

# INTERNATIONAL STANDARD



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



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Part 2-38: Tests – Test Z/AD: Composite temperature/humidity cyclic test

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## ENVIRONMENTAL TESTING –

## Part 2-38: Tests –

## Test Z/AD: Composite temperature/humidity cyclic test

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IEC 60068-2-38 has been prepared by IEC technical committee 104: Environmental conditions, classification and methods of test. It is an International Standard.

This third edition cancels and replaces the second 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) the figures have been updated;
- b) changes to the wording has been made for clarification purposes.

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

| Draft        | Report on voting |
|--------------|------------------|
| 104/891/FDIS | 104/896/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](http://www.iec.ch/members_experts/refdocs). The main document types developed by IEC are described in greater detail at [www.iec.ch/standardsdev/publications](http://www.iec.ch/standardsdev/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.

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## ENVIRONMENTAL TESTING –

### Part 2-38: Tests – Test Z/AD: Composite temperature/humidity cyclic test

#### 1 Scope

This part of IEC 60068 ~~provides~~ specifies a composite test procedure, primarily intended for component type specimens, to determine, in an accelerated manner, the resistance of specimens to the deteriorative effects of high temperature/humidity and cold conditions.

This test standard does not apply to specimens that are energized during the complete test. Specimens can be energized during the constant phases of the tests. Measurements on energized specimens are typically carried out during constant phases of the test unless specified otherwise.

#### 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 60068-1, *Environmental testing – Part 1: General and guidance*

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

~~IEC 60068-2-78, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*~~

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

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

#### 3 Terms and definitions

No terms and definitions are listed in this document.

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

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO online browsing platform: available at <http://www.iso.org/obp>

## 4 General

### 4.1 Description of the test

Test Z/AD is a cyclic temperature/humidity test which is designed to reveal defects in test specimens caused by "breathing" as distinct from the absorption of moisture.

This process can be initiated by the forming of condensation on the specimen's surface. As the temperature on parts or the whole of the specimen's surface might be lower than the corresponding dew point at the humidity value, water can accumulate in small cracks or gaps on the specimen's surface.

Once the air temperature is reduced, the air in internal voids of specimen is contracted which results in a drop of pressure and drawing-in either wet air or condensed water through cracks or other leaks inside the specimen. The wet air will condense on inner walls of a void and may gradually fill it. During the temperature rising phase, the air in the void is expanded, this time with a lower dew point than during drawing-in, and partially escape out. This cycle is repeated, and water can be accumulated inside the specimen and may gradually fill its voids.

This so-called "breathing" effect is caused by changing the temperature inside the specimen in an atmosphere with high humidity. During the excursion to sub-zero temperature phase of the test, the water trapped in cracks and other voids freezes and due to the expansion of ice volume the cracks extend, and new cracks can form.

This test differs from other cyclic damp heat tests in that it derives its increased severity from:

- a) a greater number of temperature variations or "pumping breathing" actions in a given time;
- b) a greater cyclic temperature range;
- c) a higher cyclic rate of change of temperature;
- d) the inclusion of a number of excursions to sub-zero temperatures.

The accelerated breathing and the effect of the freezing of trapped water in cracks and fissures are the essential features of this composite test.

It is emphasized, however, that the freezing effect will occur only if the fissure dimensions are large enough to allow the penetration of a coherent mass of water as is normally the case in fissures between seals and metal assemblies, or between seals and wire terminations.

The degree of condensation will depend mainly upon the thermal time constant of the surface of the test specimens and may be negligible for very small specimens but copious for large specimens.

Similarly, the breathing effect will be more apparent on specimens which contain relatively large air-filled or gas-filled voids, but again, the severity of the test will depend to some extent on the thermal characteristics of the specimens.

The condensation effect and the temperature distribution could be disturbed by functional checks, therefore the checks should be carried out during the constant phases of the temperature profiles (Figure 2 and Figure 3, areas B and F).

To simplify the programming of the test sequences, the set points are given in Annex A.

### 4.2 Application of the test

For the reasons given above, it is recommended that this test procedure be limited to component type specimens when the construction of the specimens suggests a "breathing" type of damp

heat test combined with icing and where the thermal characteristics are compatible with the rates of change of temperature, etc., of test Z/AD.

For solid type specimens, for example plastic encapsulated, where there may be small hairline cracks or porous material, the absorption or diffusion mechanisms will predominate and a steady damp heat such as test C of IEC 60068-2-78 is preferred for investigating these effects.

For larger specimens such as equipment or when it is essential for components to ensure thermal stability during the various phases of the cycle, test Db of IEC 60068-2-30 should be employed, although due to the reduced number of cycles in a given period, the degree of acceleration may not be as fast. In this case, test Db should normally form part of a sequence such as that defined in IEC 60068-1.

As in other damp heat tests, a polarizing voltage or electrical loading may be applied to the specimens. In the case of electrical loading, the loading should be such that the temperature rise of the specimens does not unduly affect the chamber conditions.

From the above, test Z/AD should not be considered to be interchangeable with, or an alternative to, either steady-state or other cyclic damp heat tests, but the choice of test procedure should be made with due regard for the physical and thermal characteristics of the test specimens and the types of failure mechanisms which are significant for each particular case.

## 5 Description of test chamber

### 5.1 General

The exposure to moisture, followed by cold, can either be performed in one chamber or in two separate chambers.

**NOTE** All temperatures and humidity values measured refer to a supply air measurement of the test chamber.

### 5.2 Chamber for exposure to moisture

The chamber for the exposure to moisture shall be so constructed that:

- the temperature can be varied between  $25\text{ °C} \pm 2\text{ K}$  and  $65\text{ °C} \pm 2\text{ K}$  in a period of between 1,5 h and 2,5 h for both rising and falling temperatures;
- the relative humidity can be maintained at  $(93^{+3}_{-3})\%$  during the periods of constant or rising temperature and between  $80\% \text{ RH}$  and  $96\% \text{ RH}$  during the falling temperature periods;
- the conditions prevailing at any point in the working space are uniform and are as similar as possible to those prevailing in the immediate vicinity of suitably located temperature- and humidity-sensing devices;

The air in the chamber shall therefore be continuously stirred at a rate necessary to maintain the specified conditions of temperature and humidity.

- the specimens under test shall not be subjected to radiant heat from the chamber conditioning processes;
- ~~water used for the maintenance of chamber humidity shall have a resistivity of not less than 500 Ωm~~ the water used for the chamber humidity system shall comply with the limits given in IEC 60068-2-67;
- condensed water shall be continuously drained from the chamber and not used again unless it has been re-purified.

Precautions shall be taken to ensure that no condensed water from the walls and roof of the test chamber can fall on the specimens.

### 5.3 Chamber for exposure to cold

The chamber for exposure to cold shall be so constructed that

- a) the temperature can be maintained at  $-10\text{ °C} \pm 2\text{ K}$ ,
- b) the conditions prevailing at any point in the working space are uniform and are as similar as possible to those prevailing in the immediate vicinity of suitably located temperature-sensing devices.

The air in the chamber shall therefore be continuously moving.

Care ~~shall~~ **should** be taken that the thermal capacity of the specimen under test does not appreciably influence conditions within the chamber.

The humidity chamber may be used for exposure to cold, in which case it shall meet the requirements of 4.1 and, in addition, shall be so constructed that

- 1) the temperature can be lowered from  $25\text{ °C} \pm 2\text{ K}$  to  $-10\text{ °C} \pm 2\text{ K}$  in a period of not more than 30 min,
- 2) the specimen can be held at a temperature of  $-10\text{ °C} \pm 2\text{ K}$  for a period of 3 h,
- 3) the temperature can be raised from  $-10\text{ °C} \pm 2\text{ K}$  to  $25\text{ °C} \pm 2\text{ K}$  in a period of not more than 90 min.

## 6 Severities

The number of 24 h cycles shall be 10, unless otherwise specified. If other than 10, the relevant specification shall define the number.

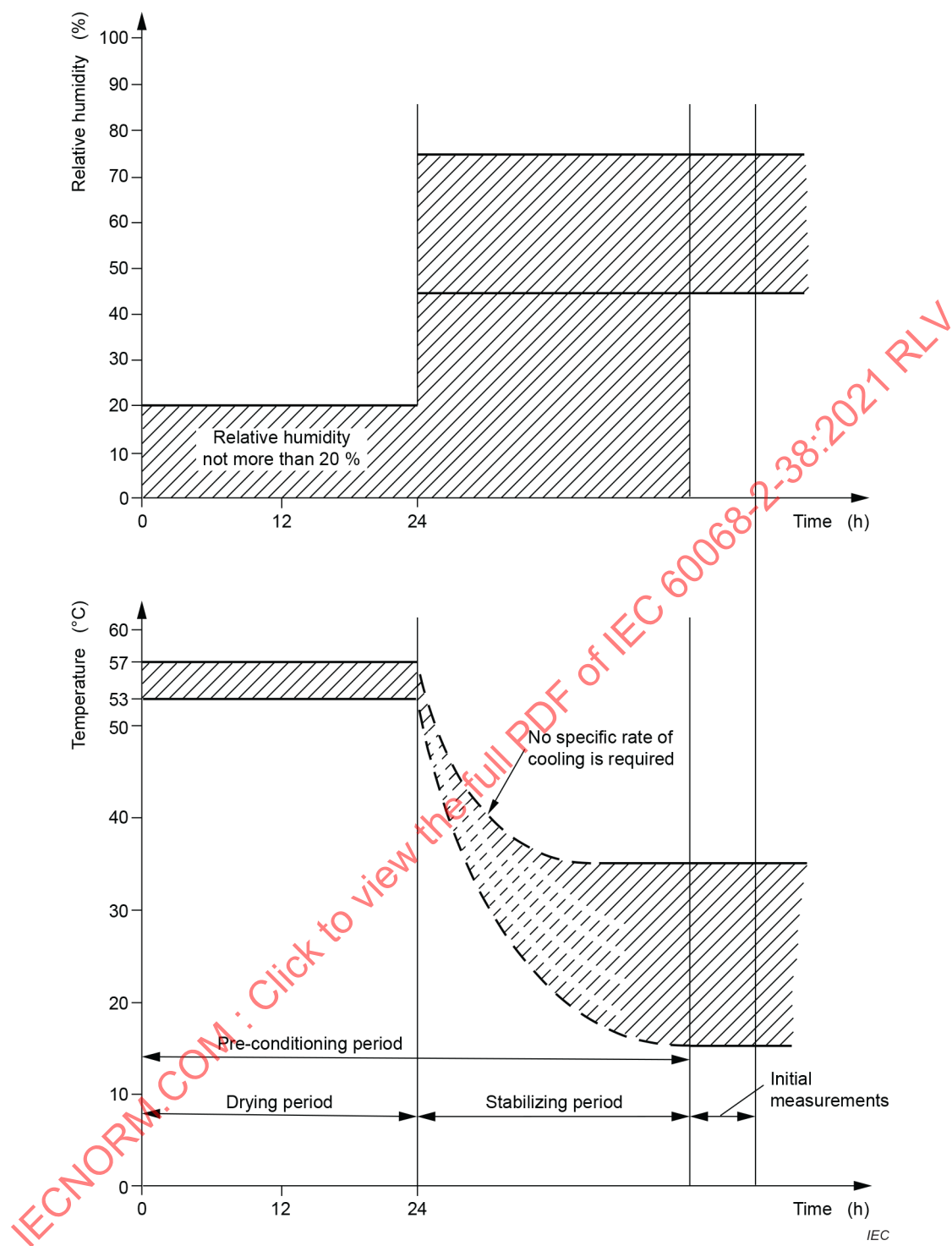
## 7 Testing procedure

### 7.1 Preconditioning (see Figure 1)

Unless otherwise specified, the specimens in the unpacked, switched-off, ready-for-use state shall be subjected to the conditions for "assisted drying" specified in IEC 60068-1 ( $55\text{ °C} \pm 2\text{ K}$  with a relative humidity not exceeding 20 %) for a period of 24 h prior to the first cycle of the damp heat test.

The specimens shall then be allowed to attain thermal stability at standard atmospheric conditions for testing or, as otherwise specified, before the initial measurements are made.

Figure 1 gives an overview about the preconditioning phase. During the stabilizing period no specific rate of cooling is specified, however it shall not exceed 1 K/min.



**Figure 1 – Preconditioning**

## 7.2 Initial measurements

The specimens shall be visually inspected and electrically and mechanically checked as required by the relevant specification.

## 7.3 Conditioning

The total temperature tolerance of  $\pm 2$  K given in this document is intended to take account of absolute errors in the measurement, slow changes of temperature and temperature variations of the working space.

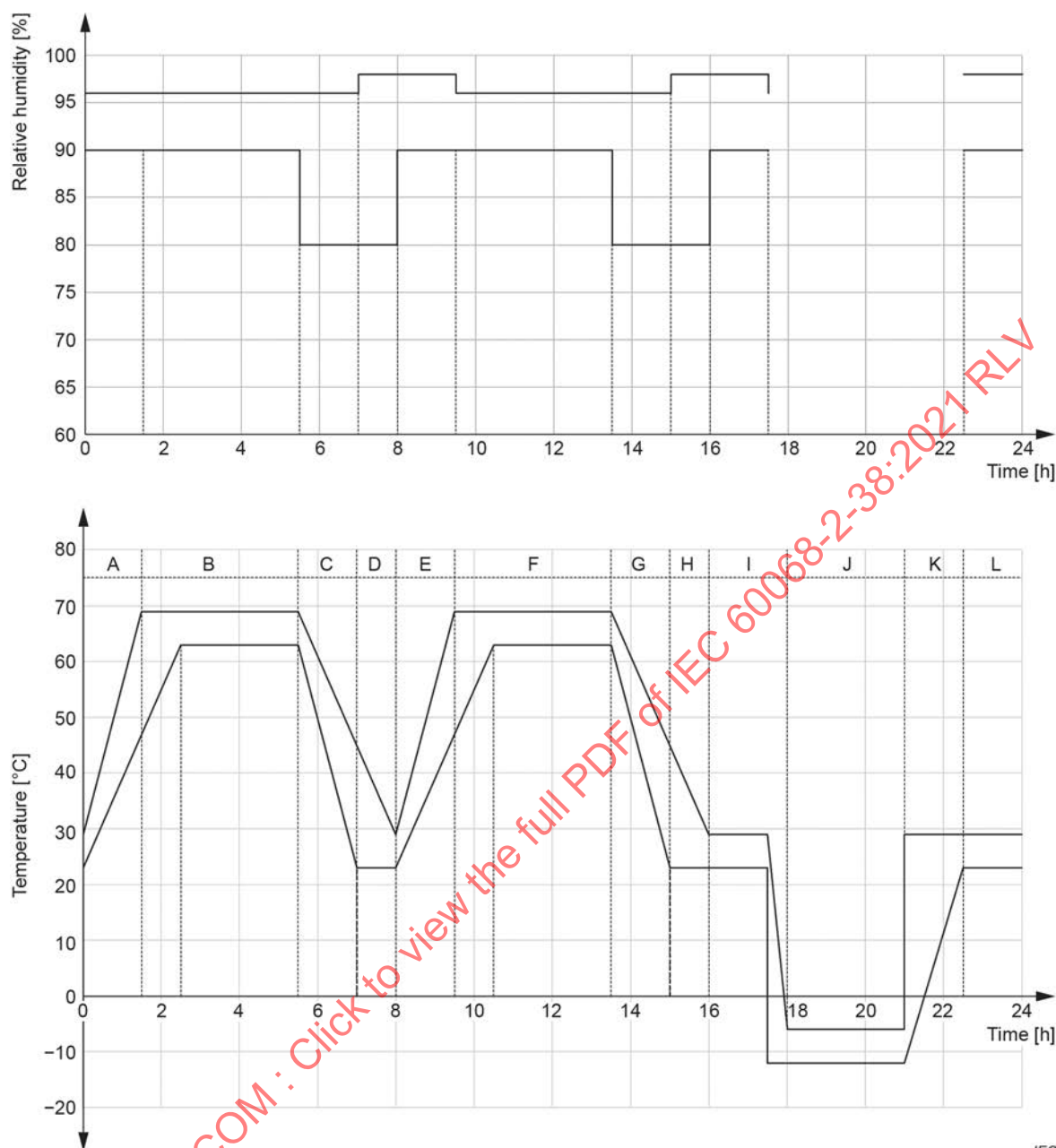
NOTE This tolerance is valid for an empty test space during stabilized temperature/humidity conditions of the test. In some conditions, where the specimen has a negligible impact on the chamber control, the tolerances can still be valid for the chamber with specimen(s).

However, in order to maintain the relative humidity within the required tolerances, it is necessary to keep the temperature difference between any two points in the working space at any moment within narrower limits. The required humidity conditions will not be achieved if such temperature differences exceed 1 K. It may also be necessary to keep short-term fluctuations within  ~~$\pm 0,5$  K~~ these limits to maintain the required humidity.

The specimens shall be introduced into the humidity chamber, in the unpacked, switched-off, ready-for-use state, and mounted in the normal orientation, if this is known, or as otherwise specified and shall be subjected to 10 temperature/humidity cycles, each of 24 h duration.

During any five of the first nine of the above cycles after exposure to the humidity subcycle (~~points a) to f)~~ areas A to H in Figure 2), the specimens shall be subjected to cold. The position of the cold subcycles should be defined in the relevant specification.

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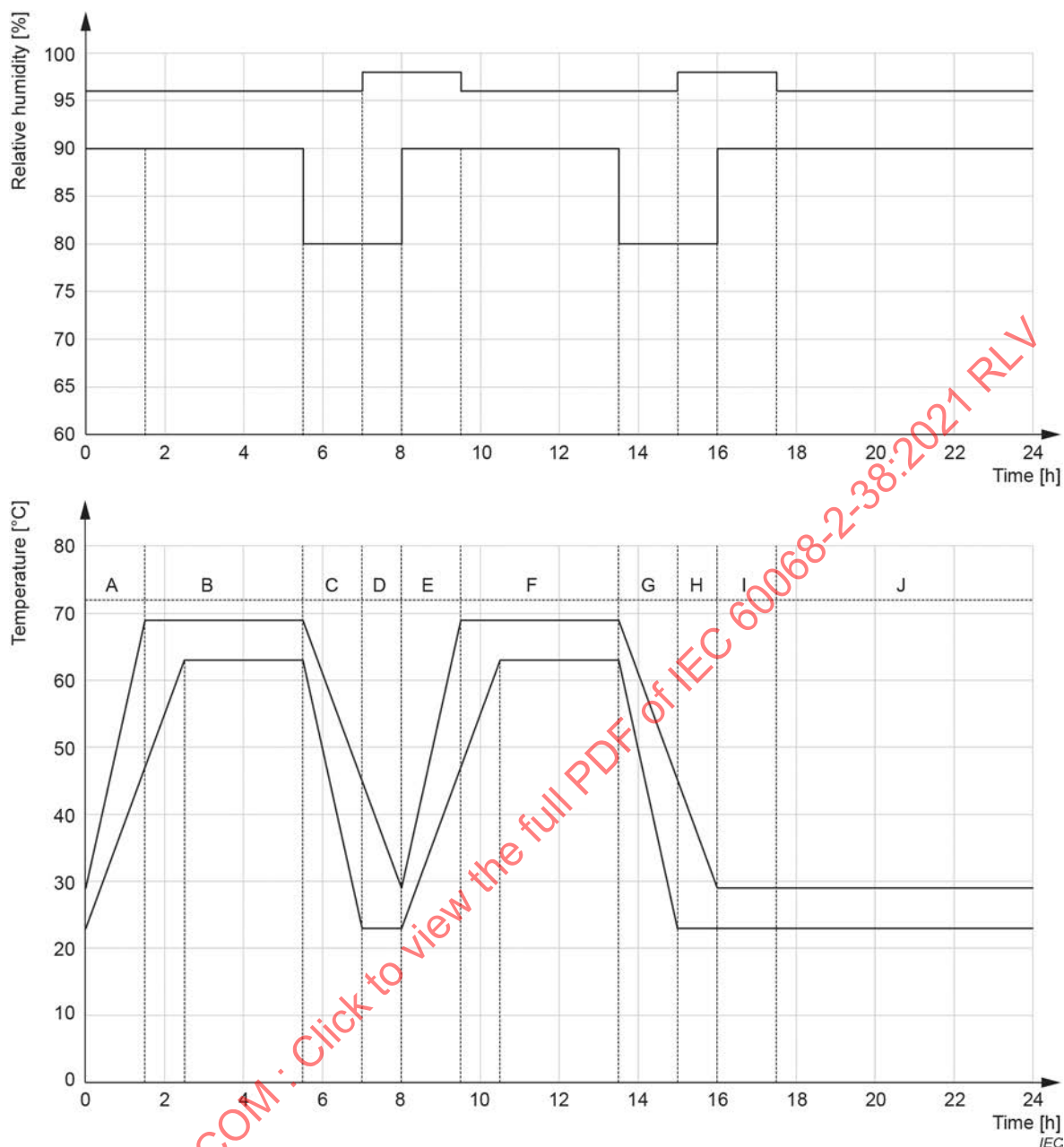


**Figure 2 – Exposure to humidity followed by exposure to cold**

This exposure may be performed either in the same chamber or in separate chambers. If separate chambers are used for the high-temperature/high-humidity and low-temperature subcycles of the test, the specimens should not be subjected to thermal shock conditions unless it is known that they are insensitive to this degree of thermal shock.

If a batch of specimens is subjected to thermal shock using the two chamber method and significant failures occur, a further batch shall be retested with gradual change of temperatures and shall be considered to have passed the test successfully if no significant failures occur under these conditions.

The remaining four of the first nine cycles shall be run without exposure to cold (see 7.4.3 and Figure 3). The humidity cycles ~~prescribed~~ specified are the same in all cases.



**Figure 3 – Exposure to humidity not followed by exposure to cold**

## 7.4 Test cycle

### 7.4.1 Description of temperature/humidity subcycle

The description of the temperature/humidity subcycles is applicable to all cycles (see Figure 2 and Figure 3).

**NOTE 1** The dotted lines in Figure 2 and Figure 3 are for orientation purposes only, aiming to give a better understanding of the test cycle. They place no indication for the order of the set points for the test.

At "zero time" of every 24 h cycle, the chamber condition shall be controlled to a temperature of  $25\text{ °C} \pm 2\text{ K}$  and relative humidity at  $(93^{+3}_{-3})\%$ .

- A The temperature of the chamber shall be continuously raised to  $65\text{ °C} \pm 2\text{ K}$  in a period of between 1,5 h and 2,5 h.

During this period, the relative humidity shall remain within the limits of  $(93^{+3}_{-3})\%$ .

- B The temperature and relative humidity in the chamber shall be maintained at  $65\text{ °C} \pm 2\text{ K}$  and  $(93^{+3}_{-3})\%$  respectively, until 5,5 h after the start of the cycle.

- C The temperature shall then be allowed to fall to  $25\text{ °C} \pm 2\text{ K}$  in a period of between 1,5 h and 2,5 h.

During this period, the relative humidity shall remain within the limits of 80 % to 96 %.

- D Beginning 7 h after the start of the cycle, the relative humidity shall remain within the limits of 80 % to 98 %.

- E Beginning 8 h after the start of the cycle, the temperature shall again be raised to  $65\text{ °C} \pm 2\text{ K}$  in a period of between 1,5 h and 2,5 h. During this period, the relative humidity shall be  ~~$(93 \pm 3)$~~   $(93^{+5}_{-3})\%$ .

- F Beginning 9,5 h after the start of the cycle, the relative humidity shall remain within the limits of  $(93^{+3}_{-3})\%$ .

The temperature and relative humidity in the chamber shall be maintained at  $65\text{ °C} \pm 2\text{ K}$  and  $(93^{+3}_{-3})\%$  respectively, until 13,5 h after the start of the cycle.

- G The temperature shall then be ~~drop~~ allowed to fall to  $25\text{ °C} \pm 2\text{ K}$  in a period of between 1,5 h and 2,5 h.

During this period, the relative humidity in the chamber shall remain within the limits of 80 % to 96 %.

- H Beginning 15 h after the start of the cycle, the relative humidity shall remain within the limits of 80 % to 98 %.

- I The chamber shall then continue to run at a stabilized temperature of  $25\text{ °C} \pm 2\text{ K}$  and relative humidity of  ~~$(93 \pm 3)\%$  until the start of the cold subcycle or until the end of the 24 h cycle as appropriate~~  $(93^{+5}_{-3})\%$ .

#### 7.4.2 Description of cold subcycle

This description is applicable to any five of the first nine cycles (see Figure 2).

- I Following the completion of the temperature/humidity subcycle (~~points a) to f)~~ areas A to H in Figure 2), the chamber is maintained at a temperature of  $25\text{ °C} \pm 2\text{ K}$  and a relative humidity of  ~~$(93 \pm 3)$~~   $(93^{+5}_{-3})\%$  for a period of at least 1 h but not more than 2 h.

- K The specimen shall then be exposed to cold by lowering the temperature of the chamber or transferring to a second chamber.

If the specimen is transferred from one chamber to another, the transfer should be completed within a period of 5 min. Beginning 17,5 h after the start of the cycle, the ambient temperature of the chamber shall be reduced to  $-10\text{ °C} \pm 2\text{ K}$ . This temperature shall be reached 18 h after the start of the cycle.

Beginning 18 h after the start of the cycle, the temperature shall be maintained at  $-10\text{ °C} \pm 2\text{ K}$  for a period of 3 h.

No requirement for humidity is ~~prescribed~~ specified during the entire cold subcycle.

- L Beginning 21 h after the start of the cycle, the temperature shall be raised to  $25\text{ °C} \pm 2\text{ K}$ . This temperature shall be reached 22,5 h after the start of the cycle (see Figure 2).

If the specimen is transferred from one chamber to another, the transfer shall be completed within a period of 10 min to 15 min.

M The temperature of the chamber shall be maintained at  $25\text{ °C} \pm 2\text{ K}$  until the 24 h cycle is completed. During this period, the relative humidity shall be  ~~$(93 \pm 3)$~~   $(93^{+5}_{-3})$  %.

### 7.4.3 Description of 24 h cycles with no exposure to cold

This description is applicable to the remaining four of the first nine cycles (Figure 3).

Cycles which do not include a cold subcycle following the humidity/temperature subcycle are the same as described in 7.4.1, ~~except that under point g) the chamber shall be maintained at a temperature of  $25\text{ °C} \pm 2\text{ K}$  and relative humidity of  $(93 \pm 3)$  % until the 24 h cycle is completed from A to H.~~

- I Following the completion of the temperature/humidity subcycle (areas A to H in Figure 2), the chamber shall be maintained at a temperature of  $25\text{ °C} \pm 2\text{ K}$  and, beginning 16 h after the start of the cycle, the relative humidity shall be  $(93^{+5}_{-3})$  %.
- J Beginning 17,5 h after the start of the cycle, the chamber shall then continue to run at a stabilized temperature of  $25\text{ °C} \pm 2\text{ K}$  and the relative humidity shall be kept within the limits of  $(93^{+3}_{-3})$  % until the end of the 24 h cycle.

NOTE This description is valid for Figure 3 (exposure to humidity not followed by exposure to cold) only.

### 7.4.4 Description of final cycle

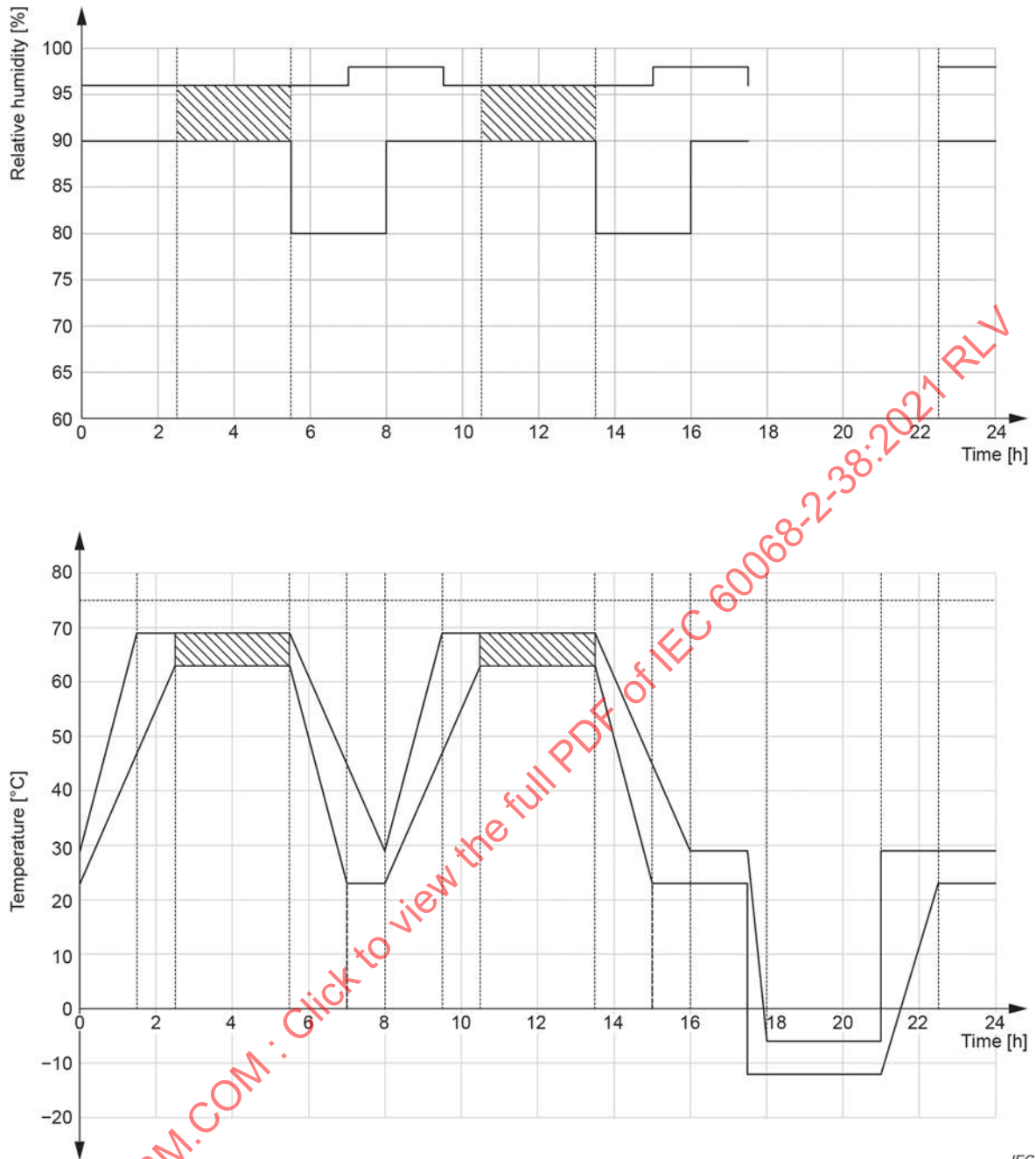
In the final cycle, following the completion of the temperature and humidity subcycle, the chamber is maintained at a temperature of  $25\text{ °C} \pm 2\text{ K}$  and relative humidity of  $(93^{+3}_{-3})$  % for a period of 3,5 h after which the final measurements are made.

### 7.4.5 Intermediate measurements

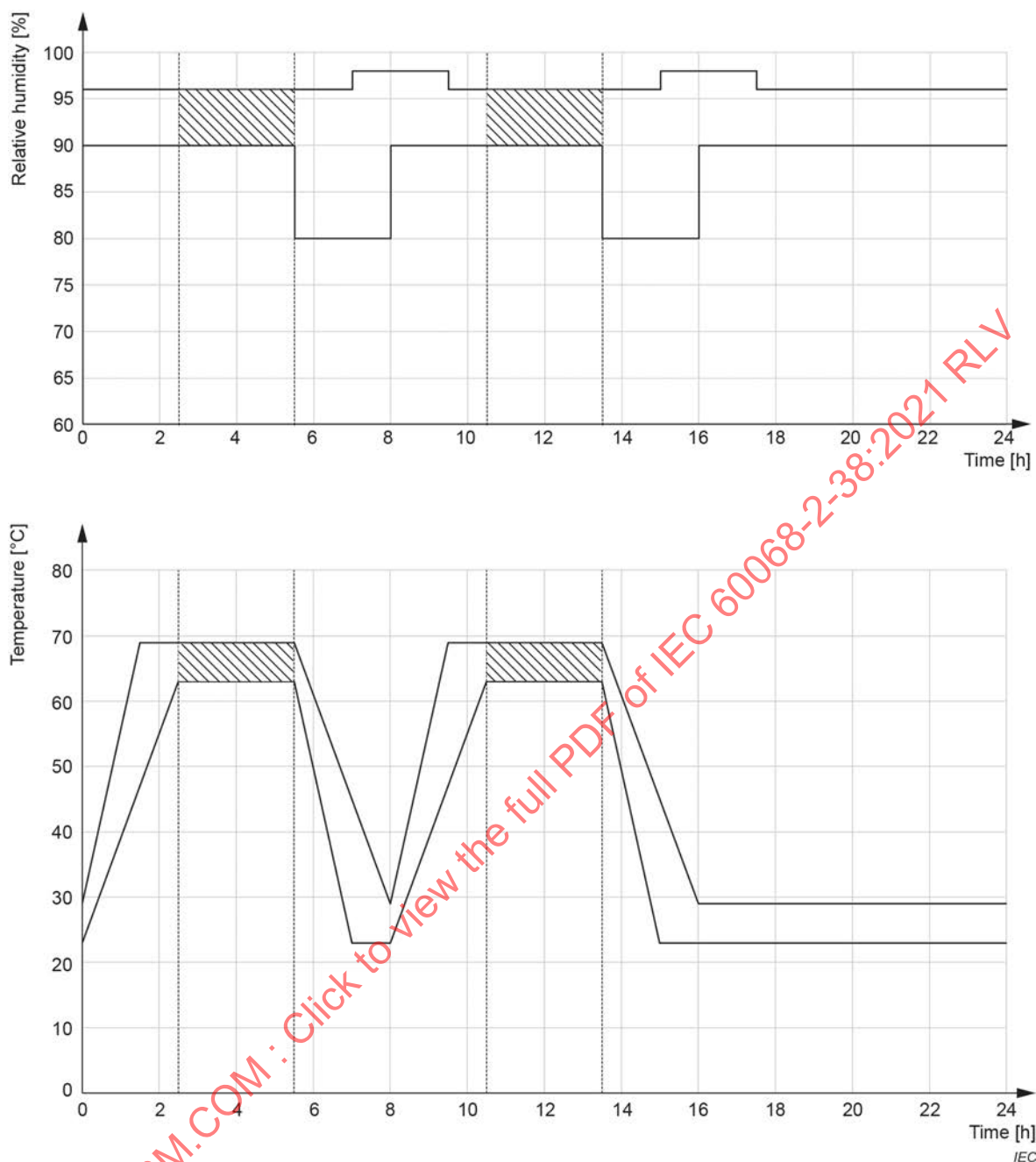
In order to carry out measurements on energized specimen, the following parts of the constant phases of the test cycles shown in Figure 2 and Figure 3 can be used:

- area beginning 2,5 h after the test has started until 5,5 h after the test has started (time indicated by end of area B in Figure 2 and Figure 3);
- area beginning 10,5 h after the test has started until 18 h after the test has started (time indicated by end of area F in Figure 2 and Figure 3)

During operation, functional checks only should be carried out, as permanent operation of the specimen could interfere with the severity of the climatic stress applied to the specimen. Figure 4 and Figure 5 indicate the areas where these measurements can be carried out.



**Figure 4 – Test times for intermediate operation of specimen – Exposure to humidity followed by exposure to cold**



**Figure 5 – Test times for intermediate operation of specimen – Exposure to humidity not followed by exposure to cold**

## 7.5 Final measurements

### 7.5.1 Introductory remarks

Electrical and mechanical measurements may be made

- at high humidity,
- immediately upon removal from the chamber,
- after a drying period, or
- as required by the relevant specification.

It should be realized that many measurements taken under high humidity conditions are not directly comparable with those taken initially or after removal from the chamber.

### 7.5.2 At high humidity

The measurements shall be made during the last two hours of the 3,5 h period referred to in ~~6.4.4~~ Figure 3.

The relevant specification shall specify the particular precautions to be followed in making measurements under conditions of high relative humidity, including the means to be adopted for the removal of surface water if this is necessary.

The specimen shall be removed from the chamber after all measurements have been completed.

### 7.5.3 Immediately upon removal from the chamber

On completion of the final cycle, the specimen shall be removed from the chamber and be kept at the laboratory ambient temperature.

If the initial measurements were made under conditions different from the laboratory ambient temperature, the same conditions shall be used for both sets of measurements.

Electrical and mechanical measurements, as specified, shall be made within a period of between 1 h and 2 h after removal from the chamber.

Measurements taken early in this time period may be repeated once only, later in the time period. The later reading will be used for failure determination.

### 7.5.4 After final drying

On completion of the final cycle, the specimen shall be removed from the chamber and shall be kept under standard atmospheric conditions for testing for a period of 24 h before the specified final measurements are made.

If the initial measurements were made under conditions other than standard atmospheric conditions for testing, the same conditions shall be used for both sets of measurements.

Measurements may be made during the 24 h period, but only measurements made at the end of the 24 h period shall be used for failure determination.

## 8 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 (subcycle);
- b) preconditioning;
- c) initial measurements;
- d) details of mounting and supports;
- e) number of cycles;
- f) position of cold subcycles;
- g) measurements and/or loading during conditioning;
- h) recovery;
- i) final measurements;
- j) any deviation in procedure as agreed upon between customer and supplier.

## 9 Information to be given in the test report

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

|    |                                                          |                                                                         |
|----|----------------------------------------------------------|-------------------------------------------------------------------------|
| a) | <del>Customer</del>                                      | <del>(name and address)</del>                                           |
| b) | <del>Test laboratory</del>                               | <del>(name and address and details of accreditation – if any)</del>     |
| c) | <del>Test dates</del>                                    | <del>(dates when test was run)</del>                                    |
| d) | <del>Type of test</del>                                  | <del>(Z/AD)</del>                                                       |
| e) | <del>Purpose of test</del>                               | <del>(development, qualification, etc.)</del>                           |
| f) | <del>Test standard, edition</del>                        | <del>(IEC 60068-2-38, edition used)</del>                               |
| g) | <del>Relevant laboratory test procedure</del>            | <del>(code and issue)</del>                                             |
| h) | <del>Test specimen description</del>                     | <del>(drawing, photo, quantity build status, etc.)</del>                |
| i) | <del>Test chamber identity</del>                         | <del>(manufacturer, model number, unique identity, etc.)</del>          |
| j) | <del>Performance of test apparatus</del>                 | <del>(set point temperature control, air flow, etc.)</del>              |
| k) | <del>Air velocity and direction</del>                    | <del>(air velocity and direction of incident air to the specimen)</del> |
| l) | <del>Uncertainties of measuring system</del>             | <del>(uncertainties data)</del>                                         |
| m) | <del>Calibration data</del>                              | <del>(last and next due date)</del>                                     |
| n) | <del>Initial, intermediate and final measurements</del>  | <del>(initial, intermediate and final measurements)</del>               |
| o) | <del>Required severities</del>                           | <del>(from relevant specification)</del>                                |
| p) | <del>Test severities</del>                               | <del>(measuring points, data, etc.)</del>                               |
| q) | <del>Performance of test specimens</del>                 | <del>(results of functional tests, etc.)</del>                          |
| r) | <del>Observations during testing and actions taken</del> | <del>(any pertinent observations)</del>                                 |
| s) | <del>Summary of test</del>                               | <del>(test summary)</del>                                               |
| t) | <del>Distribution</del>                                  | <del>(distribution list)</del>                                          |

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

|    |                                               |                                                                                        |
|----|-----------------------------------------------|----------------------------------------------------------------------------------------|
| 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                                  | (Z/AD);                                                                                |
| e) | Test standard, edition                        | (IEC 60068-2-38, 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) | Initial, intermediate and final measurements  | (if performed by the test laboratory);                                                 |
| i) | Required severities                           | (from relevant specification);                                                         |
| j) | Test severities                               | (measuring points, data, etc.);                                                        |
| k) | Performance of test specimens                 | (results of functional tests, etc.);                                                   |
| l) | Observations during testing and actions taken | (any pertinent observations);                                                          |
| m) | Test results                                  | (test summary, e.g. pass/fail decision).                                               |

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

- |    |                                                       |                                                                  |
|----|-------------------------------------------------------|------------------------------------------------------------------|
| n) | Purpose of test                                       | (development, qualification, etc.);                              |
| o) | Relevant laboratory test procedure                    | (code and issue);                                                |
| p) | Performance of test apparatus                         | (set point temperature control, air flow, etc.);                 |
| q) | Air velocity and/or direction                         | (air velocity and/or direction of incident air to the specimen); |
| r) | Uncertainties of chamber independent measuring system | (uncertainties data);                                            |
| s) | Calibration data                                      | (last and next due date).                                        |

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

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## Annex A (informative)

### Supporting documentation for test sequence

#### A.1 General

In order to simplify creating test routines for operating climatic chambers, the test steps for each test procedure are given in Table A.1 to Table A.4.

#### A.2 Preconditioning

**Table A.1 – Relative humidity tolerances**

| Test step                                  | Time<br>h       | Lower limit<br>% | Upper limit<br>% |
|--------------------------------------------|-----------------|------------------|------------------|
| 1                                          | 0               | 0                | 20               |
| 2                                          | 24              | 45               | 75               |
| 3                                          | 48 <sup>a</sup> | 45               | 75               |
| <sup>a</sup> Can be extended if necessary. |                 |                  |                  |

**Table A.2 – Temperature tolerances**

| Test step                                  | Time<br>h       | Lower limit<br>°C                                                                                                                                        | Upper limit<br>°C                                                                                                                             |
|--------------------------------------------|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| 1                                          | 0               | 53                                                                                                                                                       | 57                                                                                                                                            |
| 2                                          | 24              | 53                                                                                                                                                       | 57                                                                                                                                            |
| 3                                          | 48 <sup>a</sup> | $f(t) = -0,000\,006\,258\,71\,t^5$ $+ 0,001\,255\,169\,t^4$ $- 0,102\,362\,894\,t^3$ $+ 4,293\,766\,092\,t^2$ $- 93,907\,963\,78\,t$ $+ 882,047\,291\,3$ | $f(t) = -0,000\,003\,441\,6\,t^5$ $+ 0,000\,746\,803\,t^4$ $- 0,066\,182\,76\,t^3$ $+ 2,997\,420\,635\,t^2$ $- 69,342\,126\,98\,t$ $+ 689,24$ |
| <sup>a</sup> Can be extended if necessary. |                 |                                                                                                                                                          |                                                                                                                                               |

### A.3 Exposure to humidity followed by exposure to cold

**Table A.3 – Tolerances of relative humidity and temperature during exposure to humidity followed by exposure to cold**

| Test step | Test time<br>h    | Humidity tolerances |                  | Temperature tolerances |                   | Test subsequence<br>(see 7.4) |
|-----------|-------------------|---------------------|------------------|------------------------|-------------------|-------------------------------|
|           |                   | Lower limit<br>%    | Upper limit<br>% | Lower limit<br>°C      | Upper limit<br>°C |                               |
| 1         | 0                 | 90                  | 96               | 23                     | 27                | A                             |
| 2         | 1,5               | 90                  | 96               | 47                     | 67                |                               |
| 3         | 2,5               | 90                  | 96               | 63                     | 67                | B                             |
| 4         | 5,5               | 90                  | 96               | 63                     | 67                |                               |
| 5         | 5,5               | 80                  | 96               | 63                     | 67                | C                             |
| 6         | 7                 | 80                  | 96               | 23                     | 43                |                               |
| 7         | 7                 | 80                  | 98               | 23                     | 43                | D                             |
| 8         | 8                 | 80                  | 98               | 23                     | 27                |                               |
| 9         | 8                 | 90                  | 98               | 23                     | 27                | E                             |
| 10        | 9,5               | 90                  | 98               | 47                     | 67                |                               |
| 11        | 9,5               | 90                  | 96               | 47                     | 67                | F                             |
| 12        | 10,5              | 90                  | 96               | 63                     | 67                |                               |
| 13        | 13,5              | 90                  | 96               | 63                     | 67                | G                             |
| 14        | 13,5              | 80                  | 96               | 63                     | 67                |                               |
| 15        | 15                | 80                  | 96               | 23                     | 43                | H                             |
| 16        | 15                | 80                  | 98               | 23                     | 43                |                               |
| 17        | 16                | 80                  | 98               | 23                     | 27                | I                             |
| 18        | 16                | 90                  | 98               | 23                     | 27                |                               |
| 19        | 17,5              | 90                  | 98               | 23                     | 27                | K                             |
| 20        | 17,5 <sup>a</sup> |                     |                  | –12                    | 27                |                               |
| 21        | 18 <sup>a</sup>   |                     |                  | –12                    | –8                | L                             |
| 22        | 21 <sup>a</sup>   |                     |                  | –12                    | –8                |                               |
| 23        | 21 <sup>a</sup>   |                     |                  | –12                    | 27                | M                             |
| 24        | 22,5              | 90                  | 98               | 23                     | 27                |                               |
| 25        | 24                | 90                  | 98               | 23                     | 27                |                               |

<sup>a</sup> No humidity tolerance given between 17,5 h and 22,5 h.

**A.4 Exposure to humidity not followed by exposure to cold****Table A.4 – Tolerances of relative humidity and temperature during exposure to humidity not followed by exposure to cold**

| Test step | Test time<br>h | Humidity tolerances |                  | Temperature tolerances |                   | Test subsequence<br>(see 7.4) |
|-----------|----------------|---------------------|------------------|------------------------|-------------------|-------------------------------|
|           |                | Lower limit<br>%    | Upper limit<br>% | Lower limit<br>°C      | Upper limit<br>°C |                               |
| 1         | 0              | 90                  | 96               | 23                     | 27                | A                             |
| 2         | 1,5            | 90                  | 96               | 47                     | 67                |                               |
| 3         | 2,5            | 90                  | 96               | 63                     | 67                | B                             |
| 4         | 5,5            | 90                  | 96               | 63                     | 67                |                               |
| 5         | 5,5            | 80                  | 96               | 63                     | 67                | C                             |
| 6         | 7              | 80                  | 96               | 23                     | 43                |                               |
| 7         | 7              | 80                  | 98               | 23                     | 43                | D                             |
| 8         | 8              | 80                  | 98               | 23                     | 27                |                               |
| 9         | 8              | 90                  | 98               | 23                     | 27                | E                             |
| 10        | 9,5            | 90                  | 98               | 47                     | 67                |                               |
| 11        | 9,5            | 90                  | 96               | 47                     | 67                | F                             |
| 12        | 10,5           | 90                  | 96               | 63                     | 67                |                               |
| 13        | 13,5           | 90                  | 96               | 63                     | 67                | G                             |
| 14        | 13,5           | 80                  | 96               | 63                     | 67                |                               |
| 15        | 15             | 80                  | 96               | 23                     | 43                | H                             |
| 16        | 15             | 80                  | 98               | 23                     | 43                |                               |
| 17        | 16             | 80                  | 98               | 23                     | 27                | I                             |
| 18        | 16             | 90                  | 98               | 23                     | 27                |                               |
| 19        | 17,5           | 90                  | 98               | 23                     | 27                | J                             |
| 20        | 17,5           | 90                  | 96               | 23                     | 27                |                               |
| 21        | 24             | 90                  | 96               | 23                     | 27                |                               |

## Bibliography

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

IEC 60068-2-78, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*

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# INTERNATIONAL STANDARD

## NORME INTERNATIONALE

**Environmental testing –**

**Part 2-38: Tests – Test Z/AD: Composite temperature/humidity cyclic test**

**Essais d'environnement –**

**Partie 2-38: Essais – Essai Z/AD: Essai cyclique composite de température et d'humidité**

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## INTERNATIONAL ELECTROTECHNICAL COMMISSION

## ENVIRONMENTAL TESTING –

## Part 2-38: Tests –

## Test Z/AD: Composite temperature/humidity cyclic test

## FOREWORD

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IEC 60068-2-38 has been prepared by IEC technical committee 104: Environmental conditions, classification and methods of test. It is an International Standard.

This third edition cancels and replaces the second 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) the figures have been updated;
- b) changes to the wording has been made for clarification purposes.

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

| Draft        | Report on voting |
|--------------|------------------|
| 104/891/FDIS | 104/896/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](http://www.iec.ch/members_experts/refdocs). The main document types developed by IEC are described in greater detail at [www.iec.ch/standardsdev/publications](http://www.iec.ch/standardsdev/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 "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
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## ENVIRONMENTAL TESTING –

### Part 2-38: Tests – Test Z/AD: Composite temperature/humidity cyclic test

#### 1 Scope

This part of IEC 60068 specifies a composite test procedure, primarily intended for component type specimens, to determine, in an accelerated manner, the resistance of specimens to the deteriorative effects of high temperature/humidity and cold conditions.

This test standard does not apply to specimens that are energized during the complete test. Specimens can be energized during the constant phases of the tests. Measurements on energized specimens are typically carried out during constant phases of the test unless specified otherwise.

#### 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 60068-1, *Environmental testing – Part 1: General and guidance*

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

#### 3 Terms and definitions

No terms and definitions are listed in this document.

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

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO online browsing platform: available at <http://www.iso.org/obp>

#### 4 General

##### 4.1 Description of the test

Test Z/AD is a cyclic temperature/humidity test which is designed to reveal defects in test specimens caused by "breathing" as distinct from the absorption of moisture.

This process can be initiated by the forming of condensation on the specimen's surface. As the temperature on parts or the whole of the specimen's surface might be lower than the corresponding dew point at the humidity value, water can accumulate in small cracks or gaps on the specimen's surface.

Once the air temperature is reduced, the air in internal voids of specimen is contracted which results in a drop of pressure and drawing-in either wet air or condensed water through cracks or other leaks inside the specimen. The wet air will condense on inner walls of a void and may gradually fill it. During the temperature rising phase, the air in the void is expanded, this time with a lower dew point than during drawing-in, and partially escape out. This cycle is repeated, and water can be accumulated inside the specimen and may gradually fill its voids.

This so-called "breathing" effect is caused by changing the temperature inside the specimen in an atmosphere with high humidity. During the excursion to sub-zero temperature phase of the test, the water trapped in cracks and other voids freezes and due to the expansion of ice volume the cracks extend, and new cracks can form.

This test differs from other cyclic damp heat tests in that it derives its increased severity from:

- a) a greater number of temperature variations or "breathing" actions in a given time;
- b) a greater cyclic temperature range;
- c) a higher cyclic rate of change of temperature;
- d) the inclusion of a number of excursions to sub-zero temperatures.

The accelerated breathing and the effect of the freezing of trapped water in cracks and fissures are the essential features of this composite test.

It is emphasized, however, that the freezing effect will occur only if the fissure dimensions are large enough to allow the penetration of a coherent mass of water as is normally the case in fissures between seals and metal assemblies, or between seals and wire terminations.

The degree of condensation will depend mainly upon the thermal time constant of the surface of the test specimens and may be negligible for very small specimens but copious for large specimens.

Similarly, the breathing effect will be more apparent on specimens which contain relatively large air-filled or gas-filled voids, but again, the severity of the test will depend to some extent on the thermal characteristics of the specimens.

The condensation effect and the temperature distribution could be disturbed by functional checks, therefore the checks should be carried out during the constant phases of the temperature profiles (Figure 2 and Figure 3, areas B and F).

To simplify the programming of the test sequences, the set points are given in Annex A.

## 4.2 Application of the test

For the reasons given above, it is recommended that this test procedure be limited to component type specimens when the construction of the specimens suggests a "breathing" type of damp heat test combined with icing and where the thermal characteristics are compatible with the rates of change of temperature, etc., of test Z/AD.

For solid type specimens, for example plastic encapsulated, where there may be small hairline cracks or porous material, the absorption or diffusion mechanisms will predominate and a steady damp heat such as test C of IEC 60068-2-78 is preferred for investigating these effects.

For larger specimens such as equipment or when it is essential for components to ensure thermal stability during the various phases of the cycle, test Db of IEC 60068-2-30 should be employed, although due to the reduced number of cycles in a given period, the degree of acceleration may not be as fast. In this case, test Db should normally form part of a sequence such as that defined in IEC 60068-1.

As in other damp heat tests, a polarizing voltage or electrical loading may be applied to the specimens. In the case of electrical loading, the loading should be such that the temperature rise of the specimens does not unduly affect the chamber conditions.

From the above, test Z/AD should not be considered to be interchangeable with, or an alternative to, either steady-state or other cyclic damp heat tests, but the choice of test procedure should be made with due regard for the physical and thermal characteristics of the test specimens and the types of failure mechanisms which are significant for each particular case.

## 5 Description of test chamber

### 5.1 General

The exposure to moisture, followed by cold, can either be performed in one chamber or in two separate chambers.

NOTE All temperatures and humidity values measured refer to a supply air measurement of the test chamber.

### 5.2 Chamber for exposure to moisture

The chamber for the exposure to moisture shall be so constructed that:

- the temperature can be varied between  $25\text{ °C} \pm 2\text{ K}$  and  $65\text{ °C} \pm 2\text{ K}$  in a period of between 1,5 h and 2,5 h for both rising and falling temperatures;
- the relative humidity can be maintained at  $(93^{+3}_{-3})\%$  during the periods of constant or rising temperature and between 80 % and 96 % during the falling temperature periods;
- the conditions prevailing at any point in the working space are uniform and are as similar as possible to those prevailing in the immediate vicinity of suitably located temperature- and humidity-sensing devices;  
The air in the chamber shall therefore be continuously stirred at a rate necessary to maintain the specified conditions of temperature and humidity.
- the specimens under test shall not be subjected to radiant heat from the chamber conditioning processes;
- the water used for the chamber humidity system shall comply with the limits given in IEC 60068-2-67;
- condensed water shall be continuously drained from the chamber and not used again unless it has been re-purified.

Precautions shall be taken to ensure that no condensed water from the walls and roof of the test chamber can fall on the specimens.

### 5.3 Chamber for exposure to cold

The chamber for exposure to cold shall be so constructed that

- the temperature can be maintained at  $-10\text{ °C} \pm 2\text{ K}$ ,
- the conditions prevailing at any point in the working space are uniform and are as similar as possible to those prevailing in the immediate vicinity of suitably located temperature-sensing devices.

The air in the chamber shall therefore be continuously moving.

Care should be taken that the thermal capacity of the specimen under test does not appreciably influence conditions within the chamber.

The humidity chamber may be used for exposure to cold, in which case it shall meet the requirements of 4.1 and, in addition, shall be so constructed that

- 1) the temperature can be lowered from  $25\text{ °C} \pm 2\text{ K}$  to  $-10\text{ °C} \pm 2\text{ K}$  in a period of not more than 30 min,
- 2) the specimen can be held at a temperature of  $-10\text{ °C} \pm 2\text{ K}$  for a period of 3 h,
- 3) the temperature can be raised from  $-10\text{ °C} \pm 2\text{ K}$  to  $25\text{ °C} \pm 2\text{ K}$  in a period of not more than 90 min.

## 6 Severities

The number of 24 h cycles shall be 10, unless otherwise specified. If other than 10, the relevant specification shall define the number.

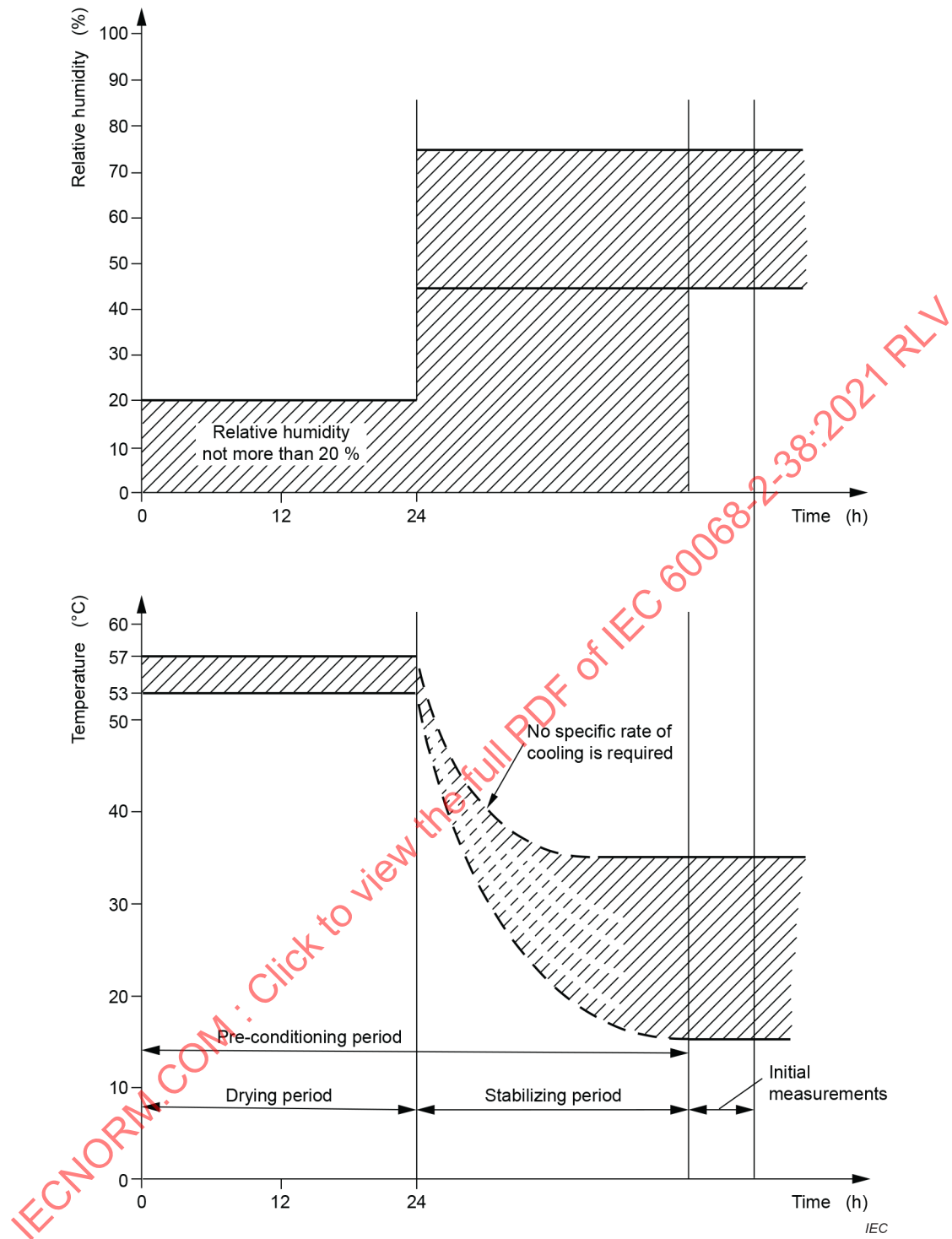
## 7 Testing procedure

### 7.1 Preconditioning

Unless otherwise specified, the specimens in the unpacked, switched-off, ready-for-use state shall be subjected to the conditions for "assisted drying" specified in IEC 60068-1 ( $55\text{ °C} \pm 2\text{ K}$  with a relative humidity not exceeding 20 %) for a period of 24 h prior to the first cycle of the damp heat test.

The specimens shall then be allowed to attain thermal stability at standard atmospheric conditions for testing or, as otherwise specified, before the initial measurements are made.

Figure 1 gives an overview about the preconditioning phase. During the stabilizing period no specific rate of cooling is specified, however it shall not exceed 1 K/min.



**Figure 1 – Preconditioning**

## 7.2 Initial measurements

The specimens shall be visually inspected and electrically and mechanically checked as required by the relevant specification.

## 7.3 Conditioning

The total temperature tolerance of  $\pm 2$  K given in this document is intended to take account of absolute errors in the measurement, slow changes of temperature and temperature variations of the working space.

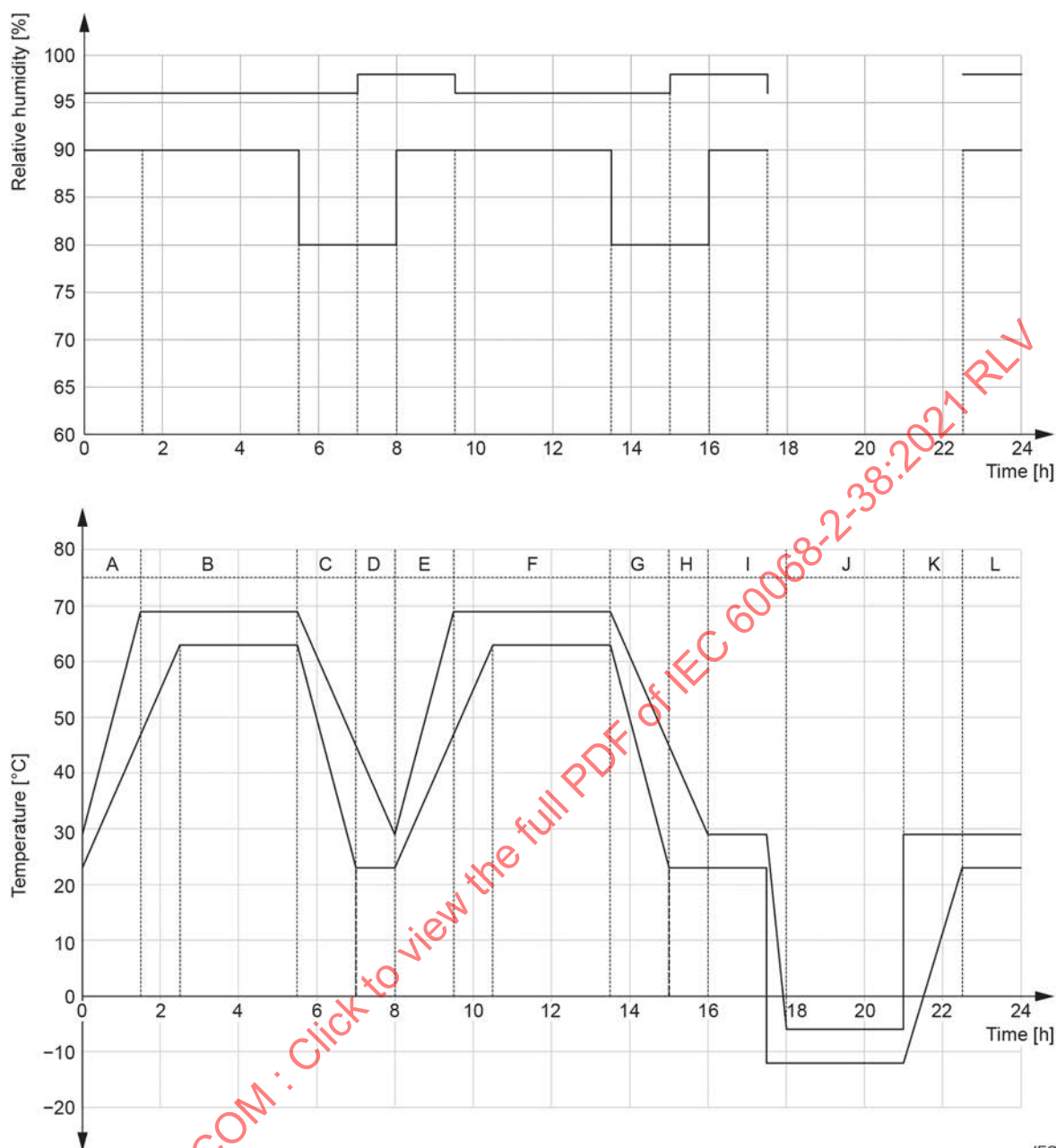
NOTE This tolerance is valid for an empty test space during stabilized temperature/humidity conditions of the test. In some conditions, where the specimen has a negligible impact on the chamber control, the tolerances can still be valid for the chamber with specimen(s).

However, in order to maintain the relative humidity within the required tolerances, it is necessary to keep the temperature difference between any two points in the working space at any moment within narrower limits. The required humidity conditions will not be achieved if such temperature differences exceed 1 K. It may also be necessary to keep short-term fluctuations within these limits to maintain the required humidity.

The specimens shall be introduced into the humidity chamber, in the unpacked, switched-off, ready-for-use state, and mounted in the normal orientation, if this is known, or as otherwise specified and shall be subjected to 10 temperature/humidity cycles, each of 24 h duration.

During any five of the first nine of the above cycles after exposure to the humidity subcycle (areas A to H in Figure 2), the specimens shall be subjected to cold. The position of the cold subcycles should be defined in the relevant specification.

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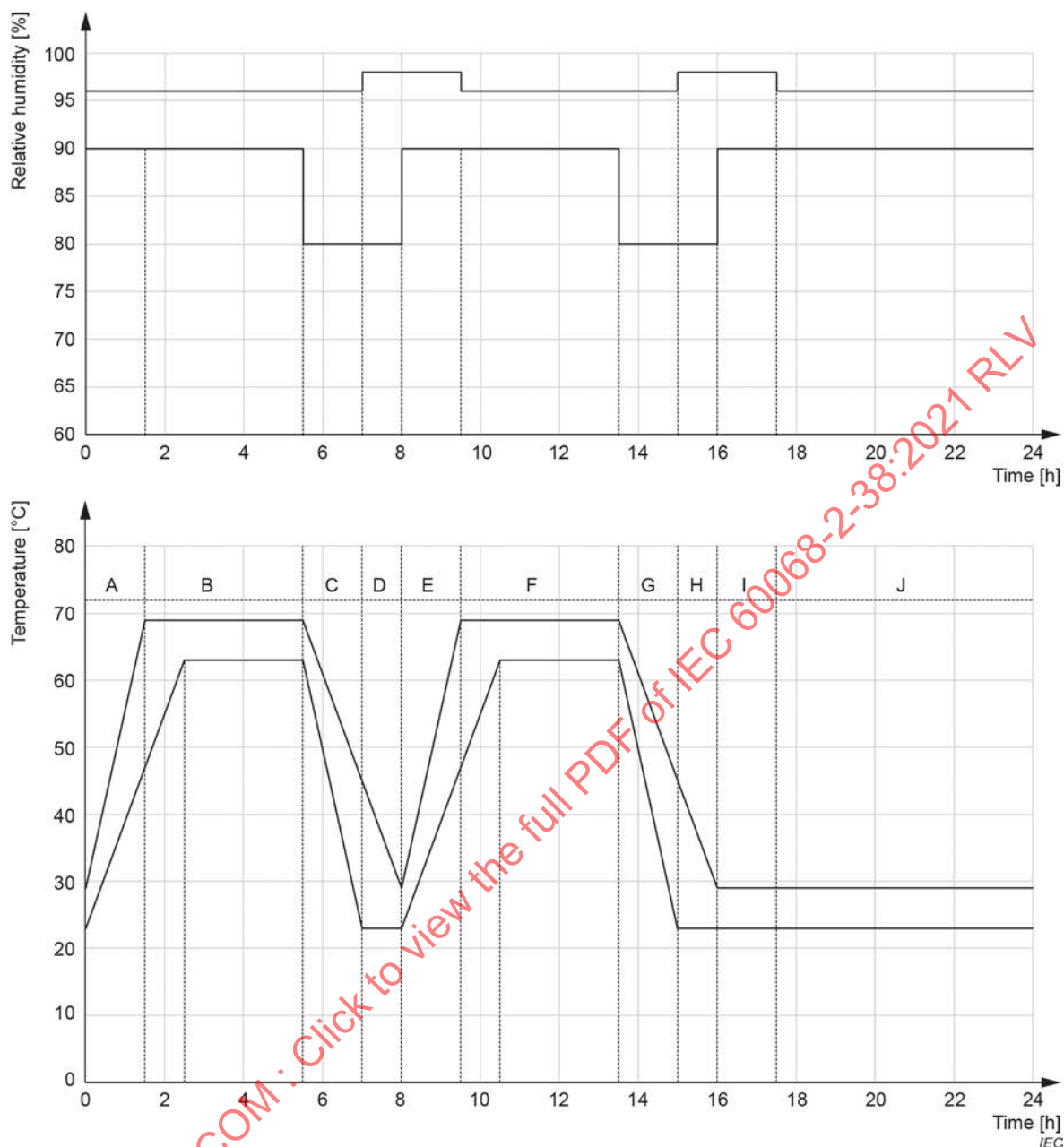


**Figure 2 – Exposure to humidity followed by exposure to cold**

This exposure may be performed either in the same chamber or in separate chambers. If separate chambers are used for the high-temperature/high-humidity and low-temperature subcycles of the test, the specimens should not be subjected to thermal shock conditions unless it is known that they are insensitive to this degree of thermal shock.

If a batch of specimens is subjected to thermal shock using the two chamber method and significant failures occur, a further batch shall be retested with gradual change of temperatures and shall be considered to have passed the test successfully if no significant failures occur under these conditions.

The remaining four of the first nine cycles shall be run without exposure to cold (see 7.4.3 and Figure 3). The humidity cycles specified are the same in all cases.



**Figure 3 – Exposure to humidity not followed by exposure to cold**

## 7.4 Test cycle

### 7.4.1 Description of temperature/humidity subcycle

The description of the temperature/humidity subcycles is applicable to all cycles (see Figure 2 and Figure 3).

NOTE 1 The dotted lines in Figure 2 and Figure 3 are for orientation purposes only, aiming to give a better understanding of the test cycle. They place no indication for the order of the set points for the test.

At "zero time" of every 24 h cycle, the chamber condition shall be controlled to a temperature of  $25\text{ °C} \pm 2\text{ K}$  and relative humidity at  $(93^{+3}_{-3})\%$ .

- A The temperature of the chamber shall be continuously raised to  $65\text{ }^{\circ}\text{C} \pm 2\text{ K}$  in a period of between 1,5 h and 2,5 h.  
During this period, the relative humidity shall remain within the limits of  $(93^{+3}_{-3})\%$ .
- B The temperature and relative humidity in the chamber shall be maintained at  $65\text{ }^{\circ}\text{C} \pm 2\text{ K}$  and  $(93^{+3}_{-3})\%$  respectively, until 5,5 h after the start of the cycle.
- C The temperature shall then be allowed to fall to  $25\text{ }^{\circ}\text{C} \pm 2\text{ K}$  in a period of between 1,5 h and 2,5 h.  
During this period, the relative humidity shall remain within the limits of 80 % to 96 %.
- D Beginning 7 h after the start of the cycle, the relative humidity shall remain within the limits of 80 % to 98 %.
- E Beginning 8 h after the start of the cycle, the temperature shall again be raised to  $65\text{ }^{\circ}\text{C} \pm 2\text{ K}$  in a period of between 1,5 h and 2,5 h. During this period, the relative humidity shall be  $(93^{+5}_{-3})\%$ .
- F Beginning 9,5 h after the start of the cycle, the relative humidity shall remain within the limits of  $(93^{+3}_{-3})\%$ .  
The temperature and relative humidity in the chamber shall be maintained at  $65\text{ }^{\circ}\text{C} \pm 2\text{ K}$  and  $(93^{+3}_{-3})\%$  respectively, until 13,5 h after the start of the cycle.
- G The temperature shall then be allowed to fall to  $25\text{ }^{\circ}\text{C} \pm 2\text{ K}$  in a period of between 1,5 h and 2,5 h.  
During this period, the relative humidity in the chamber shall remain within the limits of 80 % to 96 %.
- H Beginning 15 h after the start of the cycle, the relative humidity shall remain within the limits of 80 % to 98 %.
- I The chamber shall then continue to run at a stabilized temperature of  $25\text{ }^{\circ}\text{C} \pm 2\text{ K}$  and relative humidity of  $(93^{+5}_{-3})\%$ .

#### 7.4.2 Description of cold subcycle

This description is applicable to any five of the first nine cycles (see Figure 2).

- I Following the completion of the temperature/humidity subcycle (areas A to H in Figure 2), the chamber is maintained at a temperature of  $25\text{ }^{\circ}\text{C} \pm 2\text{ K}$  and a relative humidity of  $(93^{+5}_{-3})\%$  for a period of at least 1 h but not more than 2 h.
- K The specimen shall then be exposed to cold by lowering the temperature of the chamber or transferring to a second chamber.  
If the specimen is transferred from one chamber to another, the transfer should be completed within a period of 5 min. Beginning 17,5 h after the start of the cycle, the ambient temperature of the chamber shall be reduced to  $-10\text{ }^{\circ}\text{C} \pm 2\text{ K}$ . This temperature shall be reached 18 h after the start of the cycle.  
Beginning 18 h after the start of the cycle, the temperature shall be maintained at  $-10\text{ }^{\circ}\text{C} \pm 2\text{ K}$  for a period of 3 h.  
No requirement for humidity is specified during the entire cold subcycle.
- L Beginning 21 h after the start of the cycle, the temperature shall be raised to  $25\text{ }^{\circ}\text{C} \pm 2\text{ K}$ . This temperature shall be reached 22,5 h after the start of the cycle (see Figure 2).  
If the specimen is transferred from one chamber to another, the transfer shall be completed within a period of 10 min to 15 min.

M The temperature of the chamber shall be maintained at  $25\text{ °C} \pm 2\text{ K}$  until the 24 h cycle is completed. During this period, the relative humidity shall be  $(93^{+5}_{-3})\%$ .

#### 7.4.3 Description of 24 h cycles with no exposure to cold

This description is applicable to the remaining four of the first nine cycles (Figure 3).

Cycles which do not include a cold subcycle following the humidity/temperature subcycle are the same as described in 7.4.1, from A to H.

- I Following the completion of the temperature/humidity subcycle (areas A to H in Figure 2), the chamber shall be maintained at a temperature of  $25\text{ °C} \pm 2\text{ K}$  and, beginning 16 h after the start of the cycle, the relative humidity shall be  $(93^{+5}_{-3})\%$ .
- J Beginning 17,5 h after the start of the cycle, the chamber shall then continue to run at a stabilized temperature of  $25\text{ °C} \pm 2\text{ K}$  and the relative humidity shall be kept within the limits of  $(93^{+3}_{-3})\%$  until the end of the 24 h cycle.

NOTE This description is valid for Figure 3 (exposure to humidity not followed by exposure to cold) only.

#### 7.4.4 Description of final cycle

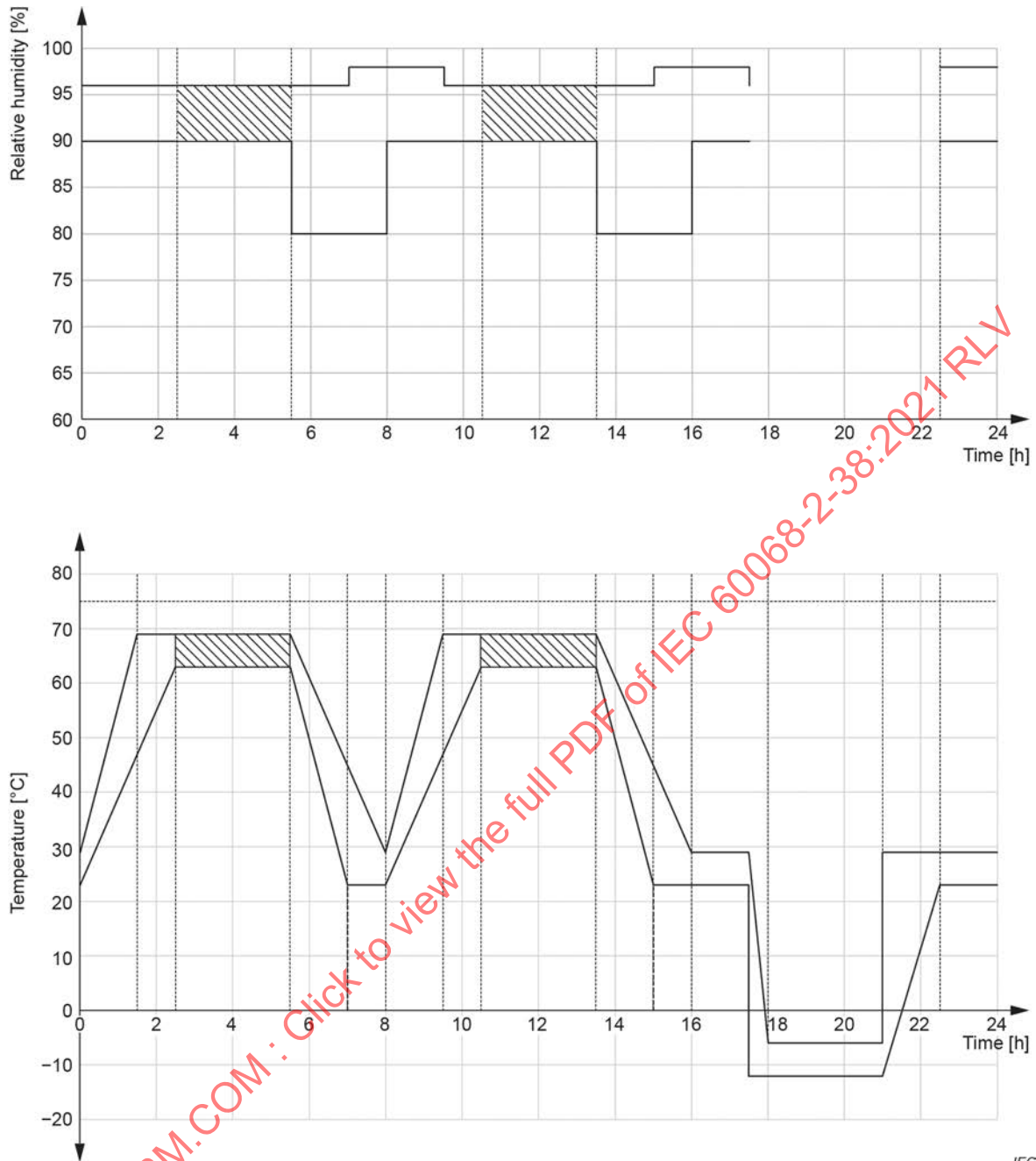
In the final cycle, following the completion of the temperature and humidity subcycle, the chamber is maintained at a temperature of  $25\text{ °C} \pm 2\text{ K}$  and relative humidity of  $(93^{+3}_{-3})\%$  for a period of 3,5 h after which the final measurements are made.

#### 7.4.5 Intermediate measurements

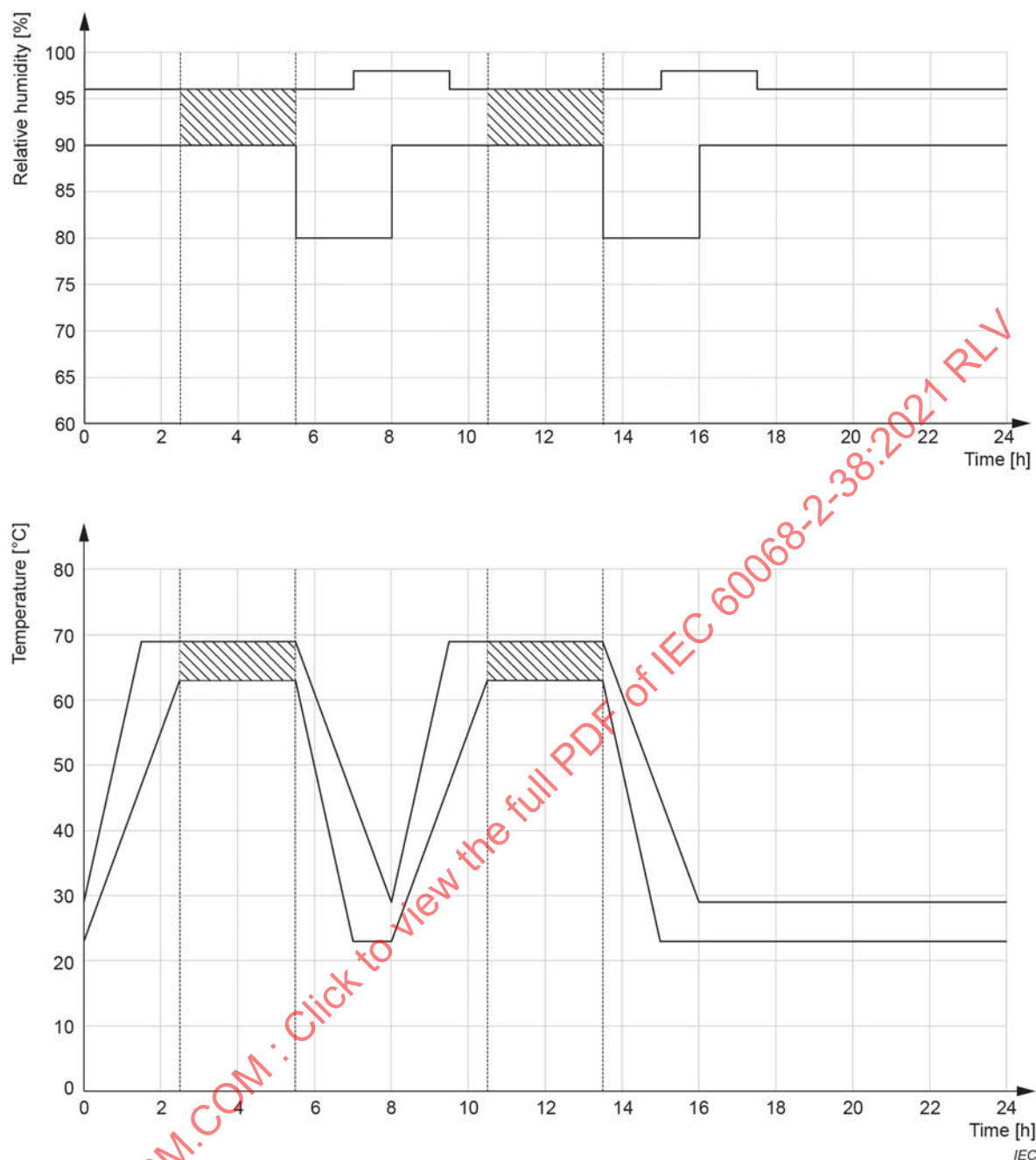
In order to carry out measurements on energized specimen, the following parts of the constant phases of the test cycles shown in Figure 2 and Figure 3 can be used:

- area beginning 2,5 h after the test has started until 5,5 h after the test has started (time indicated by end of area B in Figure 2 and Figure 3);
- area beginning 10,5 h after the test has started until 18 h after the test has started (time indicated by end of area F in Figure 2 and Figure 3)

During operation, functional checks only should be carried out, as permanent operation of the specimen could interfere with the severity of the climatic stress applied to the specimen. Figure 4 and Figure 5 indicate the areas where these measurements can be carried out.



**Figure 4 – Test times for intermediate operation of specimen – Exposure to humidity followed by exposure to cold**



**Figure 5 – Test times for intermediate operation of specimen –  
Exposure to humidity not followed by exposure to cold**

## 7.5 Final measurements

### 7.5.1 Introductory remarks

Electrical and mechanical measurements may be made

- at high humidity,
- immediately upon removal from the chamber,
- after a drying period, or
- as required by the relevant specification.

It should be realized that many measurements taken under high humidity conditions are not directly comparable with those taken initially or after removal from the chamber.

### **7.5.2 At high humidity**

The measurements shall be made during the last two hours of the 3,5 h period referred to in Figure 3.

The relevant specification shall specify the particular precautions to be followed in making measurements under conditions of high relative humidity, including the means to be adopted for the removal of surface water if this is necessary.

The specimen shall be removed from the chamber after all measurements have been completed.

### **7.5.3 Immediately upon removal from the chamber**

On completion of the final cycle, the specimen shall be removed from the chamber and be kept at the laboratory ambient temperature.

If the initial measurements were made under conditions different from the laboratory ambient temperature, the same conditions shall be used for both sets of measurements.

Electrical and mechanical measurements, as specified, shall be made within a period of between 1 h and 2 h after removal from the chamber.

Measurements taken early in this time period may be repeated once only, later in the time period. The later reading will be used for failure determination.

### **7.5.4 After final drying**

On completion of the final cycle, the specimen shall be removed from the chamber and shall be kept under standard atmospheric conditions for testing for a period of 24 h before the specified final measurements are made.

If the initial measurements were made under conditions other than standard atmospheric conditions for testing, the same conditions shall be used for both sets of measurements.

Measurements may be made during the 24 h period, but only measurements made at the end of the 24 h period shall be used for failure determination.

## **8 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 (subcycle);
- b) preconditioning;
- c) initial measurements;
- d) details of mounting and supports;
- e) number of cycles;
- f) position of cold subcycles;
- g) measurements and/or loading during conditioning;
- h) recovery;
- i) final measurements;
- j) any deviation in procedure as agreed upon between customer and supplier.

## 9 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                                  | (Z/AD);                                                                                |
| e) | Test standard, edition                        | (IEC 60068-2-38, 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) | Initial, intermediate and final measurements  | (if performed by the test laboratory);                                                 |
| i) | Required severities                           | (from relevant specification);                                                         |
| j) | Test severities                               | (measuring points, data, etc.);                                                        |
| k) | Performance of test specimens                 | (results of functional tests, etc.);                                                   |
| l) | Observations during testing and actions taken | (any pertinent observations);                                                          |
| m) | Test results                                  | (test summary, e.g. pass/fail decision).                                               |

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

- |    |                                                       |                                                                  |
|----|-------------------------------------------------------|------------------------------------------------------------------|
| n) | Purpose of test                                       | (development, qualification, etc.);                              |
| o) | Relevant laboratory test procedure                    | (code and issue);                                                |
| p) | Performance of test apparatus                         | (set point temperature control, air flow, etc.);                 |
| q) | Air velocity and/or direction                         | (air velocity and/or direction of incident air to the specimen); |
| r) | Uncertainties of chamber independent measuring system | (uncertainties data);                                            |
| s) | Calibration data                                      | (last and next due date).                                        |

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

## Annex A (informative)

### Supporting documentation for test sequence

#### A.1 General

In order to simplify creating test routines for operating climatic chambers, the test steps for each test procedure are given in Table A.1 to Table A.4.

#### A.2 Preconditioning

**Table A.1 – Relative humidity tolerances**

| Test step                                  | Time<br>h       | Lower limit<br>% | Upper limit<br>% |
|--------------------------------------------|-----------------|------------------|------------------|
| 1                                          | 0               | 0                | 20               |
| 2                                          | 24              | 45               | 75               |
| 3                                          | 48 <sup>a</sup> | 45               | 75               |
| <sup>a</sup> Can be extended if necessary. |                 |                  |                  |

**Table A.2 – Temperature tolerances**

| Test step                                  | Time<br>h       | Lower limit<br>°C                                                                                                                                        | Upper limit<br>°C                                                                                                                             |
|--------------------------------------------|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| 1                                          | 0               | 53                                                                                                                                                       | 57                                                                                                                                            |
| 2                                          | 24              | 53                                                                                                                                                       | 57                                                                                                                                            |
| 3                                          | 48 <sup>a</sup> | $f(t) = -0,000\,006\,258\,71\,t^5$ $+ 0,001\,255\,169\,t^4$ $- 0,102\,362\,894\,t^3$ $+ 4,293\,766\,092\,t^2$ $- 93,907\,963\,78\,t$ $+ 882,047\,291\,3$ | $f(t) = -0,000\,003\,441\,6\,t^5$ $+ 0,000\,746\,803\,t^4$ $- 0,066\,182\,76\,t^3$ $+ 2,997\,420\,635\,t^2$ $- 69,342\,126\,98\,t$ $+ 689,24$ |
| <sup>a</sup> Can be extended if necessary. |                 |                                                                                                                                                          |                                                                                                                                               |

### A.3 Exposure to humidity followed by exposure to cold

**Table A.3 – Tolerances of relative humidity and temperature during exposure to humidity followed by exposure to cold**

| Test step | Test time<br>h    | Humidity tolerances |                  | Temperature tolerances |                   | Test subsequence<br>(see 7.4) |
|-----------|-------------------|---------------------|------------------|------------------------|-------------------|-------------------------------|
|           |                   | Lower limit<br>%    | Upper limit<br>% | Lower limit<br>°C      | Upper limit<br>°C |                               |
| 1         | 0                 | 90                  | 96               | 23                     | 27                | A                             |
| 2         | 1,5               | 90                  | 96               | 47                     | 67                |                               |
| 3         | 2,5               | 90                  | 96               | 63                     | 67                | B                             |
| 4         | 5,5               | 90                  | 96               | 63                     | 67                |                               |
| 5         | 5,5               | 80                  | 96               | 63                     | 67                | C                             |
| 6         | 7                 | 80                  | 96               | 23                     | 43                |                               |
| 7         | 7                 | 80                  | 98               | 23                     | 43                | D                             |
| 8         | 8                 | 80                  | 98               | 23                     | 27                |                               |
| 9         | 8                 | 90                  | 98               | 23                     | 27                | E                             |
| 10        | 9,5               | 90                  | 98               | 47                     | 67                |                               |
| 11        | 9,5               | 90                  | 96               | 47                     | 67                | F                             |
| 12        | 10,5              | 90                  | 96               | 63                     | 67                |                               |
| 13        | 13,5              | 90                  | 96               | 63                     | 67                |                               |
| 14        | 13,5              | 80                  | 96               | 63                     | 67                | G                             |
| 15        | 15                | 80                  | 96               | 23                     | 43                |                               |
| 16        | 15                | 80                  | 98               | 23                     | 43                | H                             |
| 17        | 16                | 80                  | 98               | 23                     | 27                |                               |
| 18        | 16                | 90                  | 98               | 23                     | 27                | I                             |
| 19        | 17,5              | 90                  | 98               | 23                     | 27                |                               |
| 20        | 17,5 <sup>a</sup> |                     |                  | –12                    | 27                | K                             |
| 21        | 18 <sup>a</sup>   |                     |                  | –12                    | –8                |                               |
| 22        | 21 <sup>a</sup>   |                     |                  | –12                    | –8                |                               |
| 23        | 21 <sup>a</sup>   |                     |                  | –12                    | 27                | L                             |
| 24        | 22,5              | 90                  | 98               | 23                     | 27                |                               |
| 25        | 24                | 90                  | 98               | 23                     | 27                | M                             |

<sup>a</sup> No humidity tolerance given between 17,5 h and 22,5 h.

#### A.4 Exposure to humidity not followed by exposure to cold

**Table A.4 – Tolerances of relative humidity and temperature during exposure to humidity not followed by exposure to cold**

| Test step | Test time<br>h | Humidity tolerances |                  | Temperature tolerances |                   | Test subsequence<br>(see 7.4) |
|-----------|----------------|---------------------|------------------|------------------------|-------------------|-------------------------------|
|           |                | Lower limit<br>%    | Upper limit<br>% | Lower limit<br>°C      | Upper limit<br>°C |                               |
| 1         | 0              | 90                  | 96               | 23                     | 27                | A                             |
| 2         | 1,5            | 90                  | 96               | 47                     | 67                |                               |
| 3         | 2,5            | 90                  | 96               | 63                     | 67                | B                             |
| 4         | 5,5            | 90                  | 96               | 63                     | 67                |                               |
| 5         | 5,5            | 80                  | 96               | 63                     | 67                | C                             |
| 6         | 7              | 80                  | 96               | 23                     | 43                |                               |
| 7         | 7              | 80                  | 98               | 23                     | 43                | D                             |
| 8         | 8              | 80                  | 98               | 23                     | 27                |                               |
| 9         | 8              | 90                  | 98               | 23                     | 27                | E                             |
| 10        | 9,5            | 90                  | 98               | 47                     | 67                |                               |
| 11        | 9,5            | 90                  | 96               | 47                     | 67                | F                             |
| 12        | 10,5           | 90                  | 96               | 63                     | 67                |                               |
| 13        | 13,5           | 90                  | 96               | 63                     | 67                |                               |
| 14        | 13,5           | 80                  | 96               | 63                     | 67                | G                             |
| 15        | 15             | 80                  | 96               | 23                     | 43                |                               |
| 16        | 15             | 80                  | 98               | 23                     | 43                | H                             |
| 17        | 16             | 80                  | 98               | 23                     | 27                |                               |
| 18        | 16             | 90                  | 98               | 23                     | 27                | I                             |
| 19        | 17,5           | 90                  | 98               | 23                     | 27                |                               |
| 20        | 17,5           | 90                  | 96               | 23                     | 27                | J                             |
| 21        | 24             | 90                  | 96               | 23                     | 27                |                               |

## Bibliography

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

IEC 60068-2-78, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*

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## COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

### ESSAIS D'ENVIRONNEMENT –

#### Partie 2-38: Essais –

#### Essai Z/AD: Essai cyclique composite de température et d'humidité

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L'IEC 60068-2-38 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 troisième édition annule et remplace la deuxième 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) les figures ont été mises à jour;
- b) la formulation a été modifiée à des fins de clarification.

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

| Projet       | Rapport de vote |
|--------------|-----------------|
| 104/891/FDIS | 104/896/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.

Le présent 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](http://www.iec.ch/members_experts/refdocs). Les principaux types de documents développés par l'IEC sont décrits plus en détail sous [www.iec.ch/standardsdev/publications](http://www.iec.ch/standardsdev/publications).

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

Le comité a décidé que le contenu du présent document ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous "<http://webstore.iec.ch>" dans les données relatives au document recherché. A cette date, le document sera

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## ESSAIS D'ENVIRONNEMENT –

### Partie 2-38: Essais –

### Essai Z/AD: Essai cyclique composite de température et d'humidité

#### 1 Domaine d'application

La présente partie de l'IEC 60068 spécifie une procédure d'essai composite, essentiellement destinée aux spécimens de type composant, dans le but de déterminer d'une manière accélérée la résistance des spécimens aux effets destructifs dus à des séjours dans des conditions de température/d'humidité élevées, alternées avec des conditions de froid.

La présente norme d'essai ne s'applique pas aux spécimens qui sont mis sous tension durant toute la durée de l'essai. Les spécimens peuvent être mis sous tension durant les phases constantes des essais. Les mesures réalisées sur des spécimens sous tension ont généralement lieu durant les phases constantes de l'essai, sauf spécification contraire.

#### 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 60068-1, *Essais d'environnement – Partie 1: Généralités et lignes directrices*

IEC 60068-2-67, *Essais d'environnement – Partie 2-67: Essais – Essai Cy: Essai continu de chaleur humide, essai accéléré applicable en premier lieu aux composants*

#### 3 Termes et définitions

Aucun terme n'est défini dans le présent document.

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 <http://www.electropedia.org/>
- ISO Online browsing platform: disponible à l'adresse <http://www.iso.org/obp>

#### 4 Généralités

##### 4.1 Description de l'essai

L'essai Z/AD est un essai cyclique de température et d'humidité dont l'objet est de révéler les défauts des spécimens d'essai causés par le "pompage", phénomène considéré comme distinct de l'absorption d'humidité.

Ce processus peut faire suite à la formation de condensation sur la surface du spécimen. Etant donné que la température sur les éléments ou sur l'ensemble de la surface du spécimen peut être inférieure au point de rosée correspondant à la valeur d'humidité, l'eau peut s'accumuler dans les petites craquelures ou lacunes présentes à la surface du spécimen.

Lorsque la température de l'air diminue, l'air présent dans les cavités internes du spécimen se contracte, ce qui engendre une chute de pression, l'aspiration de l'air humide ou de l'eau de condensation à travers les craquelures ainsi que d'autres fuites à l'intérieur du spécimen. L'air humide se condense sur les parois intérieures d'une lacune et peut la remplir progressivement. Pendant la phase d'augmentation en température, l'air présent dans la lacune se dilate, cette fois avec un point de rosée inférieur à celui obtenu lors de l'aspiration, et s'échappe en partie. Ce cycle est répété, et l'eau peut s'accumuler à l'intérieur du spécimen et peut remplir progressivement ses lacunes.

Ce phénomène de "pompage" est causé par les variations de température à l'intérieur du spécimen dans les environnements où l'humidité est élevée. Lors de la phase d'incursion à des températures au-dessous de zéro de l'essai, l'eau infiltrée dans les craquelures et les autres lacunes gèle et les craquelures se développent sous l'effet de l'augmentation du volume de glace; de nouvelles craquelures peuvent alors se former.

Cet essai est différent des autres essais cycliques de chaleur humide par sa sévérité plus grande due à:

- a) un nombre supérieur de variations de température ou de "pompage" pendant une période donnée;
- b) une plage de températures cycliques plus étendue;
- c) un gradient plus élevé pour le cycle de variation de température;
- d) l'introduction d'un certain nombre d'incursions à des températures au-dessous de zéro.

Le pompage accéléré d'humidité et le givrage de l'eau infiltrée dans les craquelures et les fissures constituent les principaux effets étudiés lors de cet essai composite.

Néanmoins, il importe de préciser que l'effet du givrage ne se produit que si les dimensions des fissures sont suffisantes pour permettre la pénétration d'une certaine quantité d'eau, comme c'est normalement le cas avec les fissures dans les assemblages étanches ou dans les passages des fils de sortie des connexions.

Le degré de condensation dépend principalement de la constante de temps thermique de la surface des spécimens d'essai; il peut être négligeable avec des spécimens de dimensions très faibles, mais élevé avec des spécimens de grandes dimensions.

De même, l'effet du pompage est plus apparent sur les spécimens qui présentent des cavités relativement importantes remplies d'air ou de gaz, mais là aussi, la sévérité de l'essai dépend dans une certaine mesure des caractéristiques thermiques des spécimens.

L'effet de la condensation et de la distribution de la température peut être perturbé par les examens fonctionnels. Par conséquent, il convient d'effectuer les examens durant les phases constantes des profils de température (Figure 2 et Figure 3, zones B et F).

Afin de simplifier la planification des séquences d'essais, les valeurs de consigne sont données à l'Annexe A.

#### **4.2 Application de l'essai**

Pour les raisons énumérées ci-dessus, il est recommandé de limiter l'utilisation de cette procédure d'essai aux spécimens du type composant lorsque la structure des spécimens suggère un essai de chaleur humide du type "pompage" combiné à la formation de glace, et lorsque les caractéristiques thermiques sont compatibles avec les vitesses de variation de température, etc., de l'essai Z/AD.

Pour les spécimens du type solide (par exemple boîtier sous plastique) qui peuvent présenter des craquelures très fines ou un matériau poreux, les mécanismes d'absorption ou de diffusion prédominant et un essai de chaleur humide continu, comme l'essai C de l'IEC 60068-2-78, est privilégié pour l'étude de ces effets.

Pour les spécimens plus volumineux (tels que les matériels) ou, dans le cas de composants, lorsqu'il est essentiel de s'assurer que ceux-ci atteignent la stabilité thermique pendant les différentes phases du cycle, il convient d'utiliser l'essai Db de l'IEC 60068-2-30 même si, compte tenu du nombre réduit de cycles dans une période donnée, le degré d'accélération peut ne pas être très significatif. Dans ce cas, il convient normalement d'introduire l'essai Db dans une séquence telle que celle définie dans l'IEC 60068-1.

Comme dans les autres essais de chaleur humide, une tension de polarisation ou une charge électrique peut être appliquée aux spécimens. Dans le cas d'application d'une charge électrique, il convient que la charge soit telle que l'échauffement des spécimens n'affecte pas trop fortement les conditions dans la chambre.

Compte tenu des éléments susmentionnés, il convient de ne pas considérer l'essai Z/AD comme interchangeable avec les autres essais cycliques de chaleur humide ou l'essai de chaleur humide continu, ni de le considérer comme une variante éventuelle; il convient de choisir la méthode d'essai en fonction des caractéristiques thermiques et physiques des spécimens d'essai et des types de mécanismes de défaillance significatifs pour chaque cas particulier.

## 5 Description de la chambre d'essai

### 5.1 Généralités

L'exposition à l'humidité, suivie d'une exposition au froid, peut être réalisée soit dans la même chambre soit dans deux chambres distinctes.

NOTE Toutes les valeurs de température et d'humidité mesurées se rapportent à une mesure de l'air d'alimentation dans la chambre d'essai.

### 5.2 Chambre utilisée pour l'exposition à l'humidité

La chambre utilisée pour l'exposition à l'humidité doit être conçue de manière à répondre aux conditions suivantes:

- la température peut varier entre  $25\text{ °C} \pm 2\text{ K}$  et  $65\text{ °C} \pm 2\text{ K}$  en un intervalle de temps compris entre 1,5 h et 2,5 h soit pour une augmentation de la température, soit pour une diminution de la température;
- l'humidité relative peut être maintenue à  $(93^{+3}_{-3})\%$  pendant les périodes de température constante ou d'augmentation de la température et entre 80 % et 96 % pendant les périodes de diminution de la température;
- les conditions qui règnent en tout point dans l'espace de travail sont uniformes et aussi proches que possible de celles qui règnent dans le voisinage immédiat des dispositifs sensibles à l'humidité et à la température, placés de façon appropriée.  
L'air dans la chambre doit donc être brassé de façon continue à une vitesse suffisante pour maintenir les conditions de température et d'humidité spécifiées;
- les spécimens en essai ne doivent pas être soumis au rayonnement de chaleur en provenance des dispositifs de mise à température de la chambre;
- l'eau utilisée pour le système d'humidificateur de la chambre doit satisfaire aux limites spécifiées dans l'IEC 60068-2-67;
- l'eau de condensation doit être drainée de la chambre de façon continue et ne doit plus être réutilisée à moins d'avoir été repurifiée.

Des précautions doivent être prises pour que l'eau de condensation en provenance des parois latérales et supérieure de la chambre d'essai ne puisse pas tomber sur les spécimens.

### 5.3 Chambre utilisée pour l'exposition au froid

La chambre utilisée pour l'exposition au froid doit être conçue de manière à répondre aux conditions suivantes:

- a) la température peut être maintenue à  $-10\text{ °C} \pm 2\text{ K}$ ;
- b) les conditions qui règnent en tout point dans l'espace de travail sont uniformes et aussi proches que possible de celles qui règnent dans le voisinage immédiat des dispositifs sensibles à la température, placés de façon appropriée.

L'air doit donc se déplacer de manière continue dans la chambre.

Il convient de prendre des précautions pour que la capacité thermique du spécimen en essai ne perturbe pas de manière significative les conditions à l'intérieur de la chambre.

La chambre utilisée pour l'exposition à l'humidité peut être utilisée pour l'exposition au froid, auquel cas elle doit respecter les exigences du 4.1. En outre, elle doit être construite de manière à répondre aux conditions suivantes:

- 1) la température peut être abaissée de  $25\text{ °C} \pm 2\text{ K}$  à  $-10\text{ °C} \pm 2\text{ K}$  en un intervalle de temps qui ne dépasse pas 30 min;
- 2) le spécimen peut être maintenu à une température de  $-10\text{ °C} \pm 2\text{ K}$  pendant 3 h;
- 3) la température peut être augmentée de  $-10\text{ °C} \pm 2\text{ K}$  à  $25\text{ °C} \pm 2\text{ K}$  en un intervalle de temps qui ne dépasse pas 90 min.

## 6 Sévérités

Sauf spécification contraire, le nombre de cycles de 24 h doit être de 10. S'il est différent de 10, la spécification applicable doit définir ce nombre.

## 7 Procédure d'essai

### 7.1 Préconditionnement

Sauf spécification contraire, les spécimens doivent être soumis, non emballés, sans application de tension, prêts à être utilisés, aux conditions de "séchage assisté" spécifiées dans l'IEC 60068-1 ( $55\text{ °C} \pm 2\text{ K}$  avec une humidité relative qui ne dépasse pas 20 %) pendant 24 h avant le premier cycle de l'essai de chaleur humide.

Les spécimens doivent alors avoir atteint la stabilité thermique dans les conditions atmosphériques normales d'essai ou, sauf spécification contraire, avant la réalisation des mesures initiales.

La Figure 1 fournit un aperçu de la phase de preconditionnement. Pendant la période de stabilisation, aucune vitesse spécifique de refroidissement n'est spécifiée, mais elle ne doit pas être supérieure à 1 K/min.

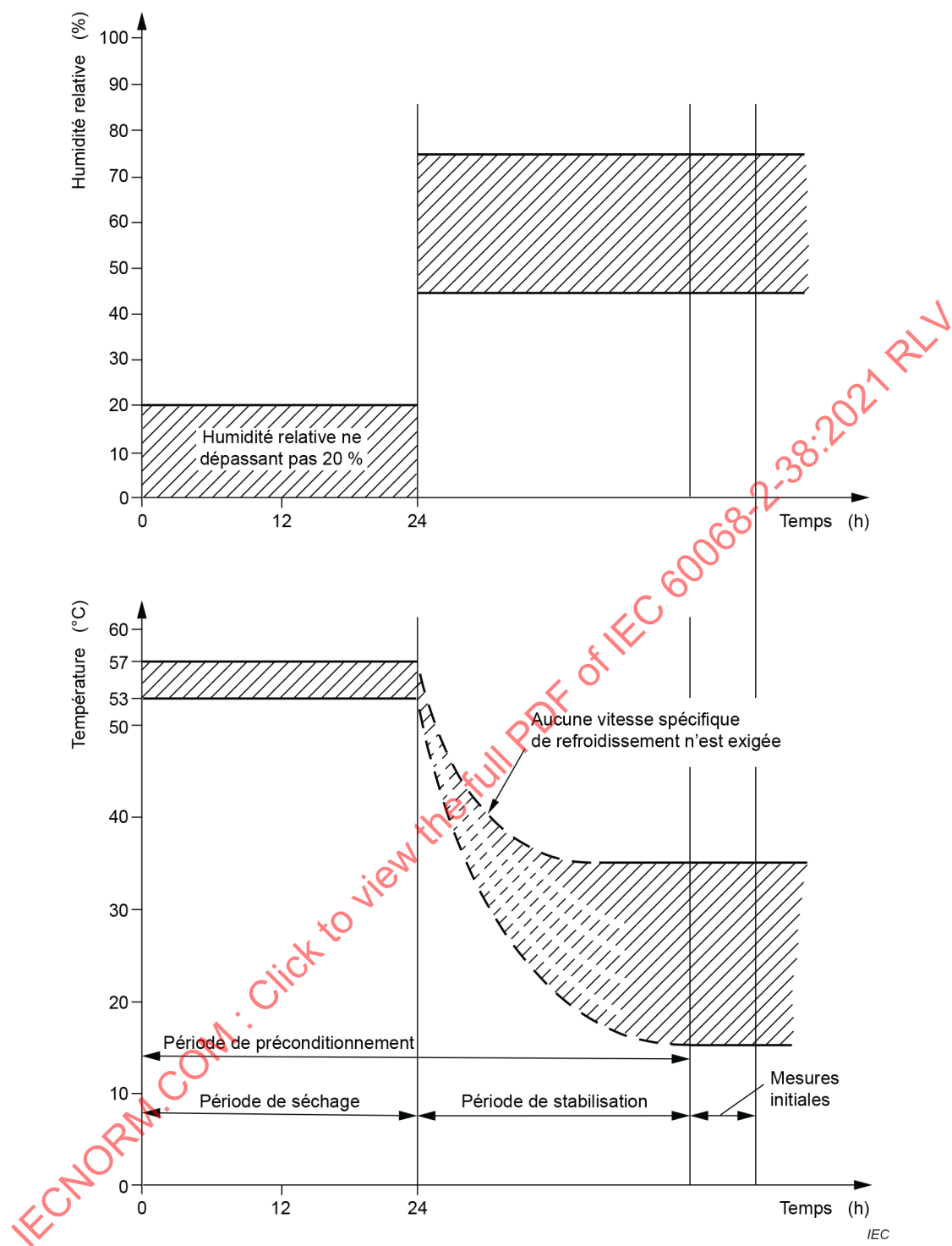


Figure 1 – Préconditionnement

## 7.2 Mesures initiales

Les spécimens doivent être examinés visuellement et soumis aux vérifications électriques et mécaniques exigées par la spécification applicable.

## 7.3 Conditionnement

Les tolérances totales sur la température de  $\pm 2$  K spécifiées dans le présent document sont destinées à tenir compte des erreurs absolues de mesure, des variations lentes de température et des variations de température de l'espace de travail.

NOTE Cette tolérance est valide pour un espace d'essai vide dans les conditions stabilisées de température et d'humidité de l'essai. Dans certaines conditions, lorsque le spécimen a un impact non significatif sur la régulation de la chambre, les tolérances peuvent demeurer valides lorsque la chambre comprend un ou plusieurs spécimens.

Cependant, afin de maintenir l'humidité relative dans les tolérances exigées, il est nécessaire de conserver constamment la différence de température entre deux points dans l'espace de travail dans des limites plus étroites. Les conditions d'humidité exigées ne sont pas atteintes si de telles différences de température dépassent 1 K. Il peut également être nécessaire de conserver des fluctuations de courte durée dans ces limites afin de maintenir l'humidité exigée.

Les spécimens doivent être introduits dans la chambre d'humidité, non emballés, sans application de tension, prêts à être utilisés et placés sur le montage selon l'orientation normale (si elle est connue) ou exigée si d'autres spécifications s'appliquent. Ils doivent ensuite être soumis à 10 cycles de température/d'humidité d'une durée de 24 h chacun.

Pendant cinq cycles parmi les neuf premiers cycles ci-dessus, les spécimens doivent être soumis au froid après avoir été exposés au sous-cycle d'humidité (zones A à H de la Figure 2). Il convient de définir la position des sous-cycles de froid dans la spécification applicable.

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