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INTERNATIONAL STANDARD

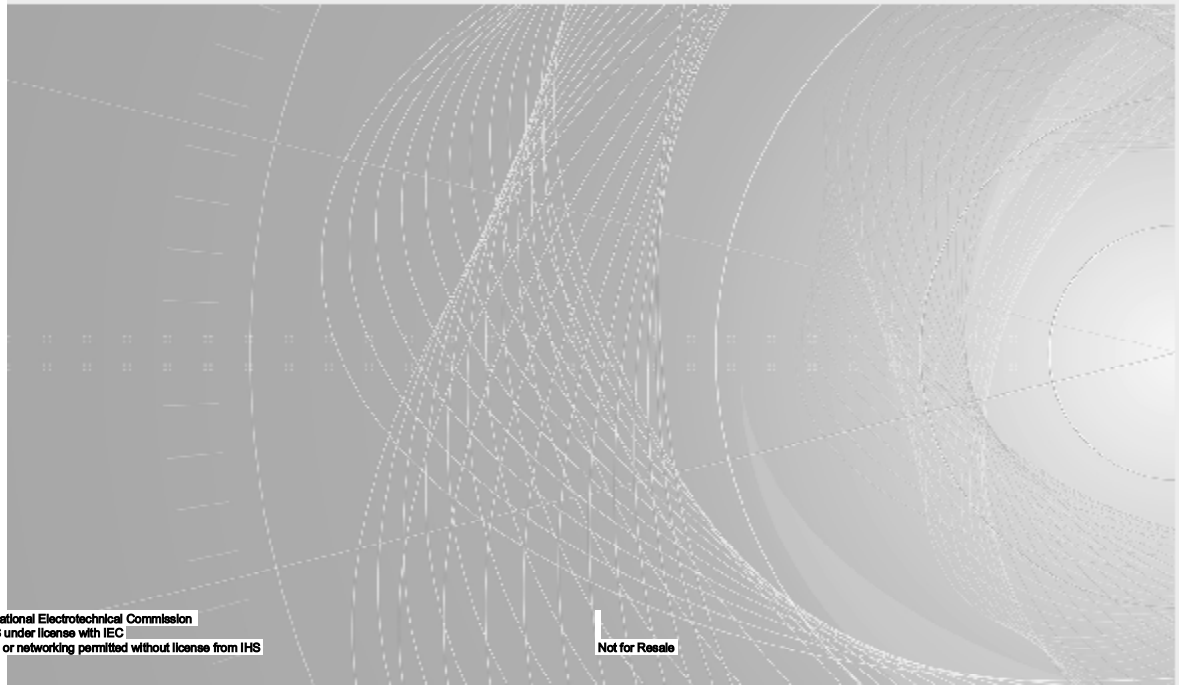
NORME INTERNATIONALE

BASIC SAFETY PUBLICATION

PUBLICATION FONDAMENTALE DE SÉCURITÉ

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

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



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

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CONTENTS

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

This sixth edition cancels and replaces the fifth edition, published in 1984, and its amendment 1 (1986) and constitutes a technical revision.

The major changes with regard to the previous edition concern:

- merging of the previous version of IEC 60068-2-14 with IEC 60068-2-33: *Guidance on change of temperature tests*;
- updating of the figures, changes to some of the wording and editorial corrections made for clarification.

The text of this standard is based on the following documents:

FDIS	Report on voting
104/481/FDIS	104/486/RVD

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

It has the status of a basic safety publication in accordance with IEC Guide 104.

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

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication 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 which are due only to high or low temperatures. For these effects, the dry heat test or the cold test should be used.

The effect of such tests is determined by

– values of high and low conditioning temperature between which the change is to be effected,
– 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.

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

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.

2 Normative references

The following referenced documents are indispensable for the application 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 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 be expected

– when equipment is transported from warm indoor environments into cold open air conditions or vice versa,
– when equipment is suddenly cooled by rainfall or immersion in cold water,
– in externally mounted airborne equipment,
– 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, e.g. in the neighbourhood of high wattage resistors, radiation can cause rise of surface temperature in neighbouring components while other portions are still cool.

Artificially cooled components may be subjected to rapid temperature changes when the cooling system is switched on. Rapid changes of temperature in components may also be induced during manufacturing processes of equipment. Both the number and amplitude of temperature changes and the time interval between them are important.

4 General

4.1 Design of change of temperature tests

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 laboratory ambient to the first conditioning temperature, then to the second conditioning temperature, then back to laboratory ambient is considered one test cycle.

4.2 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.

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.

4.3 Purpose and choice of the tests

Change of temperature testing is recommended in the following cases:

– evaluation of electrical performance during a change of temperature, Test Nb;
– evaluation of mechanical performance during a change of temperature, Test Nb,
– 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.

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.

4.4 Choice of the duration of the exposure

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 is within 3 K to 5 K, or as stated in the test specification. The stabilization period, (t_s), is from the start of exposure until the time when the temperature is within the

specified difference. A representative point (or points) on the specimen may be used for this measurement.

c) The test duration, t_1, shall be longer than the specimen stabilization time, t_s. Figure 1 provides a graphical representation of the process. This may not be appropriate for heat generating specimens.

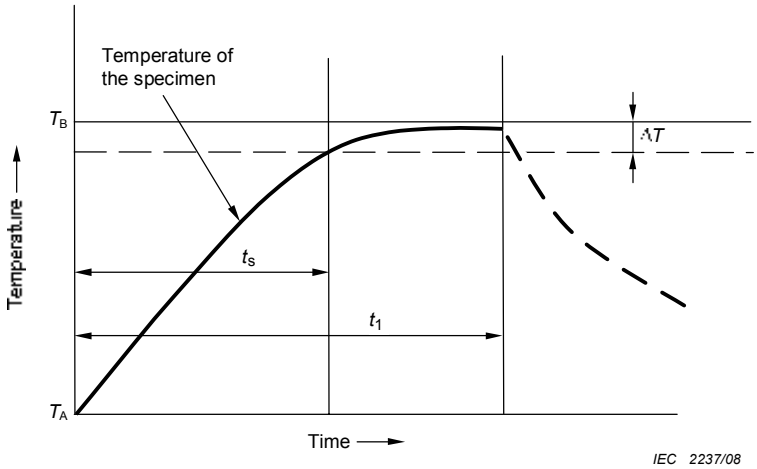


Figure 1 Determination of test duration time (t_1)

4.5 Choice of the duration of the transfer time

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.

4.6 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 and its dimensions.

The change of temperature at a point on the surface of a specimen follows approximately an exponential law. Inside large specimens, such alternate exponential rises and decreases may lead to periodic and approximately sinusoidal changes of temperature with much lower amplitudes than the applied temperature swing.

The mechanism of heat transfer between the test specimen and the conditioning medium in the chamber or bath should be taken into account. 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.

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 deteriorate by immersion.

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

NOTE To assess the applicability of the two-bath method, evaluations from Test Q: Sealing (IEC 60068-2-17) may 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. Some types of damage may not become apparent by the final measurements of a Test N, but may appear only during subsequent tests (e.g. Test Q: Sealing, Test F: Vibration or Test D: Accelerated 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

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

6.1 Initial measurements

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

6.2 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 alternate exposure to low temperature and to high temperature.

7.2 Testing procedure

7.2.1 Testing chamber

Two separate chambers or one rapid temperature change rate chamber may 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 time. Either manual or automatic transfer methods may 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.

7.2.2 Mounting or supporting of the test specimen

Unless otherwise specified in the relevant specification, the thermal conduction of the mounting or supports shall be low, such that for practical purposes the specimen is thermally isolated. 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 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 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 exposure time, t_1, of each of the two temperatures depends upon the heat capacity of the specimen. It may 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 preferred number of test cycles is five, unless otherwise specified in the relevant specification.

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

7.2.4 Conditioning

The specimen and the temperature in the test chamber shall be at the ambient temperature of the laboratory, +25 °C ± 5 K. If required by the relevant specification the specimen shall be brought into operating condition.

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.

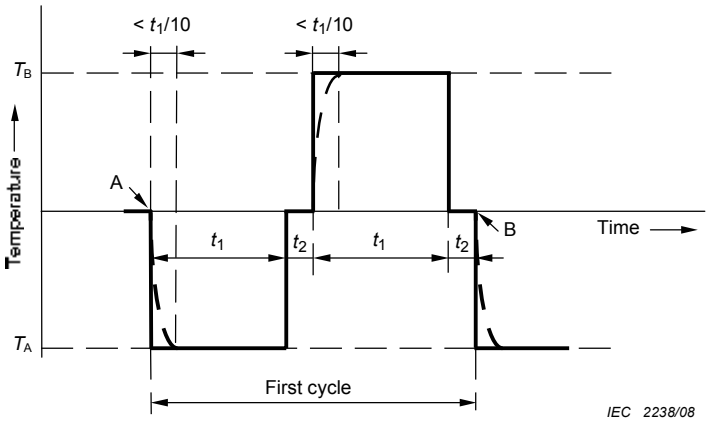
NOTE 2 For specimens with a large mass, the transfer time from one chamber to another may be increased as specified in the relevant standard or specification.

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

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.

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 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 temperatures varied at a controlled rate. During this exposure the performance of the specimen may be monitored.

8.2 Testing procedure

8.2.1 Testing chamber

The chamber for this test shall be so designed 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 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 of the test specimen

Unless otherwise specified in the relevant specification, the thermal conduction of the mounting or support shall be low, such that for practical purposes the specimen is thermally isolated. 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 lower 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 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 exposure time, t_1, to each of the two temperatures depends upon the heat capacity of the specimen. It may 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 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 Conditioning

The specimen and the temperature in test chamber shall be at the ambient temperature of the laboratory, +25 °C ±5 K. If required by the relevant specification, the specimen shall be brought into operating condition.

8.2.5 Test cycle

The air temperature in the chamber shall then be lowered to the specified low temperature, T_A, at the specified rate (see Figure 3).

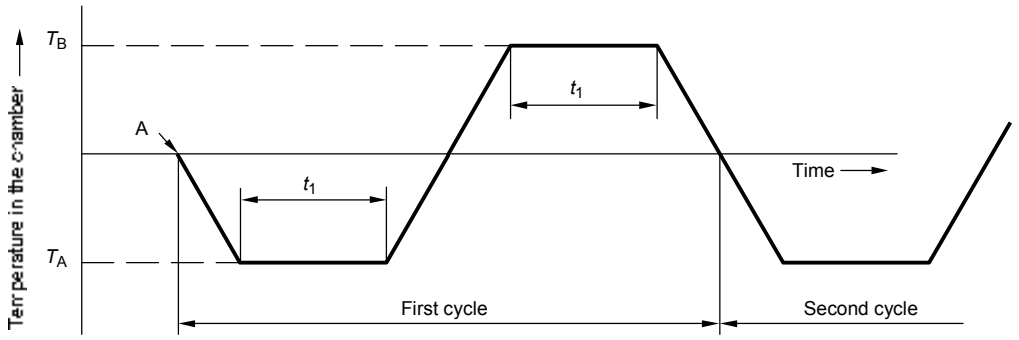
After temperature stability in the chamber has been reached, the specimen shall be exposed to the low temperature condition for the specified period, t_1.

The air temperature in the chamber shall then be raised to the specified high temperature, T_B, at the specified rate (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 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).

This procedure constitutes one cycle.



Key

A start of first cycle

Figure 3 – Nb test cycle

8.3 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.

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 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 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 from one bath to the other, t_2, and the number of cycles.

The relevant specification shall specify the duration parameters to be used and the chosen value of t_1.

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.

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 temperature T_A as stated in the relevant specification.

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

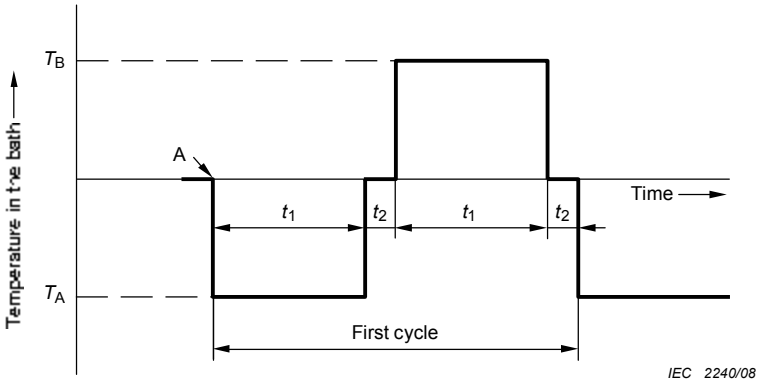
The specimen shall then be removed from the cold bath and immersed in the hot bath containing liquid at the temperature T_B as stated in the relevant specification. The transfer time t_2 shall be as stated in the relevant specification.

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

The specimen shall then be removed from the hot bath. The period 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).

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



Key

A start of first cycle

Figure 4 – Nc test cycle

9.4 Recovery

At the end of the test cycle, the specimen shall be subjected to laboratory ambient temperature. 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 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)