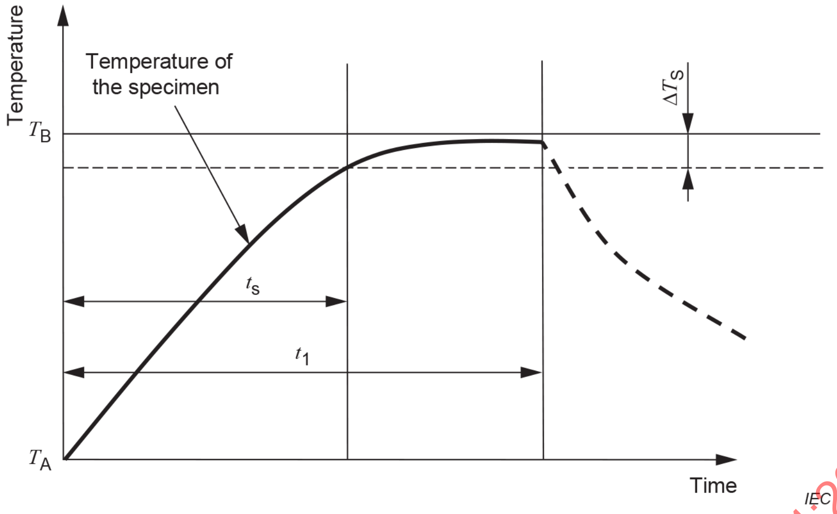


Figure 1 – Determination of the exposure time t_1 of the specimen to each conditioning temperature

5.6 Choice of the duration of the transfer time t_2

If, for example owing to the large size of the specimens, the transfer time t_2 cannot be kept within 3 min, the transfer time can be increased with a negligible influence on the test results as follows:

$$t_2 \leq 0{,}05\ t_s$$

This applies for the two-chamber test (see 7.2.1) method only. When using the one-chamber test method, period t_2 is not applicable.

5.7 Applicability limits of change of temperature tests

Inside a specimen, the temperature change rate depends on the heat conduction of its materials, the spatial distribution of its heat capacity as well as on its dimensions and surface area. A representative point (or points) on (or inside) the specimen can be used for the measurement of the temperature change rates.

NOTE 1 The rate of temperature change of specimens made of the same material and mass can vary if their surfaces differ from each other.

The change of temperature at one point on the surface of a specimen follows approximately an exponential law. Inside large specimens, such alternate exponential rises and decreases can lead to periodic and approximately sinusoidal changes of temperature with much lower amplitudes than the applied temperature swing. Annex B gives further information on the thermal responsiveness of different materials and geometries.

The mechanism of heat transfer between the test specimen and the conditioning medium in the chamber or bath should be considered. Liquid in motion leads to very high rates of change of temperature on the surface of the specimens and still air to very low rates.

NOTE 2 If more than one specimen is tested in the same test chamber, a uniform incoming airflow can be disturbed. For further information on the relation of airflow and specimen temperature, IEC 60068-3-1 can be helpful.

The two-bath method with water as a conditioning medium (Test Nc) should be restricted to specimens which are either sealed or are by their nature insensitive to water, since their performance and properties can deteriorate by immersion.

In particular cases, such as with specimens sensitive to water, a test with liquid other than water should be specified. When designing such a test, the characteristics of heat transfer of the liquid, which can differ from those of water, shall be considered.

NOTE 3 To assess the applicability of the two-bath method, evaluations from Test Q: Sealing (IEC 60068-2-17) can be helpful.

The application of Tests N is preferred as part of a sequence of tests. It is possible that some types of damage will not become apparent by the final measurements of a Test N but will appear only during subsequent tests.

An exemplary sequence of tests can be IEC 60068-2-17 Test Q: Sealing, IEC 60068-2-6 Test Fc: Vibration (sinusoidal), IEC 60068-2-30 Test Db: Damp heat, cyclic (12 h + 12 h cycle) or IEC 60068-2-67 Test Cy: Damp heat.

The change of temperature Test Nc (Two-bath method) should not be used as an alternative to Test Q (Sealing).

When specifying a change of temperature test, the properties of the objects under test which are affected by conditions of changing temperature, and their possible failure mechanisms, should be kept in mind. The initial and the final measurements should be specified accordingly.

6 Initial and final measurements

6.1 General

Tests Na, Nb and Nc all use the same initial and final measurements.

6.2 Initial measurements

The specimen shall be visually examined and electrically and mechanically checked, as required by the relevant specification.

6.3 Final measurements

The specimen shall be visually examined and electrically and mechanically checked, as required by the relevant specification.

7 Test Na: Rapid change of temperature

7.1 General description of the test

This test determines the ability of components, equipment or other articles to withstand rapid changes of ambient temperature. The exposure times adequate to accomplish this will depend upon the nature of the specimen. The specimen shall be either in the unpacked, switched-off, ready for use state, or as otherwise specified in the relevant specification. The specimen is exposed to rapid changes of temperature in air, or in a suitable inert gas, by alternating exposure to a low and a high conditioning temperature.

7.2 Testing procedure

7.2.1 Testing chamber

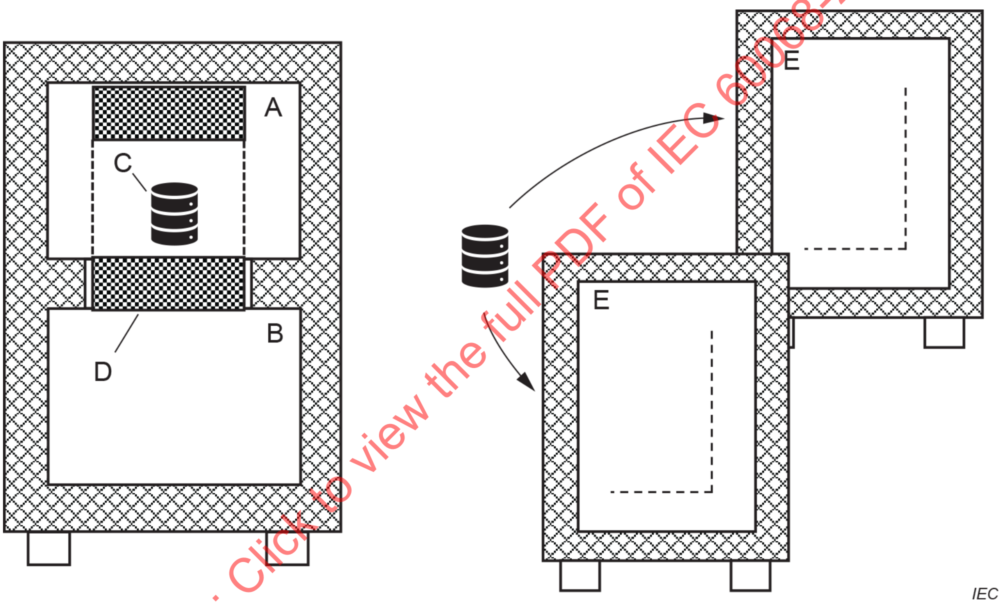
Two separate chambers (two-chamber method, see Figure 2) or one rapid temperature change rate chamber (one-chamber method, see Figure 3) can be used. If two chambers are used, one for the low temperature and one for the high temperature, the location shall be such as to allow transfer of the specimen from one chamber to the other within the specified time. Either manual or automatic transfer methods can be used.

Some two-chamber method systems are known as thermal shock test cabinets. These systems combine characteristics of two separate test chambers and are equipped with a mobile lifting cage (applies for horizontal shock test chambers as well) for the automatic transfer of the specimens from one chamber to another (see Figure 2).

Damper shock test cabinets are another embodiment of a one-chamber test system. These systems contain two conditioning and one test chamber. The test chamber is alternately exposed to conditioned air from a hot respectively cold conditioning chamber via air flaps (see Figure 3). No physical transfer is required and the transfer time t_2 is not applicable, when using this kind of test systems.

Damper shock test cabinets with a stationary test chamber, a hot chamber and a cold chamber are commonly capable of two-zone tests with hot respectively cold exposure. Some are capable of three-zone tests, including exposure to ambient air.

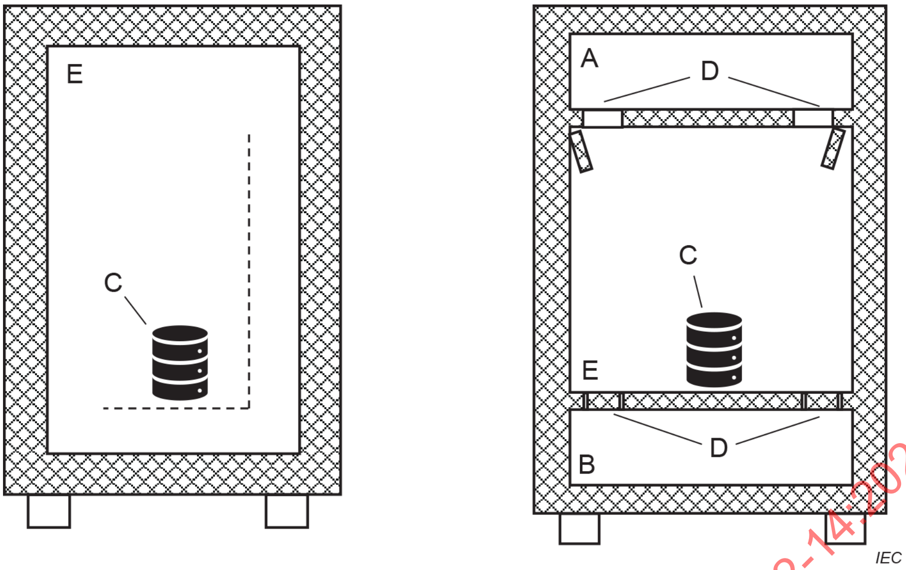
NOTE 1 Damper and basket-type test cabinets are often used for Test Na. Depending on the performance, two separate chambers or one rapid temperature change rate chamber are often used for Test Na as well. One rapid temperature change rate chamber is often used for Test Nb.



Key

A	hot chamber	**B**	cold chamber	**C**	specimen
D	mobile cage	**E**	stationary test space		

Figure 2 – Schematic representation of examples of thermal test cabinets and test procedure with two separate test chambers



Key

A	hot chamber	**B**	cold chamber	**C**	specimen
D	air flaps	**E**	stationary test space		

Figure 3 – Schematic representation of examples of thermal test cabinets with one test chamber

The chambers should be capable of maintaining the working space at the required temperatures.

After insertion of the test specimens, the temperature of the test medium shall be within the specified tolerance after a time of not more than 10 % of the exposure time t_1 of the specimen to each conditioning temperature. The temperature of the test medium refers to the control sensor of the test chamber, if not specified otherwise.

Owing to the specimen's lower rate of temperature change, its temperature can fall below the dew point temperature when bringing the specimens in the hot test environment (see Figure 4) or exposing them to ambient laboratory air (see Figure 5). During the rapid change to the high temperature T_B or when transferring the specimens from the cold chamber to the hot chamber, condensation of ambient air humidity should always be taken into consideration.

NOTE 2 Depending on the heat capacity and mass of the specimen, this phenomenon can be more or less pronounced.

Dehumidification during heating phases or compressed air dryers can be used to prevent condensation on the specimen's surface, if necessary.

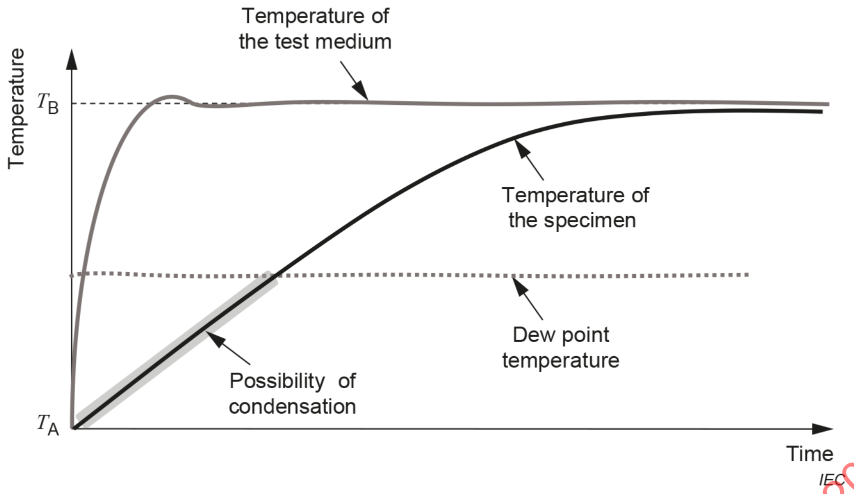


Figure 4 – Possibility of condensation during rapid temperature change

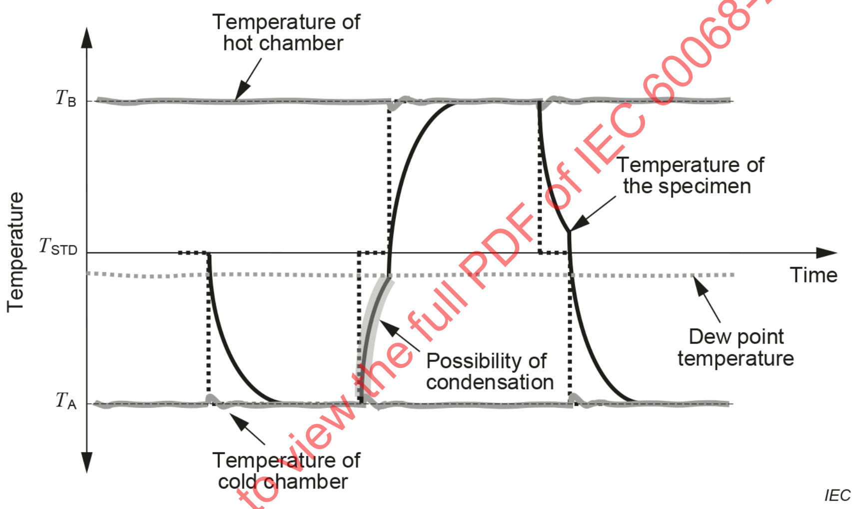


Figure 5 – Possibility of condensation during transfer of the specimen

7.2.2 Mounting or supporting of the test specimen

The thermal conduction of the mounting or supports shall be low, such that for practical purposes the specimen is thermally isolated, if not specified otherwise. When testing several specimens simultaneously they shall be so placed that free circulation shall be provided between specimens, and between specimens and chamber surfaces.

7.2.3 Severities

The severity of the test is defined by the combination of the two temperatures, the transfer time, the exposure time of the specimen and the number of cycles.

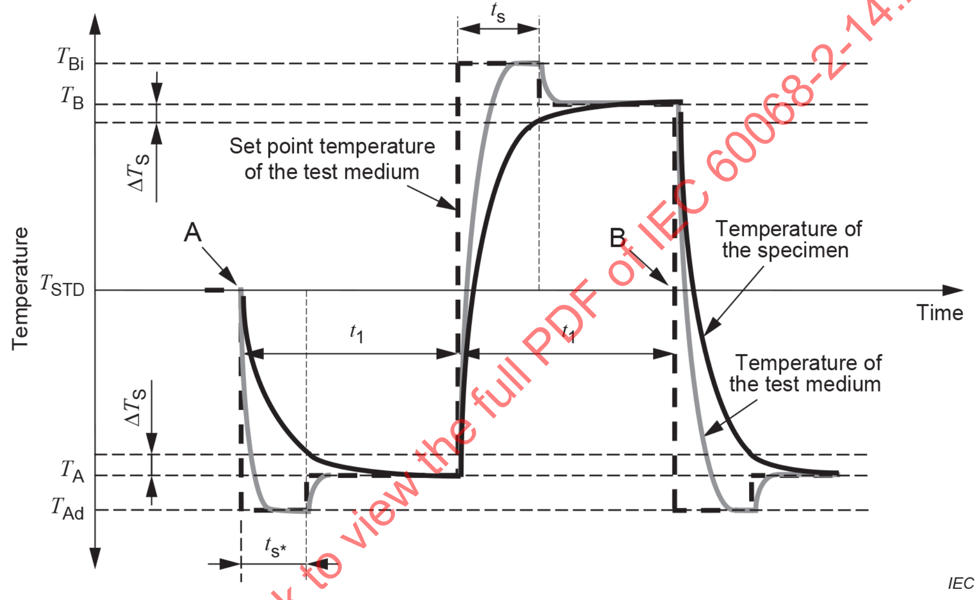
The low conditioning temperature T_A shall be specified in the relevant specification and shall be chosen from the test temperatures of either IEC 60068-2-1 or IEC 60068-2-2 or both, if not specified otherwise.

The high conditioning temperature T_B shall be specified in the relevant specification and shall be chosen from the test temperatures of either IEC 60068-2-1 or IEC 60068-2-2 or both, if not specified otherwise.

The exposure time t_1 to each of the two conditioning temperatures depends on the heat capacity of the specimen. It can be 3 h, 2 h, 1 h, 30 min or 10 min, or as specified in the relevant specification. Where no exposure period is specified in the relevant specification, it is understood to be 3 h.

NOTE The 10 min exposure time often applies to the testing of small specimens that achieve temperature stabilization without a significant time lag.

If temperature stabilization of the specimens cannot be achieved within the chosen exposure time, for example owing to a high heat capacity of the specimens, the severity of the test can be temporarily increased. The severity shall only be increased until temperature stabilization is achieved. A representative point (or points) on (or inside) the specimen can be used for this measurement. A higher severity of the test is achieved by increasing the temperature difference between the low conditioning temperature T_A and the high conditioning temperature T_B. Figure 6 provides a graphical representation of an increased severity.



Key

A start of first cycle

B end of first cycle and start of second cycle

Figure 6 – Increased severity of Test Na

The decreased low conditioning temperature T_{Ad} and the increased high conditioning temperature T_{Bi} should be chosen from the test temperatures of either IEC 60068-2-1 or IEC 60068-2-2 or both, if not specified otherwise.

When choosing the increased high conditioning temperature T_{Bi} and the decreased low conditioning temperature T_{Ad} the temperature limits of the specimen should be respected to avoid possible damage caused by the chosen temperature differences, if not specified otherwise. The chosen conditioning temperatures shall be given in the test report.

The preferred number of test cycles is 5, unless otherwise specified in the relevant specification.

7.2.4 Preconditioning

The specimen and the temperature in the test chamber shall be at the temperature of standard atmospheric conditions for measurement and test T_{STD}, 15 °C to 35 °C. If required by the relevant specification, the specimen shall be brought into operating conditions.

7.2.5 Test cycle

a) One-chamber test method

The specimen shall be brought into the test chamber and be exposed to the temperature change to the low conditioning temperature T_A (see Figure 7).

The low conditioning temperature T_A shall be maintained for the specified exposure time t_1 (see 5.5). t_1 includes an initial time, not longer than 0,1 t_1 for temperature stabilization of the test medium.

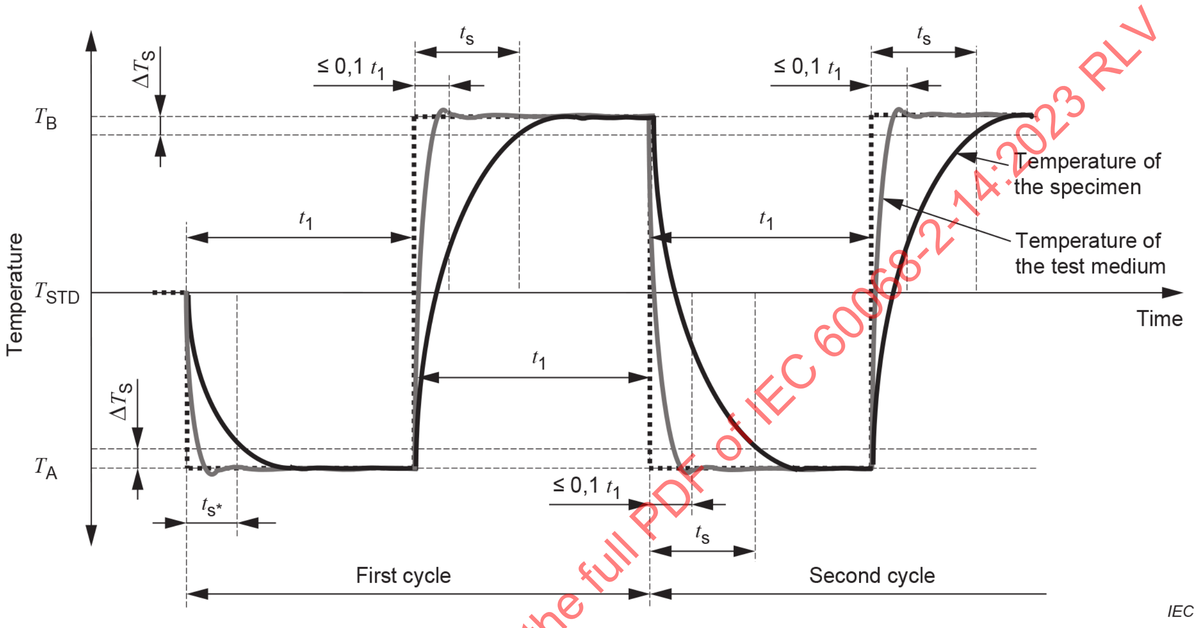


Figure 7 – Na test cycle, one-chamber method

NOTE 1 The exposure time is measured from the beginning of change of temperature within the chamber.

Temperature stabilization of the specimen (ΔT_S) can be achieved in the specified period t_1 (see Figure 7), if not specified otherwise. The time required for this is indicated with t_s.

NOTE 2 In some cases it can become necessary to extend t_1 to promote temperature equalization of the specimen or to initiate a certain relaxation process.

The specimen shall then be exposed to the temperature change to the high conditioning temperature T_B.

The high conditioning temperature T_B shall be maintained for the specified exposure time t_1. t_1 includes an initial time, not longer than 0,1 t_1 for temperature stabilization of the test medium.

Temperature stabilization of the specimen (ΔT_S) can be achieved in the specified period t_1 (see Figure 7), if not specified otherwise. The time required for this is indicated with t_s.

NOTE 3 In some cases it can become necessary to extend t_1 to promote temperature equalization of the specimen or to initiate a certain relaxation process.

For the next cycle the specimen shall be exposed to the low conditioning temperature T_A.

One cycle comprises the exposure time t_1 to both conditioning temperatures. At the end of the last cycle, the specimen shall be subjected to the recovery procedure (see 7.3).

NOTE 4 There are no transfer times required for the one-chamber test method.

b) Two-chamber test method

The test specimen shall be brought into the cold chamber and be exposed to the low conditioning temperature T_A.

The low conditioning temperature T_A shall be maintained for the specified exposure time t_1 (see 5.5). t_1 includes an initial time, not longer than 0,1 t_1, for temperature stabilization of the air temperature in the chamber (see Figure 8).

NOTE 5 The exposure time is measured from the moment of insertion of the specimen into the chamber.

Temperature stabilization of the specimen (ΔT_s) can be achieved in the specified period t_1 (see Figure 8), if not specified otherwise. The time required for this is indicated with t_s.

NOTE 6 In some cases it can become necessary to extend t_1 to promote temperature equalization of the specimen or to initiate a certain relaxation process.

The specimen shall then be brought into the hot chamber in a transfer time t_2, which should not be more than 3 min, and be exposed to the high conditioning temperature T_B.

The transfer time t_2 shall include the time needed for the removal from one chamber and the insertion into the second chamber as well as any dwell time at the ambient temperature of the laboratory.

NOTE 7 For specimens with a large mass or geometry, the transfer time from one chamber to another can be increased as specified in the relevant standard or specification (see 5.6).

The high conditioning temperature T_B shall be maintained for the specified exposure time t_1. t_1 includes an initial time, not longer than 0,1 t_1, for temperature stabilization of the air temperature in the chamber.

NOTE 8 The exposure time is measured from the moment of insertion of the specimen into the chamber.

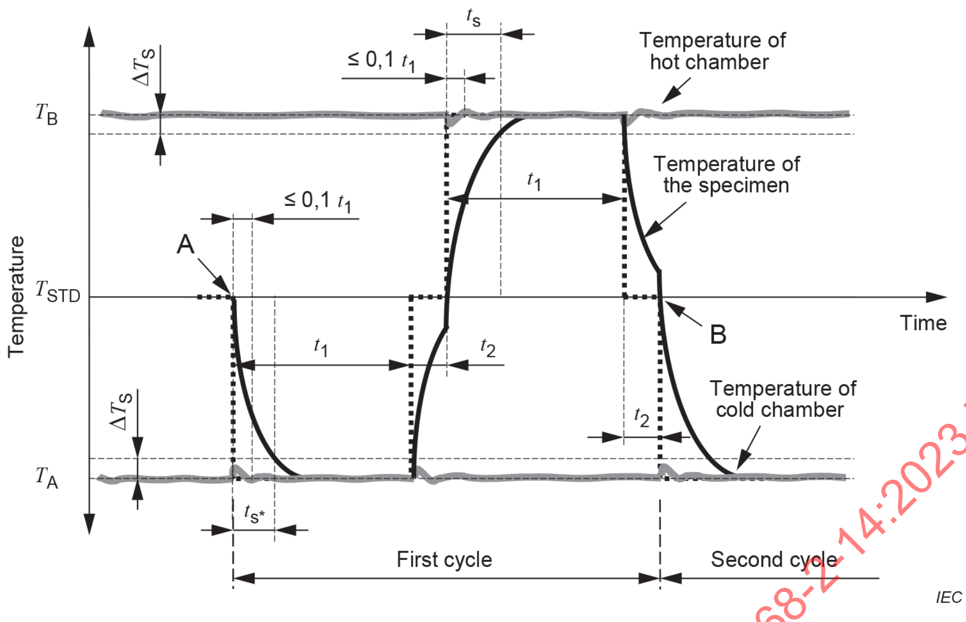
Temperature stabilization of the specimen (ΔT_s) can be achieved in the specified period t_1 (see Figure 8), if not specified otherwise. The time required for this is indicated with t_s.

NOTE 9 In some cases it can become necessary to extend t_1 to promote temperature equalization of the specimen or to initiate a certain relaxation process.

For the next cycle the specimen shall be brought into the cold chamber in a transfer time t_2, which should not be more than 3 min, and be exposed to the low conditioning temperature T_A.

NOTE 10 For specimens with a large mass or geometry, the transfer time from one chamber to another can be increased as specified in the relevant standard or specification (see 5.6).

One cycle comprises the exposure time t_1 to both conditioning temperatures and the two transfer times t_2 (see Figure 8). At the end of the last cycle, the specimen shall be subjected to the recovery procedure (see 7.3).



Key

A start of first cycle

B end of first cycle and start of second cycle

Figure 8 – Na test cycle, two-chamber method

7.3 Recovery

At the end of the test cycle, the specimen shall be brought to the temperature of standard atmospheric conditions for measurement and test T_{STD}, 15 °C to 35 °C. It is recommended that the specimen be brought to this temperature within the specified period t_1, if not specified otherwise.

If this is not possible or specified otherwise, the temperature in the test chamber shall be lowered to the temperature of standard atmospheric conditions for measurement and test T_{STD}, 15 °C to 35 °C. It is recommended that the temperature be lowered to that of standard atmospheric conditions within the specified period t_1, if not specified otherwise.

NOTE Keeping the specimen exposed to the high conditioning temperature for an extended time after completion of the test can be seen as temperature storage, which can cause unintended damages to the specimen.

The specimen shall remain at the temperature of standard atmospheric conditions for measurement and test T_{STD}, 15 °C to 35 °C, for testing for a period adequate for the attainment of temperature stability. The relevant specification should specify a specific recovery period for a given type of specimen.

8 Test Nb: Change of temperature with specified rate of change

8.1 General description of the test

This test determines the ability of components, equipment, or other articles to withstand or function, or both, during changes of ambient temperature.

The specimen shall be either in the unpacked, switched-off, ready for use state, or as otherwise specified in the relevant specification.

The specimen is exposed to changes of temperature in air by exposure in a chamber to specified temperatures varied at a controlled rate. During this exposure the performance of the specimen should be monitored.

8.2 Testing procedure

8.2.1 Testing chamber

The chamber for this test shall be designed so that in the working space, where the specimen under test is placed, a temperature cycle can be performed in such a manner that

a) the low temperature required for the test can be maintained,

b) the high temperature required for the test can be maintained,

c) the temperature change required for the test from low temperature to high temperature or vice versa can be performed at the required rate of change.

8.2.2 Mounting or supporting structure of the test specimen

The thermal conduction of the mounting or supporting structure shall be low, such that for practical purposes the specimen is thermally isolated, if not specified otherwise. When testing several specimens simultaneously they shall be so placed that free circulation is provided between the specimens, and between the specimens and chamber surfaces.

8.2.3 Severities

The severity of the test is defined by the combination of the two temperatures, the rate of temperature change, the exposure time of the specimen and the number of cycles. The severity of the test will increase with an increase in the temperature difference, the increase in rate of temperature change, and the heat transfer to the specimen.

The low conditioning temperature T_A shall be specified in the relevant specification and should be chosen from the test temperatures of IEC 60068-2-1 and IEC 60068-2-2.

The high conditioning temperature T_B shall be specified in the relevant specification and should be chosen from the test temperatures of IEC 60068-2-1 and IEC 60068-2-2.

The rate of temperature change rate dT_R shall be specified in the relevant specification. Example rates are as follows, if not specified otherwise:

– 1 K/min,

– 3 K/min,

– 5 K/min,

– 10 K/min,

– 15 K/min,

– 20 K/min,

– 25 K/min.

NOTE Temperature change rates > 15 K/min can result in severe testing conditions.

The exposure time to each of the two temperatures t_1 depends upon the heat capacity and the mass of the specimen. It can be 3 h, 2 h, 1 h, 30 min, or 10 min, or as specified in the relevant specification. Where no exposure period is specified in the relevant specification it is understood to be 3 h.

The specimen shall be subjected to two consecutive cycles, unless otherwise specified in the relevant specification.

8.2.4 Tolerance

Tolerances shall be specified in the relevant specification. If there are no tolerances specified, the following tolerances shall apply.

The calculation of the applicable temperature tolerance $\pm\sigma_T$ during the temperature transition depends on the temperature change rate dT_R and temperature difference D.

The applicable temperature tolerance of the medium temperature during temperature transition $\pm\sigma_T$ shall be selected from the larger of the two calculated values $\pm\sigma_{T,1}$ and $\pm\sigma_{T,2}$, if not specified otherwise. The value $\pm\sigma_{T,1}$ shall be calculated by using the temperature difference D multiplied with an adjustment factor of 0,075. The value $\pm\sigma_{T,2}$ shall be calculated by using the temperature change rate dT_R multiplied with a time constant of ±1 min.

The following applies:

$$\pm\sigma_T = \pm\sigma_{T,1} = \pm D \times 0{,}075 \qquad \text{for } \pm\sigma_{T,1} > \pm\sigma_{T,2} \text{ or}$$

$$\pm\sigma_T = \pm\sigma_{T,2} = \pm dT_R \times (1\text{ min}) \qquad \text{for } \pm\sigma_{T,1} < \pm\sigma_{T,2}$$

Annex C shows an auxiliary table with temperature tolerances for preferred combinations of high and low conditioning temperatures and rates of temperature change.

The applicable temperature tolerance $\pm\sigma_{Tconst}$ of the medium temperature during the constant conditioning shall respectively be taken from IEC 60068-2-1 and IEC 60068-2-2, if not specified otherwise.

NOTE 1 The constant conditioning temperature periods can be seen as phases of temperature storage.

NOTE 2 For large test chambers the tolerances $\pm\sigma_{Tconst}$ during the constant conditioning can differ, refer to IEC 60068-2-1 and IEC 60068-2-2.

The relevant specification can call for tighter tolerances under special circumstances, if necessary.

The tolerance $\pm\sigma_T$ is applied during transition starting from 10 % to 90 % of the temperature difference D. The tolerance $\pm\sigma_{Tconst}$ is applied after 0,1 t_1 but at least 5 min and at most 15 min from the start of the constant temperature conditioning period.

For the period 0,1 t_1 at the beginning of each constant temperature conditioning as well as at the beginning and end of each transition no tolerance is specified, as indicated by the hatched areas in Figure 9. For better understanding of the periods with and without applicable tolerance, see Figure 9. The tolerances apply to the temperature as measured by the chamber control sensor.

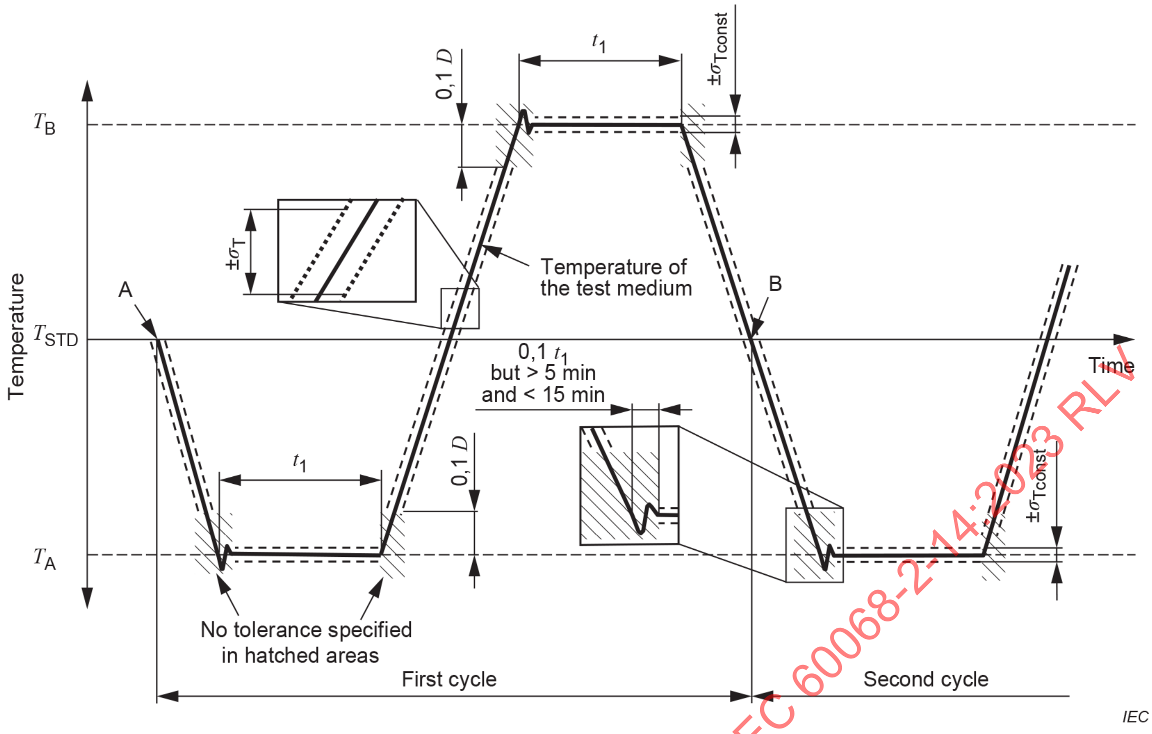


Figure 9 – Tolerance for fluctuation of test temperatures

8.2.5 Preconditioning

The specimen and the temperature in the test chamber shall be at the temperature of standard atmospheric conditions for measurement and test T_{STD}, 15 °C to 35 °C. If required by the relevant specification the specimen shall be brought into operating conditions.

8.3 Test cycle

The air temperature in the chamber shall then be lowered to the low conditioning temperature T_A at the specified rate dT_R (see Figure 10).

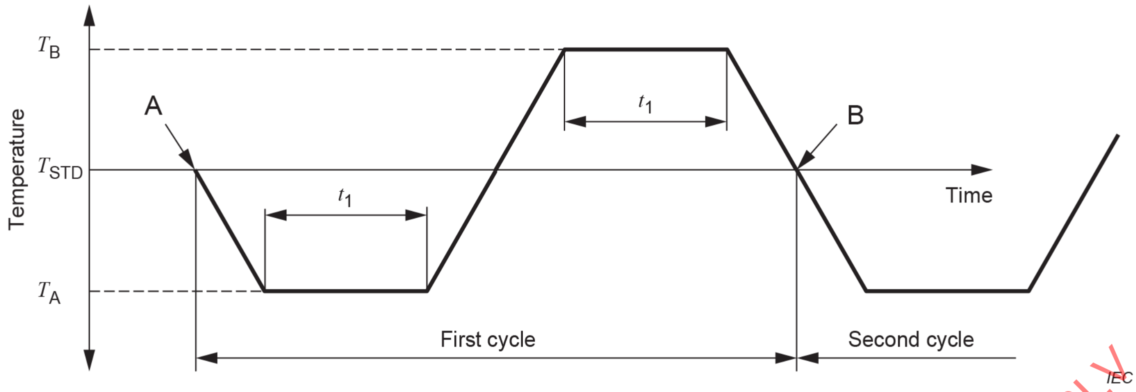
After temperature stability in the chamber has been reached, the specimen shall be exposed to the temperature T_A for the specified exposure time t_1.

The air temperature in the chamber shall then be raised to the high conditioning temperature T_B at the specified rate dT_R.

After temperature stability in the chamber has been reached, the specimen shall be exposed to the temperature T_B for the specified exposure time t_1.

The air temperature in the chamber shall then be lowered to the temperature of standard atmospheric conditions for measurement and test T_{STD}, 15 °C to 35 °C, at the specified rate dT_R.

This procedure constitutes one cycle.



Key

A start of first cycle

B end of first cycle and start of second cycle

Figure 10 – Nb test cycle

To limit the impact of the heat generating specimen on the test severity it is recommended to perform functional checks only during constant temperature phases of each test, if not specified otherwise. Continuous operation of specimen can prevent temperature equalization of the inner parts of these specimens during cooling. The designated time frames are shown in Figure 11, they should be limited to 90 % of the exposure time t_1, if not specified otherwise. The designated time frame for functional tests should start after 0,1 t_1 but at least 5 min and at most 15 min from the start of the constant temperature conditioning period, for temperature stabilization of the medium temperature in the chamber, if not specified otherwise.

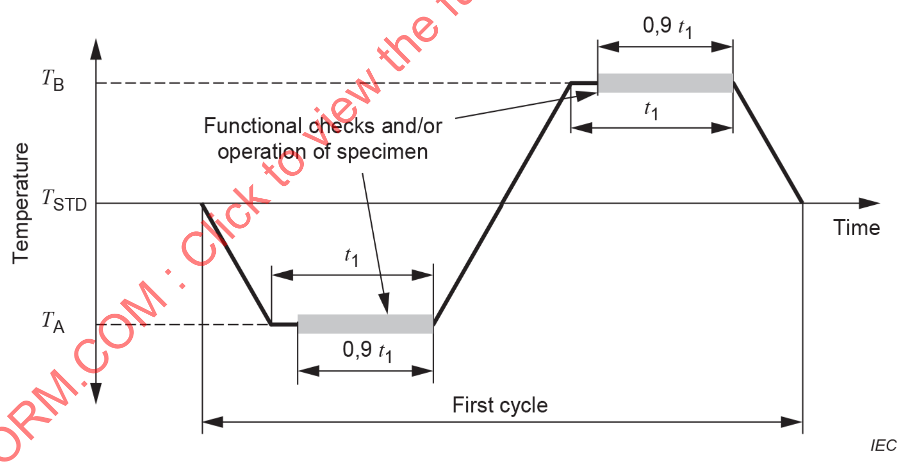


Figure 11 – Test times for intermediate operation of specimens

8.4 Recovery

At the end of the test cycle, the specimen shall remain at the temperature of standard atmospheric conditions for measurement and test T_{STD}, 15 °C to 35 °C, for testing for a period adequate for the attainment of temperature stability.

The relevant specification should specify a specific recovery period for a given type of specimen.

9 Test Nc: Rapid change of temperature, two-fluid-bath method

9.1 General description of the test

This test determines the ability of components, equipment, or other articles to withstand rapid changes of temperature.

This test procedure results in a severe thermal shock and is applicable to glass-metal seals and similar specimens.

The specimen is immersed alternately in two baths, one filled with liquid at a low temperature T_A and one filled with liquid at a high temperature T_B.

9.2 Testing procedure

9.2.1 Testing equipment

Two baths, one at low temperature and one at high temperature, shall be provided in such a way that the specimen under test can be easily immersed and be quickly transferred from one bath to the other.

The low temperature bath shall contain liquid at the low conditioning temperature T_A stated in the relevant specification. If no temperature is stated, the liquid shall have a temperature of 0 °C.

The bath for the high temperature shall contain liquid at the upper temperature T_B as required by the relevant specification. If no temperature is stated, the liquid shall have a temperature of +100 °C.

The baths shall be so constructed that at no moment during the test shall the temperature of the cold bath rise more than 2 K above T_A or the temperature of the hot bath fall more than 5 K below T_B.

The liquids used for the test shall be compatible with the materials and finishes used in the manufacture of the specimens.

NOTE The rate of heat transfer will depend upon the liquids used and will affect the severity of the test for a given temperature range.

9.2.2 Severities

The severity of the test is defined by the specified bath temperatures, the transfer time t_2 from one bath to the other and the number of cycles. The severity of the test will increase with an increase in the temperature difference, the reduction of the transfer time, and the heat transfer to the specimen.

The relevant specification shall specify the duration parameters to be used and the chosen value of the exposure time t_1 to both conditioning temperatures.

The number of test cycles is 10, unless otherwise specified in the relevant specification.

9.2.3 Conditioning

The specimen under test shall not be in operation during immersion. It shall be switched off and its movable parts shall be at rest, if not specified otherwise.

9.3 Test cycle

The specimen under test, while being at the ambient temperature of the laboratory, shall be immersed into the cold bath containing liquid at the low conditioning temperature T_A as stated in the relevant specification.

The specimen shall be maintained immersed in the cold bath for the specified exposure time t_1.

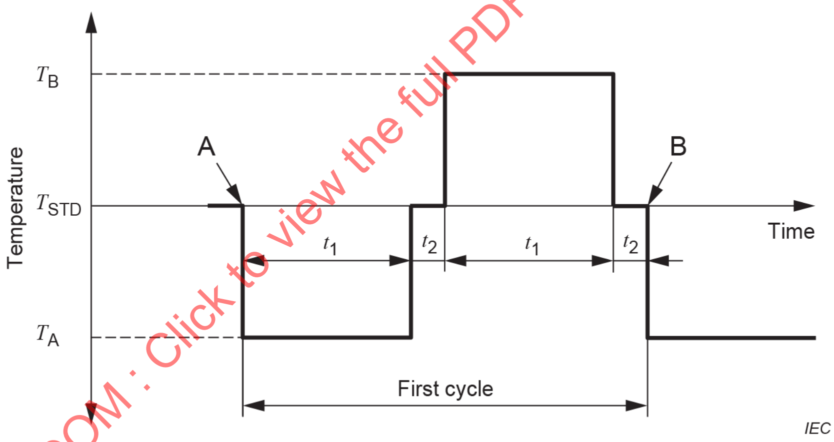
The specimen shall then be removed from the cold bath and immersed in the hot bath containing liquid at the high conditioning temperature T_B as stated in the relevant specification. The transfer time t_2 shall be as stated in the relevant specification.

The specimen shall be maintained immersed in the hot bath for the specified exposure time t_1.

The specimen shall then be removed from the hot bath. The transfer time t_2 between removal from the hot bath and immersion in the cold bath shall be as specified in the relevant specification.

One cycle comprises the exposure times t_1 to both conditioning temperatures and the transfer time t_2 (see Figure 12).

At the end of the last cycle, the specimen shall be subjected to the recovery procedure.



Key

A start of first cycle

B end of first cycle, start of second cycle

Figure 12 – Nc test cycle

9.4 Recovery

At the end of the test cycle, the specimen shall be subjected to the temperature of standard atmospheric conditions for measurement and test T_{STD}, 15 °C to 35 °C. Droplets of liquid shall be removed. If cleaning is necessary, then the method shall be defined by the relevant specification.

The relevant specification should specify a specific recovery period for a given type of specimen.

10 Information to be given in the test report

As a minimum, the test report shall show the following information:

a)	Customer	(name and address);
b)	Test laboratory	(name and address and details of accreditation – if any);
c)	Test dates	(dates when test was run);
d)	Type of test	(Na, Nb, Nc);
e)	Test standard, edition	(IEC 60068-2-14, edition used);
f)	Test specimen description	(drawing, photo, quantity build status, etc.);
g)	Test chamber identity	(unique identity of the chamber, e.g. internal Laboratory Identification number/code);
h)	Test set-up	(details of mounting and supports, measuring points, test medium, etc.);
i)	Initial, intermediate and final measurements	(if performed by the test laboratory);
j)	Required severities	(from relevant specification);
k)	Test severities	(preconditioning, temperatures, duration of exposure, data, etc.);
l)	Performance of test specimens	(results of functional tests, etc.);
m)	Observations during testing and actions taken	(any pertinent observations);
n)	Test results	(test summary, e.g. pass/fail decision).

In addition to the mandatory information the test report can include, for example:

o)	Purpose of test	(development, qualification, etc.);
p)	Relevant laboratory test procedure	(code and issue);
q)	Performance of test apparatus	(set point temperature control, air flow, etc.);
r)	Air velocity or direction or both	(air velocity or direction of incident air to the specimen or both);
s)	Uncertainties of chamber independent measuring system	(uncertainties data);
t)	Calibration data	(last and next due date);
u)	Measurements or loading during conditioning or both;	
v)	Any deviation in procedure as agreed between customer and supplier	(test set-up, applicable severities, etc.).

A test log should be written for the testing which can be attached to the report.

Annex A
(informative)

Potential consequences of improper severities

Accelerated temperature stress tests are an important aspect to evaluate the reliability of products and components over their entire life cycle. Complex geometries and differing materials cause mechanical stress within the specimens during cyclic temperature tests.

To guarantee the reliability of the test results, the intended change of temperature of the specimens should be ensured.

The change of temperature of a specimen follows an approximately exponential law. Inside large specimens or specimens with low thermal conductivity, such alternate exponential rises and decreases can lead to periodic and approximately sinusoidal changes of temperature with much lower amplitudes than the applied temperature swing. It is possible that the intended peak temperatures will not be reached in accelerated temperature tests. Figure A.1 gives a graphical display of this process.

NOTE It is common practice to examine the sample in advance to identify those parts that affect the slow temperature change of the sample. The results of the analysis can then be considered in the stabilization time of the sample.

For this reason, the monitoring of the temperature of the specimens at a representative point (or points) is recommended.

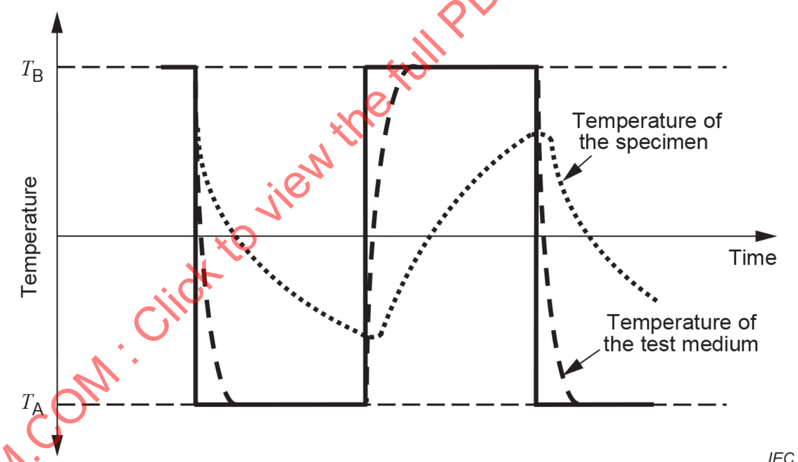


Figure A.1 – Delayed temperature change of the specimen

Annex B
(informative)

Thermal responsiveness of different materials and geometries

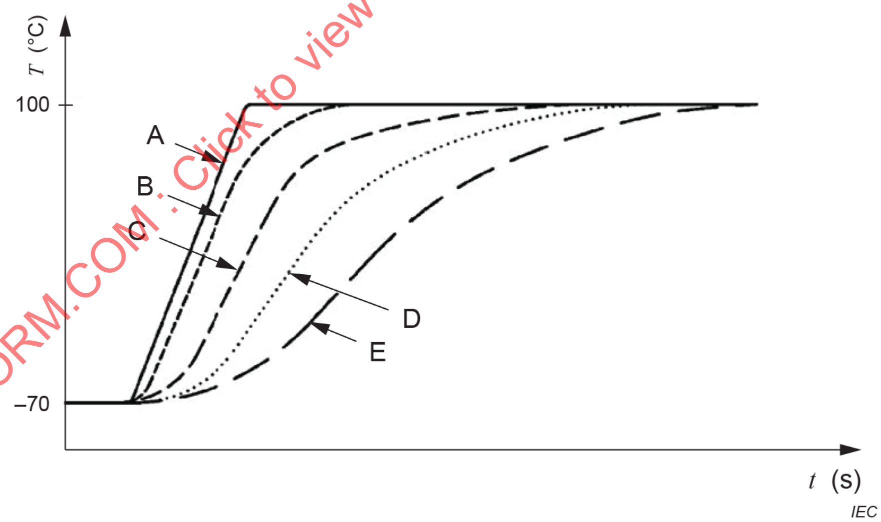
The specimen’s characteristics, such as its thermal conductivity, its specific heat capacity as well as its mass and geometry can have a significant effect on the thermal responsiveness of the specimen. The rate of temperature change of the specimen during temperature stress tests is highly affected by its thermal responsiveness.

Small specimens with low specific heat capacity, as well as specimen with a proportionally large surface, will quickly respond to temperature changes of the ambient medium. Big specimens with higher specific heat capacity, as well as specimens with a rather small surface will respond with a significant time lag and lower rates of changes. Figure B.1 gives a graphical representation of the process described above. The figure shows exemplary temperature profiles of specimens with differing thermal responsiveness (C to E).

The specimen with high thermal responsiveness (C) responds almost immediately to the rise of ambient air temperature (B), whereas both specimens with lower thermal responsiveness (D and E) show an increasing time lag.

Furthermore, low thermal conductivities can lead to non-uniform temperature changes within the specimens as seen within the cylindric specimen made of plastic. These can prevent the specimen’s core temperature from temperature equalization. This effect can be amplified in specimens with high masses.

These characteristics shall be taken into consideration when specifying any test parameters. If these characteristics are unknown, their experimental determination is recommended. For further information on the thermal responsiveness of specimens IEC 60068-3-1 can be helpful.



A set point test temperature

B air temperature within test chamber

C specimen with high thermal responsiveness

D specimen with medium thermal responsiveness

E specimen with low thermal responsiveness

Figure B.1 – Rate of temperature change of specimen with differing thermal responsiveness

Annex C
(normative)

Auxiliary table with exemplary temperature tolerances ±σ_T for preferred combinations of high and low conditioning temperatures and rates of temperature change (Test Nb)

Tolerances shall be specified in the relevant specification. If there are no tolerances specified, the following tolerances shall apply.

The calculation of the applicable temperature tolerance $\pm\sigma_T$ during the temperature transition depends on the temperature change rate and temperature difference D.

The applicable temperature tolerance of the medium temperature during temperature transition $\pm\sigma_T$ shall be selected from the larger of the two calculated values $\pm\sigma_{T,1}$ and $\pm\sigma_{T,2}$, if not specified otherwise.

The value $\pm\sigma_{T,1}$ shall be calculated by using the temperature difference D multiplied with an adjustment factor of 0,075. The value $\pm\sigma_{T,2}$ shall be calculated by using the temperature change rate dT_R multiplied with a time constant of ±1 min.

The following applies:

$$\pm\sigma_T = \pm\sigma_{T,1} = \pm D \times 0{,}075 \text{, for } \pm\sigma_{T,1} > \pm\sigma_{T,2} \quad \text{(C.1)}$$

$$\pm\sigma_T = \pm\sigma_{T,2} = \pm dT_R \times (1\ \text{min}) \text{, for } \pm\sigma_{T,1} < \pm\sigma_{T,2} \quad \text{(C.2)}$$

For a better understanding, the following example and Figure C.1 show the applicable tolerance for exemplary test parameters. Additionally, Table C.1 gives an overview of applicable tolerances for preferred combinations of high and low conditioning temperatures as well as rates of temperature change dT_R.

NOTE For large test chambers the tolerances $\pm\sigma_{Tconst}$ during the constant conditioning can differ, refer to IEC 60068-2-1 and IEC 60068-2-2.

EXAMPLE

T_A = −55 °C

T_B = 85 °C

dT_R = 3 K/min

$$\pm\sigma_{T,1} = \pm D \times 0{,}075 = \pm(85\,°C - (-55\,°C)) \times 0{,}075 = \pm 140\,K \times 0{,}075 = \pm 10{,}5\,K \quad \text{(C.3)}$$

$$\pm\sigma_{T,2} = \pm dT_R \times (1\text{min}) = \pm 3\ K/\text{min} \times (1\text{min}) = \pm 3\ K \quad \text{(C.4)}$$

$$\pm\sigma_{T,1} > \pm\sigma_{T,2} \quad \rightarrow \pm\sigma_T = \pm\sigma_{T,1} = \pm 10{,}5\,\text{K} \tag{C.5}$$

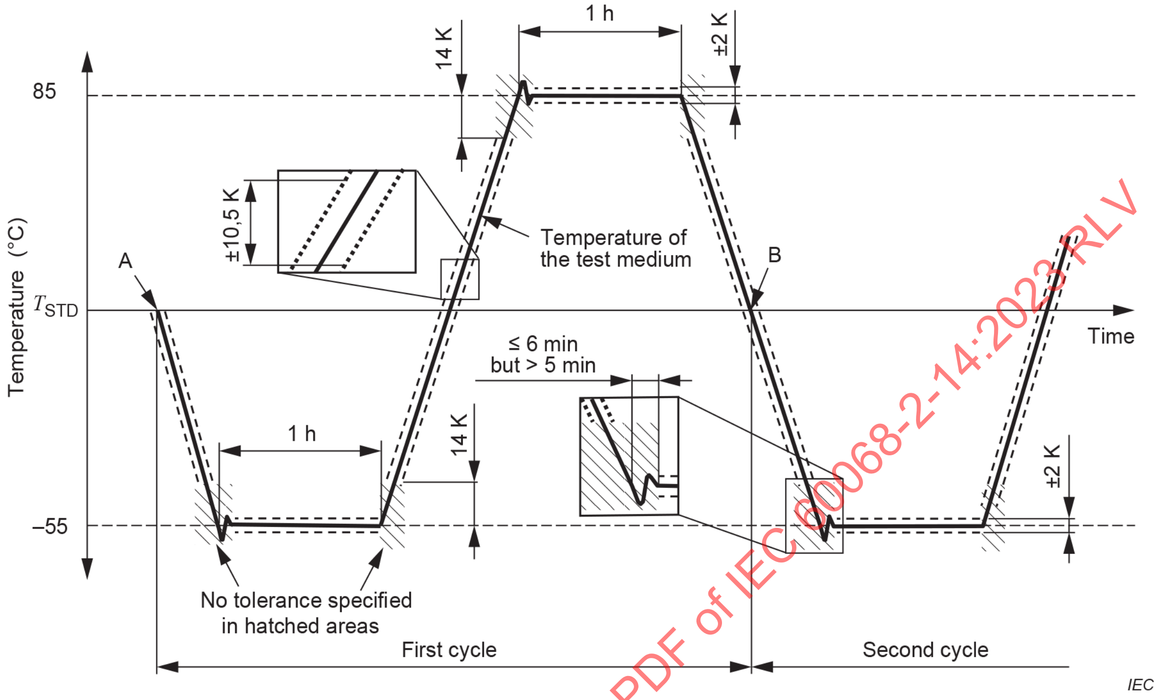


Figure C.1 – Tolerance for fluctuation of test temperatures for exemplary test parameters

Table C.1 – Applicable temperature tolerances ±σ_T in K for preferred combinations of high and low conditioning temperatures and rates of temperature change dT_R

dT_R = 1 K/min		High conditioning temperature T_B														
		30 °C	35 °C	40 °C	45 °C	50 °C	55 °C	60 °C	65 °C	70 °C	85 °C	100 °C	125 °C	155 °C	175 °C	200 °C
Low conditioning temperature T_A	−65 °C	±7,1	±7,5	±7,9	±8,3	±8,6	±9,0	±9,4	±9,8	±10,1	±11,3	±12,4	±14,3	±16,5	±18,0	±19,9
	−55 °C	±6,4	±6,8	±7,1	±7,5	±7,9	±8,3	±8,6	±9,0	±9,4	±10,5	±11,6	±13,5	±15,8	±17,3	±19,1
	−50 °C	±6,0	±6,4	±6,8	±7,1	±7,5	±7,9	±8,3	±8,6	±9,0	±10,1	±11,3	±13,1	±15,4	±16,9	±18,8
	−40 °C	±5,3	±5,6	±6,0	±6,4	±6,8	±7,1	±7,5	±7,9	±8,3	±9,4	±10,5	±12,4	±14,6	±16,1	±18,0
	−33 °C	±4,7	±5,1	±5,5	±5,9	±6,2	±6,6	±7,0	±7,4	±7,7	±8,9	±10,0	±11,9	±14,1	±15,6	±17,5
	−25 °C	±4,1	±4,5	±4,9	±5,3	±5,6	±6,0	±6,4	±6,8	±7,1	±8,3	±9,4	±11,3	±13,5	±15,0	±16,9
	−20 °C	±3,8	±4,1	±4,5	±4,9	±5,3	±5,6	±6,0	±6,4	±6,8	±7,9	±9,0	±10,9	±13,1	±14,6	±16,5
	−10 °C	±3,0	±3,4	±3,8	±4,1	±4,5	±4,9	±5,3	±5,6	±6,0	±7,1	±8,3	±10,1	±12,4	±13,9	±15,8
	−5 °C	±2,6	±3,0	±3,4	±3,8	±4,1	±4,5	±4,9	±5,3	±5,6	±6,8	±7,9	±9,8	±12,0	±13,5	±15,4
	5 °C	±1,9	±2,3	±2,6	±3,0	±3,4	±3,8	±4,1	±4,5	±4,9	±6,0	±7,1	±9,0	±11,3	±12,8	±14,6
dT_R = 3 K/min		High conditioning temperature T_B														
		30 °C	35 °C	40 °C	45 °C	50 °C	55 °C	60 °C	65 °C	70 °C	85 °C	100 °C	125 °C	155 °C	175 °C	200 °C
Low conditioning temperature T_A	−65 °C	±7,1	±7,5	±7,9	±8,3	±8,6	±9,0	±9,4	±9,8	±10,1	±11,3	±12,4	±14,3	±16,5	±18,0	±19,9
	−55 °C	±6,4	±6,8	±7,1	±7,5	±7,9	±8,3	±8,6	±9,0	±9,4	±10,5	±11,6	±13,5	±15,8	±17,3	±19,1
	−50 °C	±6,0	±6,4	±6,8	±7,1	±7,5	±7,9	±8,3	±8,6	±9,0	±10,1	±11,3	±13,1	±15,4	±16,9	±18,8
	−40 °C	±5,3	±5,6	±6,0	±6,4	±6,8	±7,1	±7,5	±7,9	±8,3	±9,4	±10,5	±12,4	±14,6	±16,1	±18,0
	−33 °C	±4,7	±5,1	±5,5	±5,9	±6,2	±6,6	±7,0	±7,4	±7,7	±8,9	±10,0	±11,9	±14,1	±15,6	±17,5
	−25 °C	±4,1	±4,5	±4,9	±5,3	±5,6	±6,0	±6,4	±6,8	±7,1	±8,3	±9,4	±11,3	±13,5	±15,0	±16,9
	−20 °C	±3,8	±4,1	±4,5	±4,9	±5,3	±5,6	±6,0	±6,4	±6,8	±7,9	±9,0	±10,9	±13,1	±14,6	±16,5
	−10 °C	±3,0	±3,4	±3,8	±4,1	±4,5	±4,9	±5,3	±5,6	±6,0	±7,1	±8,3	±10,1	±12,4	±13,9	±15,8
	−5 °C	±3,0	±3,0	±3,4	±3,8	±4,1	±4,5	±4,9	±5,3	±5,6	±6,8	±7,9	±9,8	±12,0	±13,5	±15,4
	5 °C	±3,0	±3,0	±3,0	±3,0	±3,4	±3,8	±4,1	±4,5	±4,9	±6,0	±7,1	±9,0	±11,3	±12,8	±14,6

dT_R = 5 K/min		High conditioning temperature T_B														
		30 °C	35 °C	40 °C	45 °C	50 °C	55 °C	60 °C	65 °C	70 °C	85 °C	100 °C	125 °C	155 °C	175 °C	200 °C
Low conditioning temperature T_A	−65 °C	±7,1	±7,5	±7,9	±8,3	±8,6	±9,0	±9,4	±9,8	±10,1	±11,3	±12,4	±14,3	±16,5	±18,0	±19,9
	−55 °C	±6,4	±6,8	±7,1	±7,5	±7,9	±8,3	±8,6	±9,0	±9,4	±10,5	±11,6	±13,5	±15,8	±17,3	±19,1
	−50 °C	±6,0	±6,4	±6,8	±7,1	±7,5	±7,9	±8,3	±8,6	±9,0	±10,1	±11,3	±13,1	±15,4	±16,9	±18,8
	−40 °C	±5,3	±5,6	±6,0	±6,4	±6,8	±7,1	±7,5	±7,9	±8,3	±9,4	±10,5	±12,4	±14,6	±16,1	±18,0
	−33 °C	±5,0	±5,1	±5,5	±5,9	±6,2	±6,6	±7,0	±7,4	±7,7	±8,9	±10,0	±11,9	±14,1	±15,6	±17,5
	−25 °C	±5,0	±5,0	±5,0	±5,3	±5,6	±6,0	±6,4	±6,8	±7,1	±8,3	±9,4	±11,3	±13,5	±15,0	±16,9
	−20 °C	±5,0	±5,0	±5,0	±5,0	±5,3	±5,6	±6,0	±6,4	±6,8	±7,9	±9,0	±10,9	±13,1	±14,6	±16,5
	−10 °C	±5,0	±5,0	±5,0	±5,0	±5,0	±5,0	±5,3	±5,6	±6,0	±7,1	±8,3	±10,1	±12,4	±13,9	±15,8
	−5 °C	±5,0	±5,0	±5,0	±5,0	±5,0	±5,0	±5,0	±5,3	±5,6	±6,8	±7,9	±9,8	±12,0	±13,5	±15,4
	5 °C	±5,0	±5,0	±5,0	±5,0	±5,0	±5,0	±5,0	±5,0	±5,0	±6,0	±7,1	±9,0	±11,3	±12,8	±14,6
dT_R = 10 K/min		High conditioning temperature T_B														
		30 °C	35 °C	40 °C	45 °C	50 °C	55 °C	60 °C	65 °C	70 °C	85 °C	100 °C	125 °C	155 °C	175 °C	200 °C
Low conditioning temperature T_A	−65 °C	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,1	±11,3	±12,4	±14,3	±16,5	±18,0	±19,9
	−55 °C	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,5	±11,6	±13,5	±15,8	±17,3	±19,1
	−50 °C	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,1	±11,3	±13,1	±15,4	±16,9	±18,8
	−40 °C	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,5	±12,4	±14,6	±16,1	±18,0
	−33 °C	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±11,9	±14,1	±15,6	±17,5
	−25 °C	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±11,3	±13,5	±15,0	±16,9
	−20 °C	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,9	±13,1	±14,6	±16,5
	−10 °C	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,1	±12,4	±13,9	±15,8
	−5 °C	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±12,0	±13,5	±15,4
	5 °C	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±10,0	±11,3	±12,8	±14,6

dT_R = 15 K/min		High conditioning temperature T_B														
		30 °C	35 °C	40 °C	45 °C	50 °C	55 °C	60 °C	65 °C	70 °C	85 °C	100 °C	125 °C	155 °C	175 °C	200 °C
Low conditioning temperature T_A	−65 °C	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±16,5	±18,0	±19,9
	−55 °C	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,8	±17,3	±19,1
	−50 °C	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,4	±16,9	±18,8
	−40 °C	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±16,1	±18,0
	−33 °C	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,6	±17,5
	−25 °C	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±16,9
	−20 °C	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±16,5
	−10 °C	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,8
	−5 °C	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,4
	5 °C	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0	±15,0
dT_R = 20 K/min		High conditioning temperature T_B														
		30 °C	35 °C	40 °C	45 °C	50 °C	55 °C	60 °C	65 °C	70 °C	85 °C	100 °C	125 °C	155 °C	175 °C	200 °C
Low conditioning temperature T_A	−65 °C	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0
	−55 °C	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0
	−50 °C	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0
	−40 °C	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0
	−33 °C	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0
	−25 °C	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0
	−20 °C	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0
	−10 °C	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0
	−5 °C	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0
	5 °C	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0	±20,0

dT_R = 25 K/min		High conditioning temperature T_B														
		30 °C	**35 °C**	**40 °C**	**45 °C**	**50 °C**	**55 °C**	**60 °C**	**65 °C**	**70 °C**	**85 °C**	**100 °C**	**125 °C**	**155 °C**	**175 °C**	**200 °C**
Low conditioning temperature T_A	**−65 °C**	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0
	−55 °C	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0
	−50 °C	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0
	−40 °C	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0
	−33 °C	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0
	−25 °C	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0
	−20 °C	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0
	−10 °C	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0
	−5 °C	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0
	5 °C	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0	±25,0

Bibliography

IEC 60068 (all parts), *Environmental testing*

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

IEC 60068-2-17, *Environmental testing – Part 2-17: Tests – Test Q: Sealing*

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

IEC 60068-2-67, *Environmental testing – Part 2-67: Tests – Test Cy: Damp heat, steady state, accelerated test primarily intended for components*

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

____

SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

____

ESSAIS D'ENVIRONNEMENT –

Partie 2-14: Essais – Essai N: Variation de température

AVANT-PROPOS

1) La Commission Électrotechnique Internationale (IEC) est une organisation mondiale de normalisation composée de l'ensemble des comités électrotechniques nationaux (Comités nationaux de l'IEC). L'IEC a pour objet de favoriser la coopération internationale pour toutes les questions de normalisation dans les domaines de l'électricité et de l'électronique. À cet effet, l'IEC – entre autres activités – publie des Normes internationales, des Spécifications techniques, des Rapports techniques, des Spécifications accessibles au public (PAS) et des Guides (ci-après dénommés "Publication(s) de l'IEC"). Leur élaboration est confiée à des comités d'études, aux travaux desquels tout Comité national intéressé par le sujet traité peut participer. Les organisations internationales, gouvernementales et non gouvernementales, en liaison avec l'IEC, participent également aux travaux. L'IEC collabore étroitement avec l'Organisation Internationale de Normalisation (ISO), selon des conditions fixées par accord entre les deux organisations.
2) Les décisions ou accords officiels de l'IEC concernant les questions techniques représentent, dans la mesure du possible, un accord international sur les sujets étudiés, étant donné que les Comités nationaux de l'IEC intéressés sont représentés dans chaque comité d'études.
3) Les Publications de l'IEC se présentent sous la forme de recommandations internationales et sont agréées comme telles par les Comités nationaux de l'IEC. Tous les efforts raisonnables sont entrepris afin que l'IEC s'assure de l'exactitude du contenu technique de ses publications; l'IEC ne peut pas être tenue responsable de l'éventuelle mauvaise utilisation ou interprétation qui en est faite par un quelconque utilisateur final.
4) Dans le but d'encourager l'uniformité internationale, les Comités nationaux de l'IEC s'engagent, dans toute la mesure possible, à appliquer de façon transparente les Publications de l'IEC dans leurs publications nationales et régionales. Toutes divergences entre toutes Publications de l'IEC et toutes publications nationales ou régionales correspondantes doivent être indiquées en termes clairs dans ces dernières.
5) L'IEC elle-même ne fournit aucune attestation de conformité. Des organismes de certification indépendants fournissent des services d'évaluation de conformité et, dans certains secteurs, accèdent aux marques de conformité de l'IEC. L'IEC n'est responsable d'aucun des services effectués par les organismes de certification indépendants.
6) Tous les utilisateurs doivent s'assurer qu'ils sont en possession de la dernière édition de cette publication.
7) Aucune responsabilité ne doit être imputée à l'IEC, à ses administrateurs, employés, auxiliaires ou mandataires, y compris ses experts particuliers et les membres de ses comités d'études et des Comités nationaux de l'IEC, pour tout préjudice causé en cas de dommages corporels et matériels, ou de tout autre dommage de quelque nature que ce soit, directe ou indirecte, ou pour supporter les coûts (y compris les frais de justice) et les dépenses découlant de la publication ou de l'utilisation de cette Publication de l'IEC ou de toute autre Publication de l'IEC, ou au crédit qui lui est accordé.
8) L'attention est attirée sur les références normatives citées dans cette publication. L'utilisation de publications référencées est obligatoire pour une application correcte de la présente publication.
9) L'IEC attire l'attention sur le fait que la mise en application du présent document peut entraîner l'utilisation d'un ou de plusieurs brevets. L'IEC ne prend pas position quant à la preuve, à la validité et à l'applicabilité de tout droit de brevet revendiqué à cet égard. À la date de publication du présent document, l'IEC n'avait pas reçu notification qu'un ou plusieurs brevets pouvaient être nécessaires à sa mise en application. Toutefois, il y a lieu d'avertir les responsables de la mise en application du présent document que des informations plus récentes sont susceptibles de figurer dans la base de données de brevets, disponible à l'adresse www.iso.org/patents. L'IEC ne saurait être tenue pour responsable de ne pas avoir identifié de tels droits de brevets.

L'IEC 60068-2-14 a été établie par le comité d'études 104 de l'IEC: Conditions, classification et essais d'environnement. Il s'agit d'une Norme internationale.

Cette septième édition annule et remplace la sixième édition parue en 2009. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a) mise à jour des figures à des fins de clarification;
b) mise à jour des températures et des sévérités des spécimens, ainsi que des tolérances sur les essais de variation de température;
c) révision des exigences normalisées pour les rapports d'essai des Essais Na et Nb.

Le texte de cette Norme internationale est issu des documents suivants:

Projet	Rapport de vote
104/991/FDIS	104/1016/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette norme.

La langue employée pour l'élaboration de cette Norme internationale est l'anglais.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2, il a été développé selon les Directives ISO/IEC, Partie 1 et les Directives ISO/IEC, Supplément IEC, disponibles sous www.iec.ch/members_experts/refdocs. Les principaux types de documents développés par l'IEC sont décrits plus en détail sous www.iec.ch/publications.

Une liste de toutes les parties de la série IEC 60068, publiées sous le titre général *Essais d'environnement*, se trouve sur le site web de l'IEC.

Le comité a décidé que le contenu de ce document ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous webstore.iec.ch dans les données relatives au document recherché. À cette date, le document sera

- reconduit,
- supprimé,
- remplacé par une édition révisée, ou
- amendé.

INTRODUCTION

L'objet d'un essai de variation de température est de déterminer les effets d'une variation de température ou d'une succession de variations de température sur le spécimen.

Il n'a pas pour objet de mettre en évidence les effets causés par une exposition à basse ou à haute température. Dans ce cas, il convient d'utiliser l'essai de froid ou l'essai de chaleur sèche, comme cela est spécifié dans l'IEC 60068-2-1 et l'IEC 60068-2-2 respectivement.

L'effet des essais de variation de température est déterminé par:

- les valeurs respectives des températures d'épreuve haute et basse entre lesquelles doit être effectuée la variation;
- les durées pendant lesquelles le spécimen d'essai est maintenu à ces températures;
- la vitesse de variation entre ces températures;
- le nombre de cycles de l'épreuve;
- la quantité de chaleur transférée par le spécimen vers le milieu ambiant ou inversement;
- la conduction thermique et les matériaux du spécimen;
- la vitesse de variation de la température à la surface du spécimen (respectivement dans les positions adaptées) ou dans son noyau.

Les recommandations pour le choix des paramètres d'essai appropriés à inclure dans la spécification particulière sont données dans l'ensemble du présent document.

ESSAIS D'ENVIRONNEMENT –

Partie 2-14: Essais – Essai N: Variation de température

1 Domaine d'application

Le présent document établit les essais de variations de la température ambiante spécifiée pour analyser leurs impacts sur les spécimens.

2 Références normatives

Les documents suivants sont cités dans le texte de sorte qu'ils constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60068-2-1, *Essais d'environnement – Partie 2-1: Essais – Essai A: Froid*

IEC 60068-2-2, *Essais d'environnement – Partie 2-2: Essais – Essai B: Chaleur sèche*

3 Termes et définitions

Pour les besoins du présent document, les termes et définitions de l'IEC 60068-2-1 et de l'IEC 60068-2-2 s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse https://www.electropedia.org/
- ISO Online browsing platform: disponible à l'adresse https://www.iso.org/obp

4 Symboles

D	différence entre la température d'épreuve haute T_B et la température d'épreuve basse T_A
T_A	température d'épreuve basse
T_{Ad}	température d'épreuve basse diminuée
T_B	température d'épreuve haute
T_{Bi}	température d'épreuve haute augmentée
T_{STD}	température des conditions atmosphériques normales de mesure et d'essai (15 °C à 35 °C)
ΔT_s	différence de température entre le spécimen et le milieu d'essai (l'air, par exemple)
dT_R	vitesse de variation de la température (Essai Nb)
t_s	temps de stabilisation en température du spécimen
t_{s*}	temps de stabilisation en température du spécimen pendant le premier cycle, en partant de la température ambiante du laboratoire
t_1	durée d'exposition du spécimen à chaque température d'épreuve
t_2	temps de transfert du spécimen d'une chambre d'essai à une autre (méthode à deux chambres d'essai)
$\pm_T$	tolérance sur la température applicable pour la température du milieu pendant la transition de température (Essai Nb)
$\pm_{Tconst}$	tolérance sur la température applicable pour la température du milieu pendant la période d'épreuve à température constante

5 Généralités

5.1 Conditions réelles de variation de température

Dans les équipements et composants électroniques, il se produit habituellement des variations de température. Les parties situées à l'intérieur d'un équipement sont soumises à des variations de température plus lentes que celles situées sur une surface extérieure, lorsque l'équipement n'est pas sous tension.

Des variations rapides de température peuvent se produire:

– lorsque l'équipement est transporté d'un environnement chaud à l'intérieur vers un environnement froid à l'extérieur, ou inversement;
– lorsque l'équipement est brusquement refroidi par la pluie ou par immersion dans l'eau froide;
– lorsque l'équipement est fixé ou placé à proximité de composants qui produisent d'importantes contraintes thermiques (moteurs à combustion, unités centrales, par exemple);
– lorsque l'équipement est refroidi ou réchauffé artificiellement;
– dans un équipement aéroporté, situé à l'extérieur de l'aéronef, ou lorsque l'équipement est situé dans un aéronef non chauffé ou dans une soute;
– dans certaines conditions de transport et de stockage.

Les composants sont soumis à des contraintes dues aux variations de température lorsque des gradients de haute température se produisent à l'intérieur d'un équipement après sa mise sous tension. Par exemple, à proximité de résistances de puissance élevée, les rayonnements peuvent provoquer un échauffement à la surface sur les composants situés à proximité alors que d'autres parties de ces composants demeurent froides.

Les composants refroidis artificiellement peuvent être soumis à des variations rapides de température lorsque le système de refroidissement est mis sous tension. Des variations rapides de température dans les composants peuvent également se produire pendant les étapes de la fabrication ou le transport des équipements. Le nombre et l'amplitude des variations de température, l'intervalle de temps entre ces variations et la réactivité thermique de l'équipement (ou du spécimen) sont des éléments importants.

5.2 Conception des essais de variation de température

Les Essais Na, Nb et Nc de variation de température comprennent des périodes alternées de températures haute et basse, avec des transferts bien définis d'une température à l'autre. La variation de la température ambiante du laboratoire jusqu'à la première température d'épreuve, puis jusqu'à la deuxième température d'épreuve, avec retour à la température ambiante du laboratoire, est considérée comme un cycle d'essai.

5.3 Paramètres d'essai

Les paramètres d'essai suivants sont utilisés:

- conditions ambiantes du laboratoire (principalement la température et l'humidité);
- température d'épreuve haute T_B;
- température d'épreuve haute augmentée T_{Bi}, le cas échéant;
- température d'épreuve basse T_A;
- température d'épreuve basse diminuée T_{Ad}, le cas échéant;
- durée d'exposition t_1 du spécimen à chaque température d'épreuve;
- temps de transfert t_2 ou vitesse de variation de la température dT_R;
- nombre de cycles d'essai.

Étant donné que ces essais ont pour objet de valider les effets des variations de température sur le spécimen, il convient de toujours prendre en compte les caractéristiques du spécimen (sauf spécification contraire):

- la réactivité thermique du spécimen dans les zones concernées ou le noyau;
  - la conductivité thermique;
  - la capacité thermique massique;
- la masse volumique;
- la géométrie;
- la masse.

La détermination expérimentale de ces caractéristiques est recommandée, si celles-ci ne sont pas connues et sauf spécification contraire.

L'essai est accéléré, car le nombre de variations de température sévères sur une période donnée est supérieur à celui rencontré en conditions réelles.

Les températures d'épreuve basse et haute sont définies comme étant les températures ambiantes que la plupart des spécimens atteignent avec un certain temps de retard. Il est recommandé de tenir compte des caractéristiques du spécimen lors de la spécification de l'essai. L'Annexe A fournit des informations supplémentaires concernant les conséquences potentielles de sévérités incorrectes.

Dans des cas exceptionnels uniquement, il convient de spécifier ces températures en dehors de la plage normale de températures de stockage ou de fonctionnement de l'objet d'essai.

NOTE Si les caractéristiques du spécimen (masse, masse volumique, géométrie) empêchent d'atteindre la vitesse de variation spécifiée, les températures peuvent être spécifiées en dehors de la plage normale de températures de stockage ou de fonctionnement pour augmenter la sévérité de l'essai prévu, sauf spécification contraire.

5.4 Objet et choix des essais

Les essais de variation de température sont recommandés dans les cas suivants:

– vérification des performances électriques après un nombre spécifié de variations rapides de température, Essai Na ou Essai Nc;
– vérification de l'aptitude des composants mécaniques, des matériaux et des combinaisons de matériaux à supporter des variations rapides de température, Essai Na ou Essai Nc;
– vérification de l'aptitude de la construction des composants à supporter des contraintes artificielles, Essai Na ou Essai Nc;
– vérification des performances électriques à la suite d'une variation de température, Essai Nb;
– vérification des performances mécaniques à la suite d'une variation de température, Essai Nb.

Les essais de variation de température spécifiés dans la série IEC 60068 n'ont pas pour objet d'évaluer les différences au niveau des constantes du matériau ou des performances électriques lors d'un fonctionnement sous les températures d'épreuve T_A et T_B.

5.5 Choix de la durée d'exposition à chaque température d'épreuve

Il convient de définir la durée d'exposition conformément aux exigences du 7.2.3, du 8.2.3 ou du 9.2.2 ou, comme cela est indiqué dans la spécification pertinente, en gardant à l'esprit les éléments suivants:

a) L'exposition démarre dès que le spécimen se trouve dans le nouvel environnement.
b) La stabilisation se produit lorsque la différence de température entre le spécimen et le milieu d'essai (ΔT_s) est inférieure ou égale à 5 K, ou comme cela est indiqué dans la spécification d'essai. Le temps de stabilisation en température du spécimen t_s commence au début de l'exposition et se termine au moment où la température se situe dans les limites de la différence spécifiée. Un ou plusieurs points représentatifs sur le spécimen peuvent être utilisés pour procéder à ce mesurage.
c) La durée d'exposition t_1 du spécimen à chaque température d'épreuve doit être plus longue que le temps de stabilisation en température du spécimen t_s. La Figure 1 fournit une représentation graphique du processus. Il est possible que cela ne soit pas approprié pour les spécimens générateurs de chaleur.

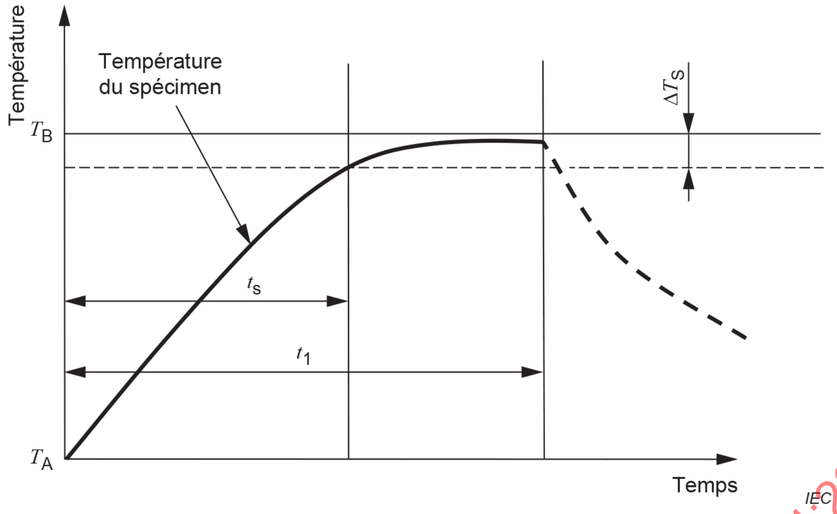


Figure 1 – Détermination de la durée d'exposition t_1 du spécimen à chaque température d'épreuve

5.6 Choix de la durée du temps de transfert t_2

Si, en raison des grandes dimensions des spécimens, par exemple, le temps de transfert t_2 ne peut pas être effectué en 3 min, le temps de transfert peut être augmenté sans influence significative sur les résultats d'essai, comme suit:

$$t_2 \leq 0{,}05\ t_s$$

Cela s'applique pour la méthode d'essai à deux chambres (voir 7.2.1) uniquement. Si la méthode d'essai à une chambre est utilisée, la période t_2 ne s'applique pas.

5.7 Limites d'applicabilité des essais de variation de température

À l'intérieur d'un spécimen, la vitesse de variation de la température dépend de la conduction thermique de ses matériaux, de la distribution spatiale de sa capacité thermique, ainsi que de ses dimensions et de sa surface. Un ou plusieurs points représentatifs sur le spécimen (ou à l'intérieur du spécimen) peuvent être utilisés pour mesurer les vitesses de variation de la température.

NOTE 1 La vitesse de variation de la température des spécimens de matériaux et de masse identiques peut varier si leurs surfaces sont différentes.

La variation de la température en un point sur la surface d'un spécimen suit approximativement une loi exponentielle. À l'intérieur de grands spécimens, de telles augmentations et diminutions exponentielles alternées peuvent conduire à des variations de température périodiques et approximativement sinusoïdales d'amplitudes beaucoup plus faibles que les variations de température appliquées. L'Annexe B fournit des informations supplémentaires concernant la réactivité thermique des différents matériaux et des différentes géométries.

Il convient de prendre en compte le mécanisme de transmission thermique entre le spécimen d'essai et le milieu d'épreuve dans la chambre ou le bain. Les liquides en mouvement conduisent à des vitesses de variation de température très élevées à la surface des spécimens et l'air calme à des vitesses très faibles.

NOTE 2 Si plusieurs spécimens sont soumis à l'essai dans la même chambre d'essai, la circulation uniforme de l'air pénétrant peut être perturbée. Pour plus d'informations sur la relation entre la circulation d'air et la température des spécimens, l'IEC 60068-3-1 peut être pertinente.

Il convient de réserver la méthode à deux bains d'eau comme milieu d'épreuve (Essai Nc) aux spécimens scellés ou, par leur nature, insensibles à l'eau, car leurs performances et leurs propriétés peuvent se détériorer sous l'effet de l'immersion.

Dans des cas particuliers, comme avec des spécimens sensibles à l'eau, il convient de spécifier un essai avec un autre liquide que l'eau. Lors de la conception d'un tel essai, les caractéristiques de transmission thermique du liquide, qui peuvent différer de celles de l'eau, doivent être prises en compte.

NOTE 3 Pour évaluer l'applicabilité de la méthode à deux bains, les évaluations de l'Essai Q: Étanchéité (IEC 60068-2-17) peuvent être pertinentes.

L'application des Essais N est privilégiée dans le cadre d'une séquence d'essais. Il est possible que certains types de dommages n'apparaissent pas au cours des mesurages finaux d'un Essai N, mais qu'ils apparaissent seulement au cours des essais ultérieurs.

Par exemple, la séquence d'essais peut être la suivante: Essai Q: Étanchéité de l'IEC 60068-2-17, Essai Fc: Vibrations (sinusoïdales) de l'IEC 60068-2-6, de l'Essai Db: Essai cyclique de chaleur humide (cycle de 12 h + 12 h) de l'IEC 60068-2-30 ou Essai Cy: Chaleur humide de l'IEC 60068-2-67.

Il convient de ne pas utiliser l'Essai Nc de variation de température (Méthode à deux bains) comme variante de l'Essai Q (Étanchéité).

Lorsqu'un essai de variation de température est spécifié, il convient de garder à l'esprit les caractéristiques des objets soumis à l'essai qui sont altérés par les conditions de variation de température ainsi que leurs mécanismes de défaillance éventuels. Il convient de spécifier les mesures initiales et finales en conséquence.

6 Mesures initiales et finales

6.1 Généralités

Les Essais Na, Nb et Nc utilisent tous les mêmes mesures initiales et finales.

6.2 Mesures initiales

Le spécimen doit être examiné visuellement et soumis aux vérifications électriques et mécaniques exigées dans la spécification pertinente.

6.3 Mesures finales

Le spécimen doit être examiné visuellement et soumis aux vérifications électriques et mécaniques exigées dans la spécification pertinente.

7 Essai Na: Variations rapides de température

7.1 Description générale de l'essai

Cet essai détermine l'aptitude des composants, équipements ou autres articles à supporter des variations rapides de la température ambiante. Les durées d'exposition adéquates à appliquer sont déterminées par la nature du spécimen. Le spécimen doit être soumis à l'essai, soit non emballé, sans application de tension, prêt à être utilisé, soit selon les exigences de la spécification correspondante si celles-ci diffèrent. Le spécimen est soumis à des variations rapides de température dans l'air ou dans un gaz inerte adapté, par une exposition alternée à une température d'épreuve basse et une température d'épreuve haute.

7.2 Procédure d'essai

7.2.1 Chambre d'essai

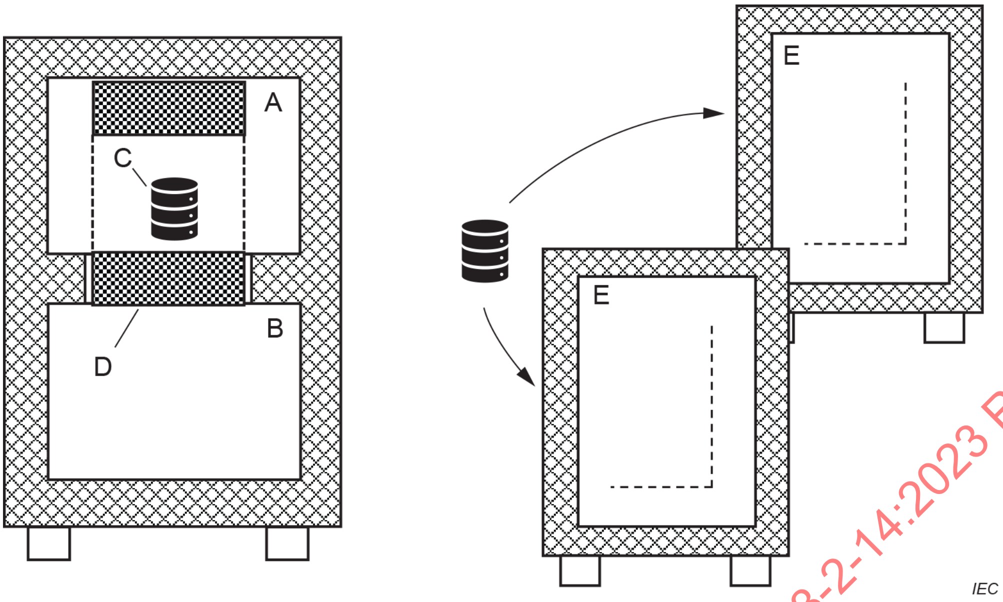
Deux chambres distinctes (méthode à deux chambres, voir Figure 2) ou une chambre pour vitesse rapide de variation de température (méthode à une chambre, voir Figure 3) peuvent être utilisées. Si deux chambres sont utilisées, l'une à basse température et l'autre à haute température, leur emplacement doit permettre le transfert du spécimen d'une chambre à l'autre pendant la durée spécifiée. Une méthode de transfert manuelle ou automatique peut être utilisée.

Certains systèmes adaptés pour la méthode à deux chambres sont appelés enceintes d'essai de chocs thermiques. Ces systèmes combinent les caractéristiques des deux chambres d'essai distinctes et sont équipés d'une cage de levage mobile (s'applique également aux chambres d'essai de chocs horizontales) pour le transfert automatique des spécimens d'une chambre à l'autre (voir Figure 2).

Les enceintes d'essai de chocs d'amortissement constituent un autre type de système d'essai à une chambre. Ces systèmes comportent deux chambres d'épreuve et une chambre d'essai. La chambre d'essai est exposée alternativement à l'air conditionné par une chambre d'épreuve chaude puis par une chambre d'épreuve froide, par des clapets d'air (voir Figure 3). Si ce type de système d'essai est utilisé, aucun transfert physique n'est exigé et le temps de transfert t_2 ne s'applique pas.

Les enceintes d'essai de chocs d'amortissement avec une chambre d'essai fixe, une chambre chaude et une chambre froide sont généralement capables d'effectuer des essais sur deux zones avec une exposition à la chaleur et au froid, respectivement. Certaines enceintes sont capables d'effectuer des essais sur trois zones, avec une exposition à l'air ambiant.

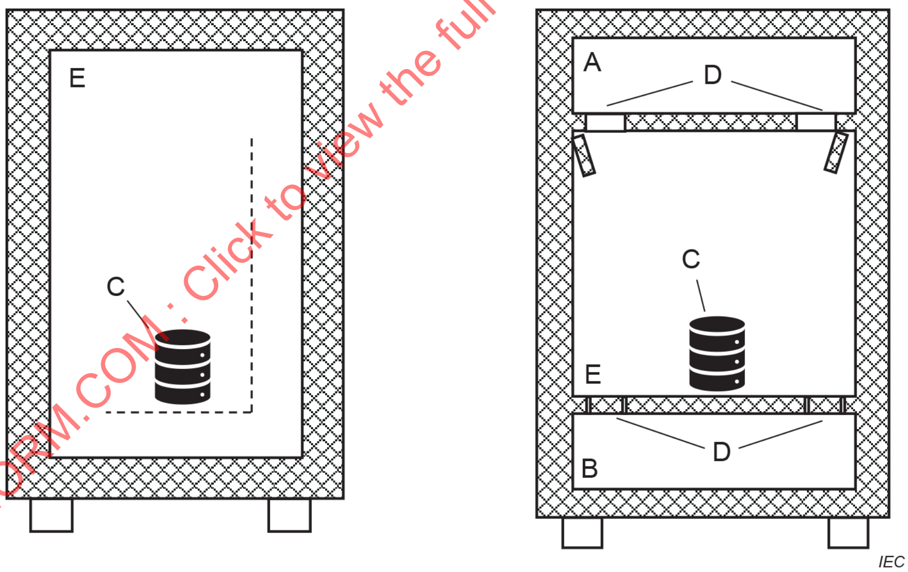
NOTE 1 Les enceintes d'essai d'amortissement et de type à panier sont souvent utilisées pour l'Essai Na. Selon les performances, deux chambres distinctes ou une chambre pour vitesse rapide de variation de température sont également souvent utilisées pour l'Essai Na. Une chambre pour vitesse rapide de variation de température est souvent utilisée pour l'Essai Nb.



Légende

A chambre chaude
B chambre froide
C spécimen
D cage mobile
E zone d'essai fixe

Figure 2 – Représentation schématique d'exemples d'enceintes d'essai thermique et de procédure d'essai avec deux chambres d'essai distinctes



Légende

A chambre chaude
B chambre froide
C spécimen
D clapets d'air
E zone d'essai fixe

Figure 3 – Représentation schématique d'exemples d'enceintes d'essai thermique avec une chambre d'essai

Il convient que les chambres soient capables de maintenir l'espace de travail aux températures exigées.