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BSI Standards Publication

Electronic paper displays

Part 4-2: Environmental test methods

bsi.

National foreword

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Part 4-2: Environmental test methods

INTERNATIONAL
ELECTROTECHNICAL
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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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ELECTRONIC PAPER DISPLAYS –

Part 4-2: Environmental test methods

FOREWORD

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International Standard IEC 62679-4-2 has been prepared by IEC technical committee 110: Electronic display devices.

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

CDV	Report on voting
110/730/CDV	110/773A/RVC

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

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

A list of all parts in the IEC 62679 series, published under the general title *Electronic paper displays*, 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- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

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ELECTRONIC PAPER DISPLAYS –

Part 4-2: Environmental test methods

1 Scope

This part of IEC 62679 specifies the environmental conditions to determine the environmental reliability of electronic paper display (EPD) panels and/or modules for storage under the assumed usage environment. The scope of this document is restricted to EPDs using either segment, passive, or active matrix with either monochromatic or colour type displays. The measuring methods are intended for EPDs operated in a reflective mode.

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 62679-1-1, *Electronic paper displays – Part 1-1: Terminology*

IEC 62679-3-1, *Electronic paper displays – Part 3-1: Optical measuring methods*

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

IEC 60068-2-38:2009, *Environmental testing – Part 2: Tests – Test Z/AD: Composite temperature/humidity cyclic test*

CIE 085-1989, *Solar spectral irradiance*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62679-1-1, IEC 60068-1 and the following apply.

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

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

3.1
air mass
path length that light from a celestial object takes through the earth’s atmosphere relative to the length at the zenith where air mass = 1

Note 1 to entry: The air mass is 1/sin (gamma), where gamma is the elevation angle of the sun.

3.2
black standard temperature
temperature of an insulated stainless-steel plate, having a black coating

Note 1 to entry: The black standard temperature represents the maximum surface temperature of specimens exposed to radiation.

Note 2 to entry: The black coated surface absorbs at least 90 % of the incident radiation flux below λ = 2 500 nm.

Note 3 to entry: The plate is attached to a 5 mm thick baseplate made of a weather resistant polymer for the insulation.

3.3
black panel temperature
temperature of an un-insulated stainless-steel plate, having a black coating

Note 1 to entry: The back of the metal plate is open to the atmosphere.

3.4
solar constant
E_0
irradiance by the sunlight on a plane perpendicular to the incident radiation outside the earth's atmosphere at the mean earth-sun distance

Note 1 to entry: The value of the solar constant is E_0 = 1 367 W/m^2.

3.5
optical depth
measure of how much light is absorbed when travelling through a medium

Note 1 to entry: A completely transparent medium has an optical depth of zero.

4 Measuring conditions

4.1 Standard measuring environmental conditions

Measurements shall be carried out under the standard environmental conditions:

- temperature: 25 °C ± 3 °C,
- relative humidity: 25 %RH to 85 %RH,
- atmospheric pressure: 86 kPa to 106 kPa.

When different environmental conditions are used, they shall be noted in the measurement report.

4.2 Standard atmospheric conditions for reference measurements and tests

If the parameters to be measured depend on temperature, pressure and humidity and their dependence on temperature, pressure and humidity is unknown, the atmospheres to be specified shall be selected from the following values, as shown in Table 1. The selected values shall be noted in the relevant specifications.

Table 1 – Standard conditions for reference measurements and tests

Temperature [a] °C	Relative humidity [a, b] % RH	Air pressure [a] kPa
20, 25, 30, and 35 ± 3	45 to 75	86 to 106

[a] Including extreme values.

[b] Absolute humidity ≤ 22 g/m^3.

4.3 Recovery conditions

4.3.1 General

After the conditioning period and before making the final measurements, the specimens should be allowed to stabilize at the ambient temperature, i.e. the temperature at which the measurements are to be made.

The controlled recovery conditions (see 4.3.2) shall be applied if the electrical parameters to be measured are affected by the absorbed humidity or surface conditions of the specimens and change rapidly, for example if the insulation resistance rises considerably within approximately 2 h after removal of the specimens from a humidity chamber.

If the electrical parameters of the specimens affected by the absorbed humidity or surface conditions do not vary rapidly, recovery may be carried out in the conditions of 4.2.

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

Most test procedures give the appropriate recovery conditions and duration. These conditions apply unless otherwise prescribed by the relevant specification.

4.3.2 Controlled recovery conditions

The controlled recovery conditions are as follows:

- Temperature: actual laboratory temperature ± 1 °C provided that it is within the limits fixed in 4.2, that is, between + 15 °C and + 35 °C.
- Relative humidity: between 45 % and 75 %.
- Air pressure: between 86 kPa and 106 kPa.
- Recovery period: to be stated in the relevant specification if different from that given in the appropriate method of test.

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

4.3.3 Recovery procedure

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

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

5 Measuring methods of environmental properties

5.1 High temperature storage test

5.1.1 Purpose

The purpose of this non-operational test is to measure the ability of EPD panels and modules to withstand high temperature in storage.

5.1.2 Storage conditions

Standard measuring is implemented under the standard environmental conditions.

Temperature and duration time are as follows:

a) Temperature

The temperature shall be selected from the values given below depending on application. The temperature used shall be noted in the report.

(100, 95, 90, 85, 80, 75, 70, 65, 60, 55, 50, 45, 40, 35, 30 ± 3) °C

b) Duration time

The duration shall be selected from the values given below depending on application. The duration used shall be noted in the report.

2 h, 16 h, 24 h, 48 h, 72 h, 96 h, 120 h, 168 h, 192 h, 240 h, 300 h, 500 h and 1 000 h

5.2 Low temperature storage test

5.2.1 Purpose

The purpose of this non-operational test is to measure the ability of EPD panels and modules to withstand low temperature in storage.

5.2.2 Storage conditions

Standard measuring is implemented under the standard environmental conditions.

Temperature and duration time are as follows:

a) Temperature

The temperature shall be selected from the values given below depending on application. The temperature used shall be noted in the report.

(–50, –45, –40, –35, –30, –25, –20, –15, –10, –5, 0 ± 3) °C

b) Duration time

The duration shall be selected from the values given below depending on application. The duration used shall be noted in the report.

2 h, 16 h, 24 h, 48 h, 72 h, 96 h, 120 h, 168 h, 192 h, 240 h, 300 h, 500 h and 1 000 h

5.3 Temperature shock test – Two chambers

5.3.1 Purpose

The purpose of this non-operational test is to measure the ability of EPD panels and modules to withstand rapid changes of ambient temperature.

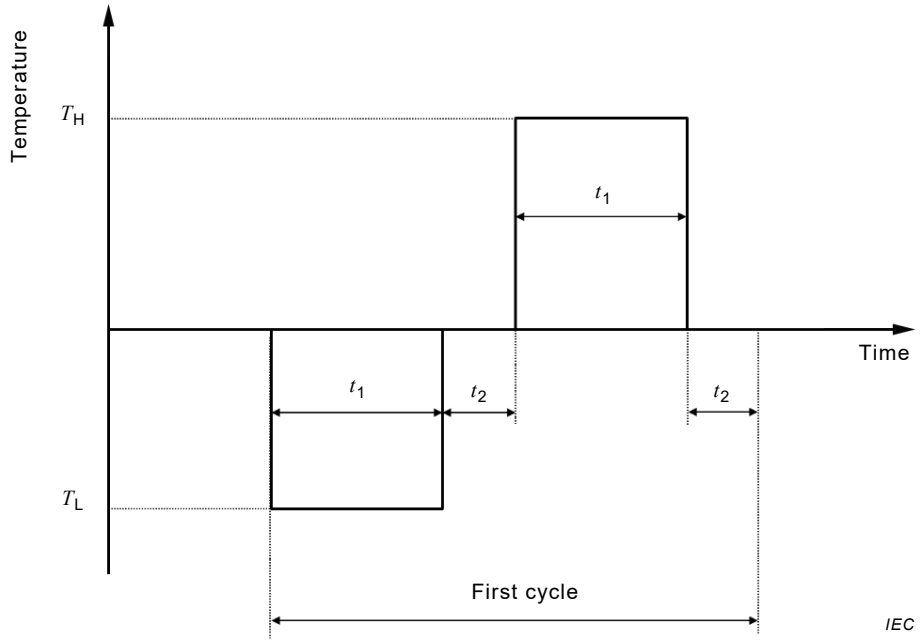
5.3.2 Storage conditions

Standard measuring is implemented under the standard environmental conditions.

The schematic diagram of temperature profile is shown in Figure 1.

Temperature, duration time, transition time and number of cycles are as follows:

a) High temperature
   The temperature shall be selected from the values given below depending on application.
   (100, 95, 90, 85, 80, 75, 70, 65, 60, 55, 50, 45, 40, 35, 30 ± 3) °C
   The temperature used shall be noted in the report.
b) Low temperature
   The temperature shall be selected from the values given below depending on application.
   (–50, –45, –40, –35, –30, –25, –20, –15, –10, –5, 0 ± 3) °C
   The temperature used shall be noted in the report.
c) Duration time
   3 h, 2 h, 1 h, 30 min, 10 min
d) Transition time
   2 min to 3 min, 20 s to 30 s, less than 10 s
e) Number of cycles
   5 or 10



T_H High temperature
T_L Low temperature
t_1 Duration time
t_2 Transition time

Figure 1 – Temperature profile

5.4 Specified change rate test of temperature – One chamber

5.4.1 Purpose

The purpose of this non-operational test is to measure the ability of EPD panels and modules to withstand specified change rate of ambient temperature.

5.4.2 Storage conditions

Standard measuring is implemented under the standard environmental conditions.

The schematic diagram of temperature profile is shown in Figure 2.

Temperature and duration time are as follows:

a) High temperature

The temperature shall be selected from the values given below depending on application.

(100, 95, 90, 85, 80, 75, 70, 65, 60, 55, 50, 45, 40, 35, 30 ± 3) °C

The temperature used shall be noted in the report.

b) Low temperature

The temperature shall be selected from the values given below depending on application.

(–50, –45, –40, –35, –30, –25, –20, –15, –10, –5, 0 ± 3) °C

The temperature used shall be noted in the report.

c) Temperature change rate

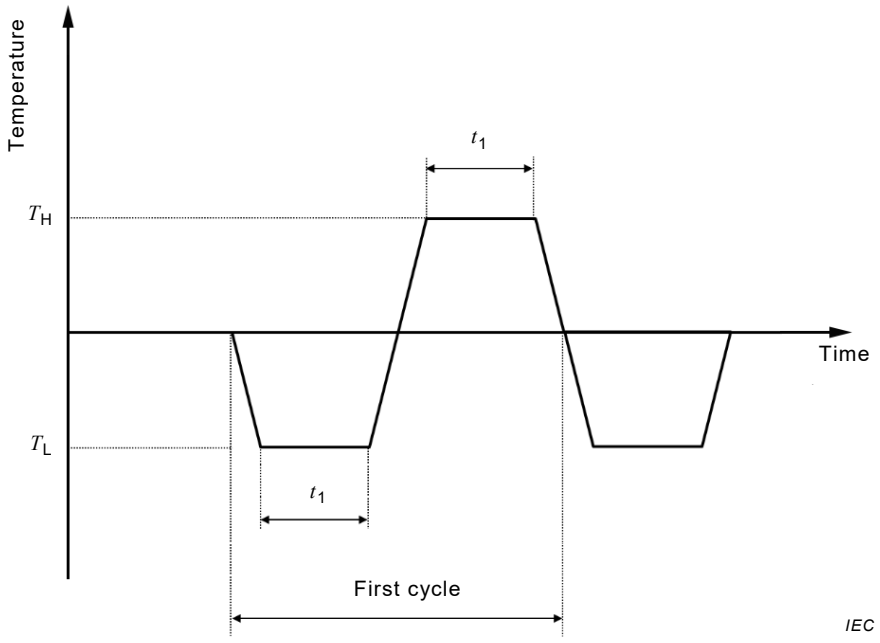
1 °C/min ± 0,2 °C/min, 3 °C/min ± 0,6 °C/min, 5 °C/min ± 1 °C/min, 10 °C/min ± 2 °C/min, 15 °C/min ± 3 °C/min

d) Duration time

3 h, 2 h, 1h, 30 min, 10 min

e) Number of cycles

5 or 10



T_H High temperature

T_L Low temperature

t_1 Duration time

Figure 2 – Temperature profile

5.5 Combination temperature/humidity test

5.5.1 Purpose

The purpose of this non-operational test is to measure the ability of EPD panels and modules to withstand a combination of temperature and relative humidity (RH).

5.5.2 Storage conditions

Standard measuring is implemented under the standard environmental conditions.

Temperature and duration time are as follows:

a) Temperature

The temperature shall be selected from the values given below depending on application.

(100, 95, 90, 85, 80, 75, 70, 65, 60, 55, 50, 45, 40, 35, 30 ± 3) °C

The temperature used shall be noted in the report.

b) Humidity

(80, 85, 90, 93 ± 3) %RH

c) Duration time

The duration time at test temperature and humidity shall be selected from the values given below depending on application.

2 h, 16 h, 24 h, 48 h, 72 h, 96 h, 120 h, 168 h, 192 h, 240 h, 300 h, 500 h and 1 000 h

The duration time used shall be noted in the report.

5.6 Combination temperature/humidity cycle test

5.6.1 Purpose

The purpose of this non-operational test is to measure the ability of EPD panels and modules to withstand the deteriorative effects of high temperature/humidity and cold conditions.

5.6.2 Storage conditions

Standard measuring is implemented under the standard environmental conditions.

Temperature and duration time are as follows:

a) High temperature

The temperature shall be selected from the values given below depending on application.

(100, 95, 90, 85, 80, 75, 70, 65, 60, 55, 50, 45, 40, 35, 30 ± 3) °C

The temperature used shall be noted in the report.

b) Low temperature

The temperature shall be selected from the values given below depending on application.

(-50, -45, -40, -35, -30, -25, -20, -15, -10, -5, 0 ± 3) °C

The temperature used shall be noted in the report.

c) Temperature change rate

1 °C/min ± 0,2 °C/min, 3 °C/min ± 0,6 °C/min, 5 °C/min ± 1 °C/min, 10 °C/min ± 2 °C/min, 15 °C/min ± 3 °C/min

d) Duration time

3 h, 2 h, 1 h, 30 min, 10 min

e) Humidity

(85 ± 5 %) %RH, (93 $^{+2}_{-3}$) %RH

f) Number of cycles

5 or 10

The absolute humidity of the atmosphere shall not exceed 20 g/m^3.

5.6.3 Test cycle

Test Z/AD, the composite temperature/humidity cyclic test specified in IEC 60068-2-38, is applicable.

The following steps use 65 °C as high temperature and -10 °C as low temperature as examples. As described in 5.6.2, select the proper temperature depending on application, then proceed as follows:

1) At "zero time" of every 24 h cycle, the chamber condition shall be controlled to a temperature of 25 °C ± 3 °C and relative humidity of (93 $^{+2}_{-3}$) %.
2) The temperature of the chamber shall be continuously raised to 65 °C ± 2 °C 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 $^{+2}_{-3}$) %.
3) The temperature and relative humidity in the chamber shall be maintained at 65 °C ± 2 °C and (93 $^{+2}_{-3}$) % respectively until 5,5 h after the start of the cycle.
4) The temperature shall then be allowed to fall to 25 °C ± 2 °C 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 %.
5) Beginning 8 h after the start of the cycle, the temperature shall again be raised to 65 °C ± 2 °C in a period of between 1,5 h and 2,5 h. During this period, the relative humidity shall be (93 $^{+2}_{-3}$) %.
6) The temperature and relative humidity in the chamber shall be maintained at 65 °C ± 2 °C and (93 $^{+2}_{-3}$) % respectively until 13,5 h after the start of the cycle.
7) The temperature shall then be dropped to 25 °C ± 2 °C 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 %.
8) The chamber shall then continue to run at a stabilized temperature of 25 °C ± 2 °C and relative humidity of (93 $^{+2}_{-3}$) % until the start of the cold sub-cycle or until the end of the 24 h cycle as appropriate.
9) Following the completion of the temperature/humidity sub-cycle, the chamber is maintained at a temperature of 25 °C ± 2 °C and a relative humidity of (93 $^{+2}_{-3}$) % for a period of at least 1 h but not more than 2 h.
10) 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 °C ± 2 °C. This temperature shall be reached 18 h after the start of the cycle.

11) Beginning 18 h after the start of the cycle, the temperature shall be maintained at -10 °C ± 2 °C for a period of 3 h. No requirement for humidity is prescribed during the entire cold sub-cycle.

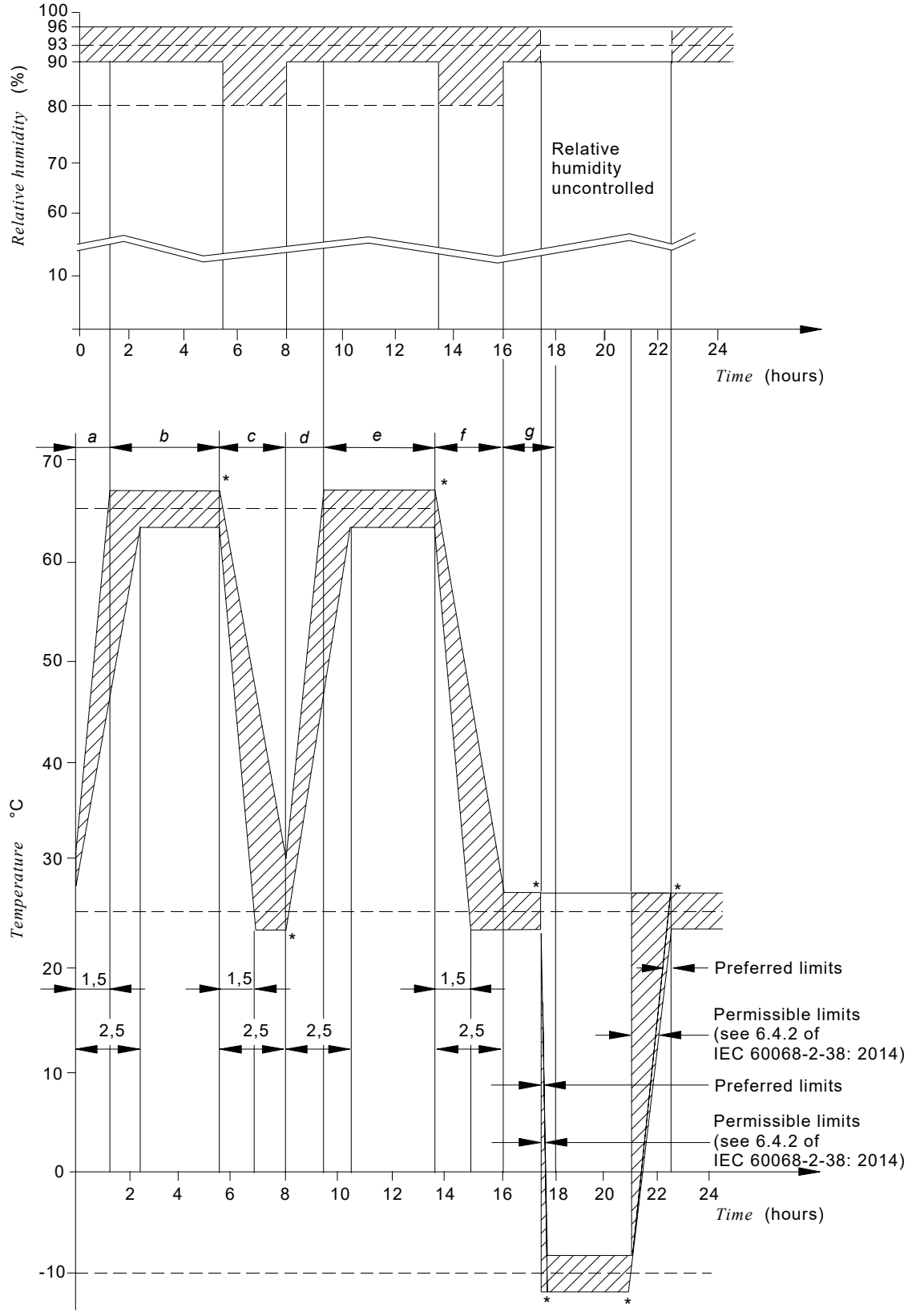
12) Beginning 21 h after the start of the cycle, the temperature shall be raised to 25 °C ± 2 °C . This temperature shall be reached 22,5 h after the start of the cycle. If the specimen is transferred from one chamber to another, the transfer shall be completed within a period of 10 min to 15 min.

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

14) Cycles which do not include a cold sub-cycle following the humidity/temperature sub-cycle are the same as described in items 1) to 9), except the time zone in Figure 4, where the chamber shall be maintained at a temperature of 25 °C ± 2 °C and relative humidity of $(93\ ^{+2}_{-3})$ % until the 24 h cycle is completed.

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

The schematic diagrams of temperature and humidity cycle followed by exposure to cold are shown in Figure 3, and the schematic diagrams of temperature and humidity cycle not followed by exposure to cold are shown in Figure 4.



* Tolerance on time at these points ±5 min.

Figure 3 – Combination temperature/humidity cycle followed by exposure to cold

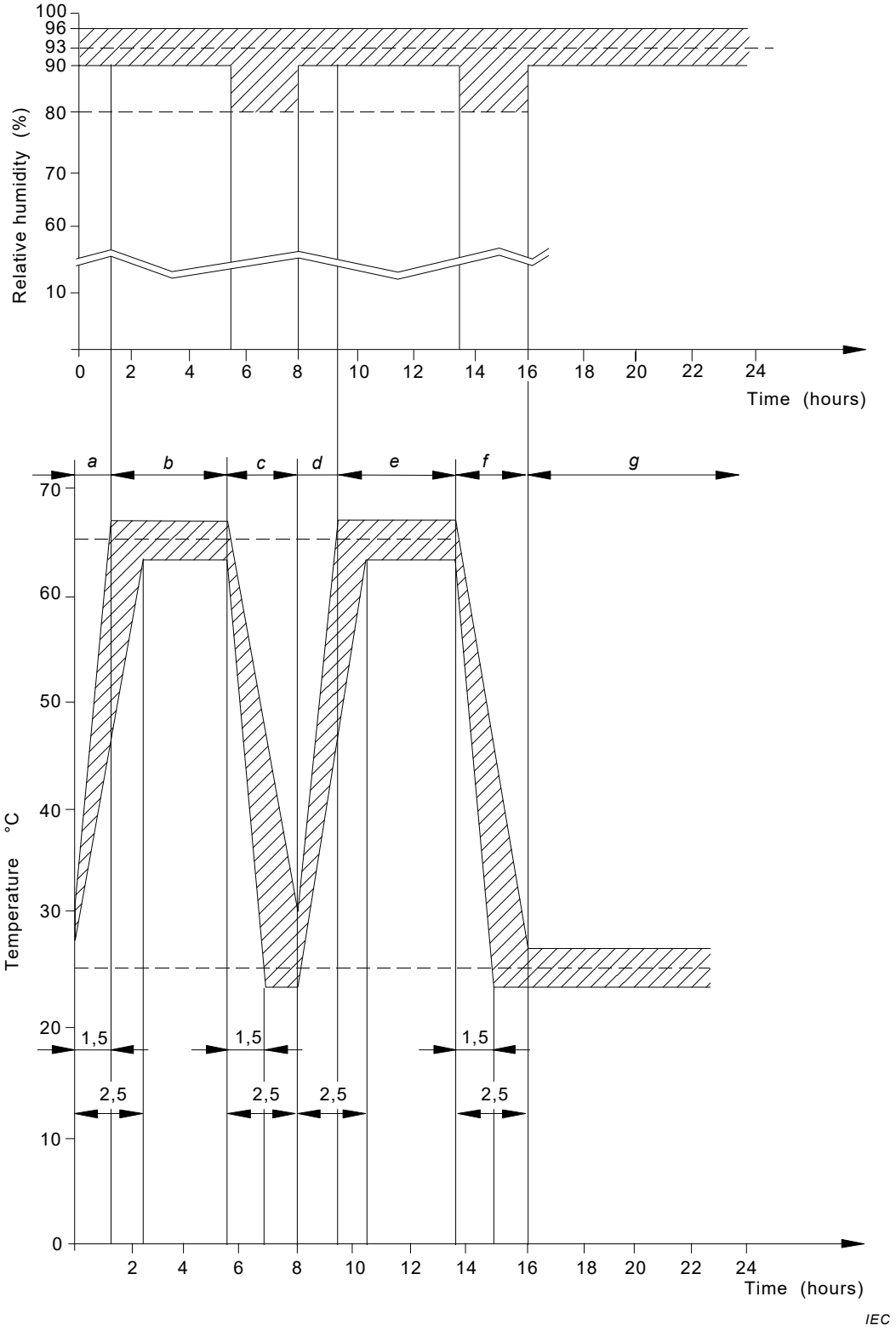


Figure 4 – Combination temperature/humidity cycle not followed by exposure to cold

5.7 Low air pressure test

5.7.1 Purpose

The purpose of this non-operational test is to measure the ability of EPD panels and modules to withstand low air pressure tests at room temperature.

5.7.2 Storage conditions

Standard measuring is implemented under the standard environmental conditions.

Air pressure and duration time are as follows:

a) Air pressure

Air pressure is reduced to 4 kPa/min or slower, starting from atmospheric pressure (86 kPa to 106 kPa) down to P_{st}.

P_{st} shall be selected from the values given below.

(15 ± 5) kPa

(20 ± 5) kPa

(30 ± 5) kPa

(40 ± 5) kPa

(50 ± 5) kPa

The pressure used shall be noted in the report.

b) Duration time

5 min, 30 min, 1 h, 2 h, 4 h, 6 h

5.8 Reporting

The following details shall be given as far as they are applicable:

1) preconditioning;
2) initial measurements; electrical tests, optical tests and appearance inspection;
3) details of mounting or supports;
4) state of EPD panels and modules (unpowered, powered, packaged, unpackaged, etc.);
5) type of EPD panels and modules;
6) test severities and tolerances; temperature, relative humidity, duration time, temperature cycle order;
7) recovery conditions;
8) final measurements; electrical tests, optical tests and appearance inspection;
9) any deviation in procedure.

6 Measuring methods of light exposure properties

6.1 General remarks

6.1.1 Overview

The effect of radiation on the device(s) will depend on the level of irradiance, the spectral irradiance, the location, the time of day and the sensitivity of the material of the device(s).

6.1.2 Irradiance of the sunlight

The irradiance at sea level is influenced by the solar constant and the attenuation and scattering of radiation in the atmosphere. For test purposes, CIE 085-1989, Table 4, gives a value of 1 090 W/m^2 for the global radiation at the surface of the earth from sun at zenith (value based on a solar constant E_0 = 1 367 W/m^2).

6.1.3 Spectral irradiance of the sunlight

The standard spectral irradiance of the global radiation specified for this test, in accordance with the recommendations of CIE 085-1989, Table 4, is given in Figure 5 and in Table 2.

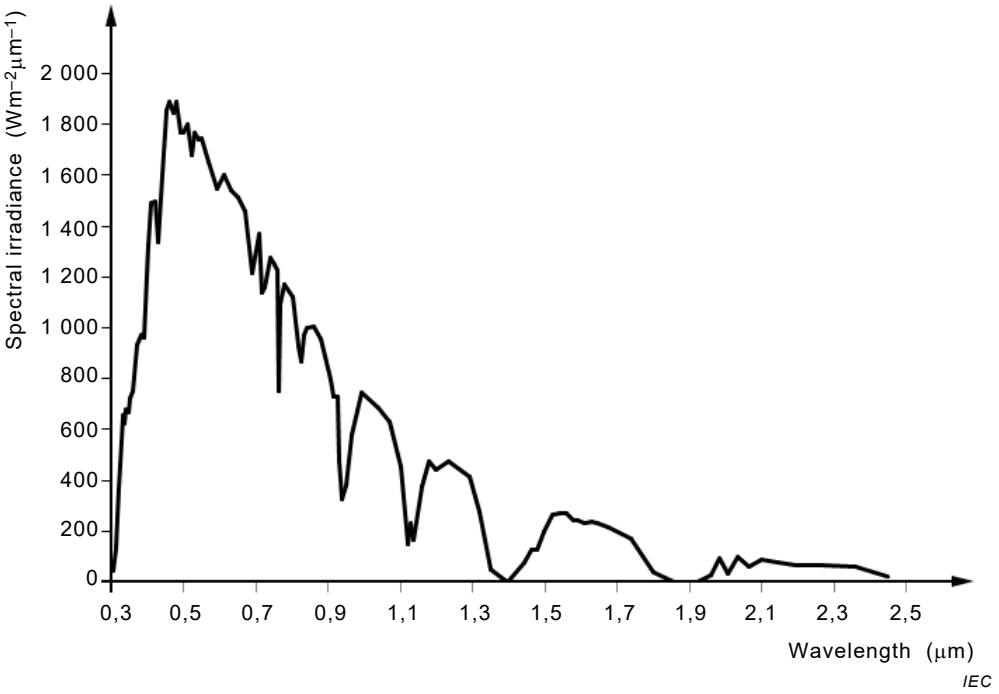


Figure 5 – Global solar spectral irradiance at sea level

Table 2 – Spectral irradiance (condensed from CIE 085-1989, Table 4)

Spectral region	Ultraviolet B[a]	Ultraviolet A	Visible	Infrared	Total radiation
Bandwidth	300 nm to 320 nm	320 nm to 400 nm	400 nm to 800 nm	800 nm to 2 450 nm	300 nm to 2 450 nm
Irradiance	4,06 W/m^2	70,5 W/m^2	604,2 W/m^2	411,2 W/m^2	1 090 W/m^2
Proportion of total radiation	0,4 %	6,4 %	55,4 %	37,8 %	100 %
[a] Radiation shorter than 300 nm reaching the earth's surface is insignificant.					

If the source of radiation used for the test does not meet the standard spectral irradiance given in Table 2, for this procedure the exact spectral absorption data of the exact spectral irradiance of the alternative radiation source in the required wavelength range shall be known or measured.

6.2 Conditioning

6.2.1 General

During the entire test, the irradiation, the temperature within the chamber, the humidity and any other specified environmental conditions shall be maintained at the levels appropriate to the particular test procedure specified in the relevant specification. The relevant specification shall state which preconditioning requirements are to be applied.

6.2.2 Temperature

The temperature within the chamber during irradiation shall be controlled in accordance with the procedure specified in Table 5 otherwise the temperature within the chamber may be controlled at one of the preferred values given in the relevant specification by agreement between the interested parties. The surface temperature of test device(s) shall be controlled with a black standard thermometer or a black panel thermometer (see Table 5).

The temperature-sensing element shall be shielded from the radiation source. The chamber air temperature measured at this position may not be the same as the chamber air temperature near the surface of the exposed test specimen(s).

6.2.3 Humidity

Different humidity conditions can markedly affect photochemical degradation.

The humidity within the chamber during irradiation periods shall be controlled in accordance with the procedure specified in Table 5, otherwise the humidity within the chamber may be controlled at one of the preferred values given in IEC 60068-2-78 or the relevant specification by agreement between the interested parties.

6.2.4 Surface contamination

Dust and other surface contamination may significantly change the absorption characteristics of irradiated surfaces. Unless otherwise required, device(s) should be tested in a clean condition. However, if effects of surface contamination are to be assessed, the relevant specification should include the necessary information on preparation of surfaces, etc.

6.2.5 Mounting of device(s)

Attach the device(s) to the sample holders in the equipment in such a manner that the device(s) is/are not subject to any applied stress. Identify each test specimen by suitable indelible marking, avoiding areas to be used for subsequent testing. As a check, a plan of the test device positions may be made.

6.2.6 Test facility

It shall be ensured that the optical parts of the test facility, lamps, reflectors and filters, etc., are clean.

The level of irradiation over the specified measurement plane shall be measured immediately prior to each test.

If used, mount and calibrate the radiometer so that it measures the irradiance at the exposed surface of the test device(s).

Any ancillary environmental conditions, for example ambient temperature, humidity, and other parameters if specified, should be monitored continuously throughout the test.

6.2.7 Test apparatus

The chamber in which the tests are to be carried out should be provided with means for obtaining, over the prescribed irradiation measurement plane, an irradiance of 1 090 W/m^2 $\pm$ 10 % with the spectral irradiance given in Table 5.

The value of 1 090 W/m^2 shall include any radiation reflected from the test chamber and received by the specimens under test. It should not include long-wave infrared radiation emitted by the test chamber.

Means shall also be provided whereby the specified conditions of temperature, air flow and humidity can be maintained within the chamber.

The temperature-sensing element shall be shielded from the radiation source and water spray. The chamber air temperature measured at this position may not be the same as the chamber air temperature near the surface of the exposed device(s).

6.2.8 Laboratory light source

6.2.8.1 General

The light source shall comprise one or more quartz-jacketed xenon-arc lamps which emit radiation from below 270 nm in the ultraviolet through the visible spectrum and into the infrared. In order to simulate sunlight, filters shall be used to remove short-wavelength UV radiation (see Table 3). Filters to minimize irradiance at wavelengths shorter than 310 nm shall be used to simulate daylight through window glass (see Table 4). In addition, filters to remove infrared radiation may be used to prevent unrealistic heating of the test device(s), which can cause thermal degradation not experienced during outdoor exposures.

6.2.8.2 Spectral irradiance of xenon-arc lamps with daylight filters

Filters are used to filter xenon-arc emissions in order to simulate sunlight (CIE 085-1989, Table 4). The minimum and maximum levels of the relative spectral irradiance in the UV wavelength range are given in Table 3.

Table 3 – Relative spectral irradiance of xenon-arc lamps with daylight filters [a] [b]

Spectral passband (λ = wavelength in nm)	Minimum[c] %	CIE 085-1989, Table 4[d] [e] %	Maximum[c] %
$\lambda < 290$			0,15
$290 \leq \lambda \leq 320$	2,6	5,4	7,9
$320 < \lambda \leq 360$	28,2	38,2	39,8
$360 < \lambda \leq 400$	54,2	56,4	67,5

[a] This table gives the irradiance in the given passband, expressed as a percentage of the irradiance in the passband to the total irradiance between 290 nm and 400 nm, which is critical for the test. The irradiance of the other range is determined by the light source used. See 6.2.8.4.

[b] To determine whether a specific filter or set of filters for a xenon-arc lamp meet the requirements of this table, the spectral irradiance shall be measured from 250 nm to 400 nm. The total irradiance in each wavelength passband is then summed and divided by the total irradiance from 290 nm to 400 nm. Typically, this is done in 2 nm increments.

[c] The minimum and maximum limits in this table are based on more than 100 spectral irradiance measurements with water- and air-cooled xenon-arc lamps with daylight filters from different production lots and of various ages, used in accordance with the recommendations of the manufacturer. As more spectral irradiance data become available, minor changes in the limits are possible. The minimum and maximum limits are at least three sigma from the mean for all the measurements.

[c] The minimum and maximum columns will not necessarily sum to 100 % because they represent the minima and maxima for the measurement data used. For any individual spectral irradiance, the percentages calculated for the passbands in this table will sum to 100 %. For any individual xenon-arc lamp with daylight filters, the calculated percentage in each passband shall fall within the minimum and maximum limits given. Exposure results can be expected to differ if obtained using xenon-arc apparatus in which the spectral irradiances differ by as much as that allowed by the tolerances. Contact the manufacturer of the xenon-arc apparatus for specific spectral irradiance data for the xenon-arc lamp and filters used.

[d] The data from CIE 085-1989, Table 4, is the global solar irradiance on a horizontal surface for an air mass of 1,0, an ozone column of 0,34 cm at standard temperature and pressure, 1,42 cm of precipitable water vapour and a spectral optical depth of aerosol extinction of 0,1 at 500 nm. These data are target values for xenon-arc lamps with daylight filters.

[e] For the solar spectrum represented by CIE 085-1989, Table 4, the UV irradiance (between 290 nm and 400 nm) is 11 % and the visible irradiance (between 400 nm and 800 nm) is 89 %, expressed as a percentage of the total irradiance between 290 nm and 800 nm. The percentage of the UV irradiance and that of the visible irradiance incident on specimen(s) exposed in xenon-arc apparatus might vary due to the number of specimens being exposed and their reflectance properties.

6.2.8.3 Radiation source

As the radiation source for simulating solar radiation in the laboratory, a xenon-arc lamp is appropriate for the purpose of testing. If other radiation source is used, its exact spectral irradiance data shall be measured and reported.

6.2.8.4 Spectral irradiance of xenon-arc lamps with window glass filters

Filters are used to filter the xenon-arc lamp emissions in order to simulate sunlight which has passed through window glass. The minimum and maximum levels of the relative spectral irradiance in the UV region are given in Table 4.

Table 4 – Relative spectral irradiance for xenon-arc lamps with window glass filters [ab]

Spectral passband (λ = wavelength in nm)	Minimum[c] %	CIE 085-1989, Table 4, plus effect of window glass [de] %	Maximum[c] %
$\lambda < 300$			0,29
$300 \leq \lambda \leq 320$	0,1	≤ 1	2,8
$320 < \lambda \leq 360$	23,8	33,1	35,5
$360 < \lambda \leq 400$	62,4	66,0	76,2

[a] This table gives the irradiance in the given passband, expressed as a percentage of the total irradiance between 290 nm and 400 nm. To determine whether a specific filter or set of filters for a xenon-arc lamp meet the requirements of this table, the spectral irradiance shall be measured from 250 nm to 400 nm. The total irradiance in each passband is then summed and divided by the total irradiance between 290 nm and 400 nm.

[b] The minimum and maximum limits in this table are based on more than 30 spectral irradiance measurements with water- and air-cooled xenon-arc lamps with window glass filters from different production lots and of various ages, used in accordance with the recommendations of the manufacturer. As more spectral irradiance data become available, minor changes in the limits are possible. The minimum and maximum limits are at least three sigma from the mean for all the measurements.

[c] The minimum and maximum columns will not necessarily sum to 100 % because they represent the minima and maxima for the data used. For any individual spectral irradiance, the percentages calculated for the passbands in this table will sum to 100 %. For any individual xenon-arc lamp with window glass filters, the calculated percentage in each passband shall fall within the minimum and maximum limits given. Exposure results can be expected to differ if obtained using xenon-arc apparatus in which the spectral irradiances differ by as much as that allowed by the tolerances. Contact the manufacturer of the xenon-arc apparatus for specific spectral irradiance data for the xenon-arc lamp and filters used.

[d] The data from CIE 085-1989, Table 4, plus the effect of window glass was determined by multiplying CIE 085-1989, Table 4, data by the spectral transmittance of a 3-mm-thick window glass. These data are target values for xenon-arc lamps with window glass filters.

[e] For CIE 085-1989 plus window glass data, the UV irradiance between 300 nm and 400 nm is typically about 9 % and the visible irradiance (between 400 nm and 800 nm) is typically about 91 %, expressed as a percentage of the total irradiance between 300 nm and 800 nm. The percentage of the UV irradiance and that of the visible irradiance incident on specimens exposed in xenon-arc apparatus might vary due to the number of specimens being exposed and their reflectance properties.

6.3 Procedures

6.3.1 General

The specified test pattern shall be displayed on the screen of the device(s) upon application of the electronic voltage or current. The initial measurement shall be done while the electronic voltage or current is applied.

The electronic voltage or current shall be turned off and the device(s) shall be exposed to light for the specified duration.

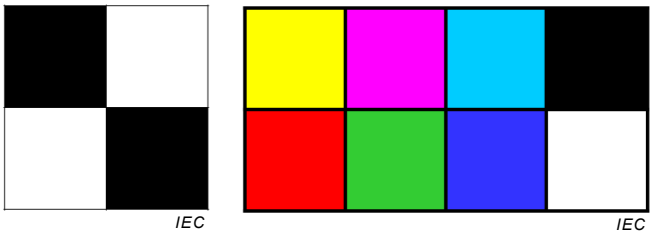
NOTE The electronic voltage or current can be applied during the light exposure, when it is in accordance with the actual use case. However, it can be difficult to apply the electronic voltage or current during the light exposure.

After the light exposure, the electronic voltage or current for the specified test pattern shall be applied to the device(s) again, and the measurements shall be carried out.

6.3.2 Test patterns

The test patterns specified in the detailed specification shall be used.

An example of the test pattern for a black and white, or monochrome, EPD is shown in Figure 6 a). An example of the test pattern for a colour EPD is shown in Figure 6 b).



a) b)

Figure 6 – Examples of test pattern for black and white EPD and for colour EPD

6.3.3 Measurements

The reflectance factors and/or the chromaticity of each patch of the EPD shall be measured before and after the light exposures. The measurement procedures shall be in accordance with IEC 62679-3-1.

6.4 Light exposure testing

6.4.1 General

The irradiation, temperature and humidity shall be controlled as specified. Throughout the specified test duration, the temperature within the chamber shall be maintained within ±2 °C of that shown for the appropriate procedure.

6.4.2 Procedure A – Direct sunlight

Procedure A specifies methods for exposing device(s) in the presence of moisture to reproduce the weathering effects that occur when materials are exposed in actual end-use environments to direct sunlight.

The irradiance, temperature and relative humidity are given in Table 5.

6.4.3 Procedure B – Daylight through window glass

Procedure B specifies methods for exposing device(s) in the presence of moisture to reproduce the weathering effects that occur when materials are exposed in actual end-use environments to daylight filtered through window glass.

The irradiance, temperature and relative humidity are given in Table 5.

NOTE The black panel temperatures of 63 °C, and the black standard temperatures of 65 °C, are the ones most commonly used, but have no relationship to each other. The exposure results might therefore not be comparable.

Table 5 – Exposure cycles

Procedure A – Direct sunlight						
Exposure period	Irradiance [a b]		Temperature [c d]		Chamber temperature	Relative humidity
	Broadband (300 nm to 400 nm)	Narrowband (340 nm)	Black standard temperature	Black panel temperature		
	W/m^2	$W/(m^2 \times nm)$	°C	°C	°C	%
Continuous irradiation	60 ± 2	0,51 ± 0,02	65 ± 3	63 ± 3	38 ± 3	50 ± 10
Procedure B – Daylight through window glass						
Exposure period	Irradiance [a b]		Temperature [cd]		Chamber temperature	Relative humidity
	Broadband (300 nm to 400 nm)	Narrowband (420 nm)	Black standard temperature	Black panel temperature		
	W/m^2	$W/(m^2 \times nm)$	°C	°C	°C	%
Continuous irradiation	50 ± 2	1,10 ± 0,02	65 ± 3	63 ± 3	38 ± 3	50 ± 10

NOTE The ± tolerances given for irradiance, black standard temperature and relative humidity are the allowable fluctuations of the parameter concerned about the given value under equilibrium conditions. This does not mean that the value may vary by plus or minus the amount indicated from the given value.

[a] The values of the irradiance stipulated in this table have been historically used, and they are based on the consideration of attenuation of the irradiance in other areas because of the inclination of incident sun light. Therefore, the values are different from those of Table 2, which is a spectral irradiance right on the equator.

[b] Higher values for irradiance can be used when it is prescribed by the relevant specification agreed between the interested parties. In apparatus capable of producing higher irradiances, the actual irradiance might be significantly higher than the stated values, e.g. up to 180 W/m^2 (300 nm to 400 nm) for xenon-arc lamps with daylight filters or 162 W/m^2 (300 nm to 400 nm) for xenon-arc lamps with window glass filters. The higher irradiance test usually produces different test results from the standard irradiance shown in this table, due to the reciprocity failure and the higher temperature of the sample temperature. The test results from the higher irradiance exposure test cannot be compared to the test results of the standard irradiance exposure test.

[c] For exposures, one of these irradiance levels (total radiation, broadband or narrowband) shall be controlled.

[d] For exposures, either black-standard temperature or black-panel temperature shall be controlled.

6.4.4 Procedure C – Inner parts

For the evaluation of inner parts of EPD devices, the light exposure should be done through the component(s) which is/are at the front sides of the parts.

6.5 Reporting

6.5.1 Information to be given in the relevant specification

When the test described in Clause 6 is included in a relevant specification, the following details shall be given, in so far as they are applicable:

a) exposure time to radiation
b) black standard temperature or black panel temperature
c) source and power of radiation
d) duration of the test
e) state of operation
f) preconditioning
g) number of specimens
h) humidity if relevant
i) type and scope of initial measurement

j) test procedure
k) temperature during the test
l) type and scope of intermediate measurement
m) recovery
n) type and scope of final measurement
o) criteria for evaluation
p) description of specimen(s) support used for testing

6.5.2 Reporting

The following details shall be given as far as they are applicable:

a) preconditioning;
b) initial measurements; electrical tests, optical tests and appearance inspection;
c) details of mounting or supports;
d) state of EPD panels and modules (unpowered, powered, packaged, unpackaged, etc.);
e) type of EPD panels and modules;
f) test severities and tolerances; temperature, relative humidity, duration time, temperature cycle order;
g) recovery conditions;
h) final measurements; electrical tests, optical tests and appearance inspection;
i) any deviation in procedure.

Bibliography

[1] IEC 60068-2-1:2007, *Environmental testing – Part 2-1: Tests – Test A: Cold*

[2] IEC 60068-2-2:2007, *Environmental testing – Part 2-2: Tests – Test B: Dry heat*

[3] IEC 60068-2-5, *Environmental testing – Part 2-5: Tests – Test Sa: Simulated solar radiation at ground level and guidance for solar radiation testing*

[4] IEC 60068-2-13, *Environmental testing – Part 2: Tests – Test M: Low air pressure*

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

[6] IEC 60068-2-78:2001, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*

[7] IEC 60904-9, *Photovoltaic devices –Part 9: Solar simulator performance requirements*

[8] IEC 62679-3-2:2013, *Electronic paper display – Part 3-2: Measuring method – Electro-optical*

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