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INTERNATIONAL STANDARD

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Printed electronics –
Part 502-2: Quality assessment – Organic light emitting diode (OLED) elements – Combined mechanical and environmental stress test methods for flexible OLED elements

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PRINTED ELECTRONICS –

Part 502-2: Quality assessment – Organic light emitting diode (OLED) elements – Combined mechanical and environmental stress test methods for flexible OLED elements

FOREWORD

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International Standard IEC 62899-502-2 has been prepared by IEC technical committee 119: Printed Electronics.

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

FDIS	Report on voting
119/271/FDIS	119/278/RVD

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 62899 series, published under the general title *Printed electronics*, 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- withdrawn,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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INTRODUCTION

Electronic devices made by printing processes have very unique characteristics, as they are flexible, with foldable, rollable and/or conformable capabilities, compared to the electronic devices made through conventional non-printing processes that are mostly rigid. Given these characteristics, these devices can show different phenomena from those by non-printing processes under some conditions. In order to evaluate these phenomena, several unique evaluation methods are used for these devices made by the printing process. This document will provide one of them.

PRINTED ELECTRONICS –

Part 502-2: Quality assessment – Organic light emitting diode (OLED) elements – Combined mechanical and environmental stress test methods for flexible OLED elements

1 Scope

This part of IEC 62899 specifies the combined mechanical and environmental stress test methods for flexible OLED (organic light emitting diode) elements fabricated using the printing method. Mechanical stress tests include the static and cycling vending test, and the dynamic and static rolling test.

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 60068-1:2013, *Environmental testing – Part 1: General and guidance*

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

IEC 62341-6-1, *Organic light emitting diode (OLED) displays – Part 6-1: Measuring methods of optical and electro-optical parameters*

IEC 62341-6-2, *Organic light emitting diode (OLED) displays – Part 6-2: Measuring methods of visual quality and ambient performance*

IEC 62341-6-3, *Organic light emitting diode (OLED) displays – Part 6-3: Measuring methods of image quality*

IEC 62715-5-1, *Flexible display devices – Part 5-1: Measuring methods of optical performance*

IEC 62715-5-3, *Flexible display devices – Part 5-3: Visual assessment of image quality and defects*

IEC 62715-6-1, *Flexible display devices – Part 6-1: Mechanical test methods – Deformation tests*

IEC 62899-502-1, *Printed electronics – Part 502-1: Quality assessment – Organic light emitting diode (OLED) elements – Mechanical stress testing of OLED elements formed on flexible substrates*

IEC 62922, *Organic light emitting diode (OLED) panels for general lighting – Performance requirements*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62899-502-1 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

4 General

4.1 Overview

The flexible OLED elements can show some level of property variation applied by mechanical stress in certain environmental conditions such as a hot or cool atmosphere. In order to evaluate adequately these variations, environmental test conditions combined with a mechanical test are introduced.

4.2 Structure of measuring equipment

The system diagrams and/or operating conditions of the measuring equipment shall comply with the structure specification of each item.

4.3 Standard conditions

The standard testing conditions shall be as follows:

– temperature: 25 °C

– atmosphere: 101,3 kPa

If the parameters to be measured depend on temperature and/or pressure, and their dependence on temperature and pressure is known, the parameter values can be measured under the conditions specified in 4.5 and corrected by calculation to the standard reference atmosphere above.

4.4 Standard atmospheric conditions for referee 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 referee measurements and tests

Temperature [a] °C	Relative humidity [b] % RH	Air pressure [b] kPa
20 ± 1 (close)/ ± 2 (wide)	63 to 67 (close), 60 to 70 (wide)	86 to 106
25 ± 1 (close)/ ± 2 (wide)	48 to 52 (close), 45 to 55 (wide)	86 to 106
30 ± 1 (close)/ ± 2 (wide) 35 ± 1 (close)2/ ± 2 (wide)	45 to 75	86 to 106

[a] The close tolerances may be used for the referee measurements. The wider tolerances may be used only when allowed by the relevant specification.

[b] Inclusive values.

4.5 Standard atmospheric conditions for measurements and tests

Unless otherwise specified, all tests and measurements shall be carried out under standard atmospheric conditions:

– temperature: (25 ± 5) °C
– relative humidity: (60 ± 15) %
– atmospheric pressure: (96 ± 10) kPa

4.6 Recovery conditions

The recovery conditions specified in IEC 60068-1:2013, 4.4 shall be applied.

The OLED element shall be subjected to the recovery procedure in the chamber or otherwise as appropriate.

The OLED element shall then remain under standard atmospheric conditions for recovery for a period adequate for the attainment of temperature stability, for a minimum of 1 h.

If required by the relevant specification, the element shall be switched on or loaded and measured continuously during the recovery period.

If the standard conditions given above are not appropriate for the device to be tested, the relevant specification may call for other recovery conditions.

4.7 Operating conditions

Apply the proper driving current and voltage to the OLED element to provide luminosity at normal intended operation.

4.8 Flexible OLED element test configuration

Unless otherwise specified, the OLED element shall be tested in a state that is ready for normal operation without any protective elements added, nor voltage applied.

5 Measurements and analysis

5.1 General

Both before and after the combined stress testing in Clause 6, the following measurements on the electrical, optical and mechanical characteristics of OLED element(s) shall be performed in the standard environmental conditions defined in Clause 4. Measurement samples shall be prepared according to 5.2 before the measurements defined in 5.3 and 5.4. Both IEC 62922 and IEC 62341-6-1 are applied to measure the optical and electro-optical parameters.

a) Visual inspection (see 5.3): Visual inspection shall be performed according to IEC 62715-5-3.
b) IVL (intensity of electric current, voltage, luminance) characteristics (see 5.4).
c) Luminous flux (see 5.5): Optical performance measurement shall refer to IEC 62715-5-1.
d) Mechanical status (5.6).
e) Image quality: Image quality measurement shall refer to IEC 62341-6-2 and IEC 62341-6-3.

Depending on the purpose of the test, only one, some, or all of the methods shall be used. The measuring frequency and evaluation criteria shall be specified in the detailed specifications.

NOTE Measurements of luminous intensity distribution and maintenance of luminous flux are important parameters for OLED elements, however these measurements, in particular for maintenance of luminous flux, can cause degradation of OLED elements which will disturb evaluation of the mechanical stress testing of OLED elements. Since these measurements would be applicable for an evaluation as a final product, but not practically suitable for an evaluation as an element for this case, they are eliminated for evaluating the OLED elements both before and after the mechanical stress testing.

5.2 Sample preparation of OLED element(s) for optical and electrical measurements

Before and after the combined stress test, the specimens are evaluated by putting them on a flat surface with appropriate support. In addition, the specimens used for the measurement shall be of appropriate geometry for mechanical stress testing. If some are small or have a narrow edge that will make clamping impossible for mechanical testing, they should be fixed on a bendable support substrate with a suitable adhesive strip or glue. Both adhesive strip and glue should not influence the measurement.

For precise optical measurements, it is very important to define the alignment of the measurement specimen because flexible printed OLED element(s) can be easily deformed by an external force. Measurements of the optical and electrical characteristics of flexible element(s) shall be made with the light emitting area aligned in a flat state. If flexible element(s) are aligned in a curved state, it will be difficult to make precise optical measurements. The measurement element(s) shall be supported or fixed to be flat.

The flatness and size of the sample(s) shall be separately agreed in writing between supplier and customer.

NOTE In some cases, the testing sample might be short or have a very narrow clamping edge for the mechanical stress testing.

5.3 Visual inspection

As stated in 5.1 a), visual inspection shall be performed according to IEC 62715-5-3.

5.4 IVL characteristics

Measurements of IVL characteristics shall be performed using the electrical testing method as shown in Annex A. Measurements are considered to have failed when the sample is electrically leaky due to a short circuit. A short circuit of the element(s) can be caused by the extraordinarily large current flowing between the anode and cathode on the element(s).

5.5 Luminous flux

Measurement of the luminous flux, namely the light intensity of the light source, is performed according to Annex B.

5.6 Mechanical status

Measure the shape of the OLED element based upon the requirements.

6 Combined mechanical and environmental stress test

6.1 Mechanical stress test (deformation)

There are several mechanical stress test methods described in IEC 62715-6-1. Depending on the requirement(s), one or more proper mechanical stress test(s) is chosen, and the test equipment is prepared accordingly. The mechanical stress test apparatus shall work properly in an environmental chamber. Environmental stress is described in 6.5.

NOTE In order to avoid redundancy of description, this document only describes the cyclic bending test as an example of mechanical stress.

6.2 Cyclic bending test

6.2.1 General

This procedure is for conditioning the sample under mechanical stress by repeated bending.

6.2.2 Purpose

The purpose of this test is to provide a standard procedure for evaluating the robustness of a flexible display against a cyclic bending stress which might typically happen in application. The bending properties might cover several typical parameters of the characteristics of the quality of the OLED elements.

6.2.3 Test apparatus

The cyclic bending test equipment includes the clamp to hold a bending test sample, the moving part, the control system which regulates the number of cyclic bendings, the moving distance, and the moving speed while testing. The specimen shall be securely clamped with a gripping part during the test. An example of cyclic bending test equipment is shown in Figure 1.

To evaluate cyclic bending without putting another force, such as tension, U-shaped cyclic bending equipment can be preferable.

6.2.4 Testing conditions

Testing conditions are specified as follows:

– bending radius

  r (bending radius): 50 mm, 40 mm, 20 mm, 10 mm

– bending velocity, procedure for one cycle

  t (time for one bend and interval): 0,5 s, 1 s, 2 s, 3 s, 5 s, 10 s

– load

– number of repeating cycles

– criteria for acceptance

– number of samples

– the bending inner surface is the top surface (face-up) or the back side surface (face-down)

– bending direction: either X (bending along the longer edge) or Y (bending along the shorter edge) of the specimen

NOTE 1 The numerical values of the test conditions are examples.

NOTE 2 The criteria for acceptance include the visual performance and sample geometry both before and after the stressing.

All conditions shall be reported if the test uses conditions other than those mentioned above.

6.2.5 Test procedure

The cyclic bending test shall be performed using repeated motion to move regularly between two points or two states (folded state and unfolded state) as follows:

a) Prepare the required number of specimens according to 5.2.

b) Perform the initial performance test for the prepared specimens and record the result.

c) Clamp one edge of the specimen and support the other edge properly.

d) Bend the specimen properly with defined conditions such as the rotation angle of the clamp roll and the bending angular velocity.

e) Bring the specimen back to the initial state before the bending.

f) If required, bend the specimen in another direction with defined conditions such as the rotation angle of the clamp roll and the bending angular velocity.

g) Bring the specimen back to the initial state before bending with the same angular velocity and reverse direction.

h) Repeat d) to g) for a defined number of cycles.

i) After the test, remove the specimen from the apparatus.

j) Repeat the tests with (an)other specimen(s) following c) to i).

k) Evaluate the specimen(s), such as the visual characteristics, and record the results. Compare the result of the initial evaluation and the final evaluation.

l) Record the test procedure and results.

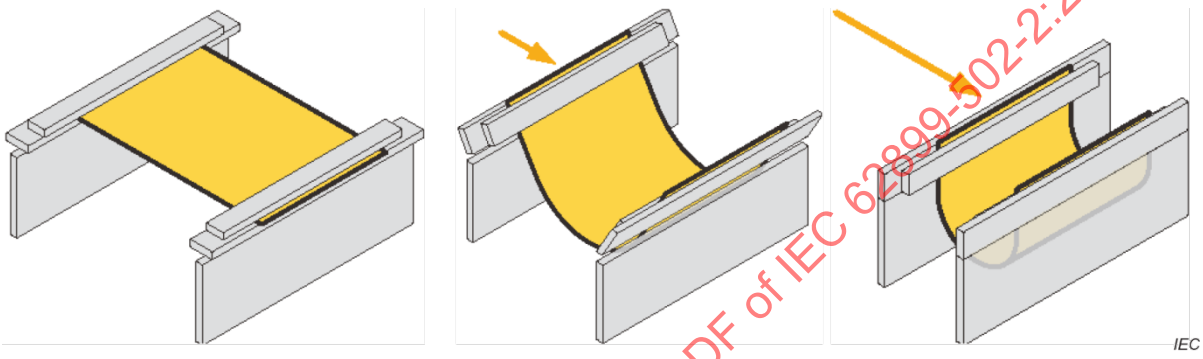


Figure 1 – Apparatus for cyclic bending test

6.3 Static bending test

6.3.1 General

This test is especially applicable for evaluating the bending properties of a flexible OLED element by measuring its performance after it remains bent for a certain period of time. Each specimen is bent at a fixed bending radius for any length of time.

6.3.2 Purpose

The purpose of this test is to provide a standard procedure for evaluating the bending properties of a flexible OLED element under constant stress for a certain period of time. Each specimen is bent at a fixed bending radius for a controlled length of time.

6.3.3 Test apparatus

The body of the OLED element shall firmly adhere to the surface of the test equipment during the test, where the test equipment should have a round shape with a certain radius as in Figure 2. The specimen shall be bent at a fixed bending radius for a period of time.

During the test, the flexible printed circuit (FPC) and the driver should be carefully handled so that they are not subjected to bending damage. The chip on film (COF) method is preferable in order to avoid the occurrence of bending damage on the driver's IC (integrated circuit) that drives the specimen during the bending test.

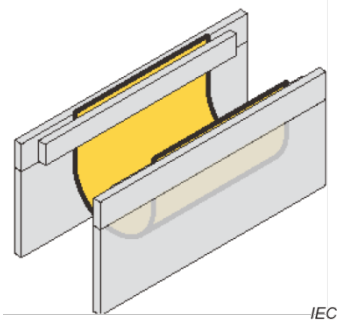


Figure 2 – Apparatus for static bending test

6.3.4 Testing conditions

Testing conditions are specified as follows:

– bending radius

  r (bending radius): 50 mm, 40 mm, 20 mm, 10 mm

– bending angle

– holding duration

– load

– criteria for acceptance

– number of samples

– the bending inner surface is the top surface (face-up) or the back side surface (face-down)

– bending direction: either X (bending along the longer edge) or Y (bending along the shorter edge) of the specimen

NOTE 1 The numerical values of the test conditions are examples.

NOTE 2 The criteria for acceptance include the visual performance and sample geometry both before and after the stressing.

All conditions shall be reported if the test uses conditions other than those mentioned above.

6.3.5 Test procedure

The static bending test shall be carried out with a fixed bending radius for a certain period of time, as follows:

a) Prepare the required number of specimens according to 5.2.

b) Perform the initial performance test for the prepared specimens and record the result.

c) Clamp one edge of the specimen and support the other edge properly.

d) Bend the specimen properly with defined conditions such as the rotation angle of the clamp roll and the bending angular velocity.

e) Keep the bent specimen for certain period of time.

f) Bring the specimen back to the initial state before the bending.

g) Repeat d) to f) for a defined number of tests.

h) After the bending, remove the specimen from the apparatus.

i) Repeat the tests with (an)other specimen(s) following c) to g).

j) Evaluate the specimen(s), such as the visual characteristics, and record the results. Compare the result of the initial evaluation and the final one.

k) Record the test conditions and evaluation results.

6.4 Dynamic and static rolling test

6.4.1 General

This test is especially applicable for evaluating the rolling properties of a flexible OLED segment after it is rolled out, rolled in, or remains in the shape of a roll.

6.4.2 Purpose

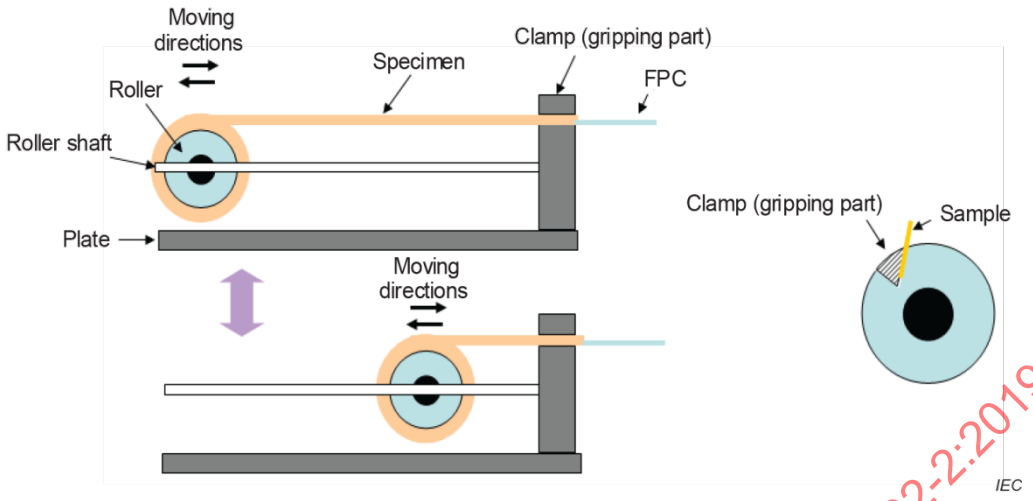
The purpose of this test is to provide a standard procedure for evaluating the robustness of the rolling properties of the flexible OLED element.

6.4.3 Test apparatus

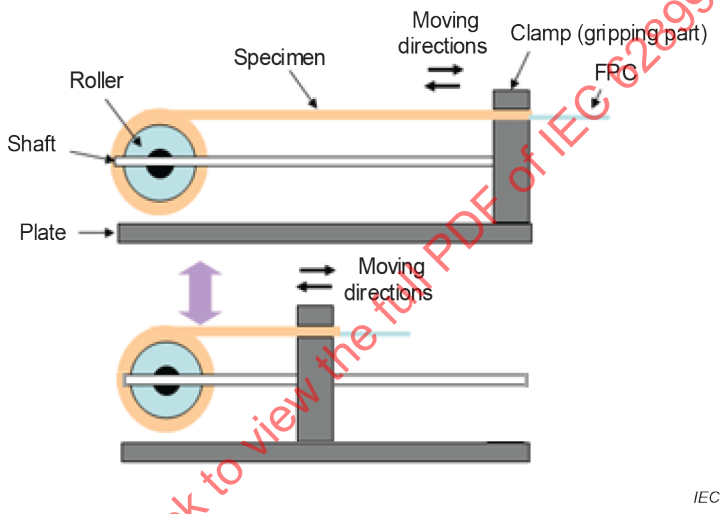
The specimen shall be firmly clamped with a gripping part on the roller side and on the stationary side. The roller shall be reciprocated (move back and forth) at a fixed distance, speed, and rolling number as in Figure 3. The roller side has the slot where the edge of the specimen is inserted and clamped. The roller repeatedly shuttles along the roller shaft and the specimen does not touch the plate of the equipment during the rolling test as shown as in Figure 3.

During the test, the flexible printed circuit (FPC) and the driver should be carefully handled so that they are not subjected to twist damage. The chip on film (COF) method is preferable in order to avoid the occurrence of twist damage on the driver's IC during the rolling test.

An appropriate tension control system and road cell are required.



Type A



Type B

Figure 3 – Example of apparatus for rolling test

6.4.4 Testing conditions

Testing conditions are specified as follows:

– roll radius
– angular velocity, procedure for one cycle
– holding duration
– load
– number of repeating cycles
– criteria for acceptance
– number of samples
– the rolling inner surface is the top surface or the back side surface
– rolling direction: either X (rolling along the longer edge) or Y (rolling along the shorter edge) of the specimen

NOTE The criteria for acceptance include the visual performance and sample geometry both before and after the stressing.

All conditions shall be reported if the test uses conditions other than those mentioned above.

6.4.5 Test procedure

The rolling test shall be carried out as follows:

a) Prepare the required number of specimens according to 5.2.

b) Perform the initial performance test for the prepared specimens and record the result.

c) Each sample size is measured and recorded.

d) One edge of the specimen is fixed on the roll as shown in Figure 3 and the other edge clamp is supported with an individually defined load. Align the specimen as the top surface on the inner or the outer side of the roller.

e) Roll up the specimen with defined conditions such as the rolling radius, rolling distance, rolling angular velocity and load.

f) If requited, keep the rolled up shape for a certain period.

g) Bring the specimen back to the initial state before rolling with the same angular velocity and reversed rotation direction.

h) If required, keep the rolled out shape for a certain period.

i) Repeat e) to h) for a defined number of cycles. It is optional to test with the other surface side at the same conditions by agreement between supplier and customer. In this case, follow d) to i) with the reversed surface side.

j) After the test, remove the specimen from the apparatus.

k) Repeat the test with (an)other specimen(s) following c) to j).

l) Record the electrical performance and optical characteristics after the mechanical stress. Compare the initial evaluation and the evaluation after mechanical stress, then determine the degree of change.

m) The test and performance measurement for individual samples are conducted and recorded in the test report.

6.5 Environmental testing methods

6.5.1 General

For combined mechanical and environmental tests, the mechanical stress test shall be done at certain temperature and humidity levels. Before the combined test, the specimen is evaluated as described in 5.2. After the initial evaluation, the specimen is put onto the mechanical stress apparatus in the environmental chamber.

Before the final measurements, the recovery procedure referred to in 6.5.2.4 should be completed.

6.5.2 Environmental test at certain temperatures

6.5.2.1 Purpose

The purpose of this test is to check the mechanical performance of the flexible OLED elements at certain temperatures. The test procedure of IEC 60068-2-2 shall be applied.

6.5.2.2 Test conditions

Test Bd or Be of IEC 60068-2-2 shall be applied with the following specific conditions.

The relevant specification shall define the test (Bd or Be) to be used.

Depending on the application, the combination of temperature and operating time should be considered.

Test Bd: Dry heat for heat-dissipating specimens with gradual change of temperature that are not powered during the conditioning period.

Test Be: Dry heat for heat-dissipating specimens with gradual change of temperature that are required to be powered throughout the test.

6.5.2.3 Operating conditions

Examples of operating conditions are specified in Table 2. The conditions shall be noted in the report.

Table 2 – Examples of the test conditions

Condition	Temperature	Humidity	Note
H-L	55 °C	30 % RH	Hot and dry
H-H	60 °C	90 % RH	Hot and humid
L-H	10 °C	80 % RH	Cold and humid
L-L	20 °C	10 % RH	Cold and dry

6.5.2.4 Recovery conditions

The recovery conditions specified in IEC 60068-1:2013, 4.4, shall be applied.

The OLED element shall be subjected to the recovery procedure in the chamber or otherwise as appropriate.

The specimen shall then remain under standard atmospheric conditions for recovery for a period adequate for the attainment of temperature stability, for a minimum of 1 h.

If required by the relevant specification, the panel or module shall be switched on or loaded and measured continuously during the recovery period.

If the standard conditions given above are not appropriate for the device to be tested, the relevant specification may call for other recovery conditions.

6.5.2.5 Test procedure

The combined mechanical and environmental test shall be carried out with a fixed bending radius for a certain period of time, as follows:

a) Prepare the required number of specimens according to 5.2.
b) Perform the initial performance test for the prepared specimens and record the result.
c) One edge of the specimen is fixed by the clamp and the other edge is supported properly.
d) Set the environmental chamber at the designated environmental condition by following the setup instructions of that chamber.
e) Perform the mechanical deformation test with the defined conditions for bending velocity.
f) Bring the specimen back to the initial state before applying mechanical deformation.
g) Repeat e) to f) for a defined number of tests.
h) Bring the environmental chamber back to the normal condition by following the procedure for bringing that chamber back to normal condition.
i) Remove the specimen from the apparatus.
j) Repeat the tests with (an)other specimen(s) following c) to i).

k) Evaluate the specimen(s), such as the mechanical characteristics, and record the results. Compare the initial result and the tested result.

l) Report the test conditions and the evaluation results.

7 Reports and results

After processing the required tests, report the following items:

a) OLED elements vendor

b) number of specimens

c) environmental testing conditions
   - start conditions
   - tested environmental condition(s)
   - recovery duration after environmental conditions

d) mechanical deformation tests
   - radius: r
   - velocity, procedure of one cycle: 0,5 s, 1 s, 2 s, 3 s, 5 s, 10 s
   - load
   - number of repeating cycles
   - criteria for acceptance
   - number of samples
   - surface: inner surface is top surface (face-up) or backside surface (face-down)
   - direction: either X (along the longer edge) or Y (along the shorter edge)

e) OLED element conditions, both before and after evaluation
   - visual inspection
   - IVL characteristics
   - luminous flux
   - mechanical status (5.6)
   - image quality

f) other items, if agreed between the customer and a supplier

Annex A
(normative)

IVL measurement methods

A.1 General

Annex A defines the measurement methods for IVL characteristics. The measurement apparatus and measurement method given in IEC 62341-6-1 and IEC 62922 apply.

A.2 Measurement method

A.2.1 General

Measurements of IVL characteristics are made according to A.2.2 to A.2.5.

A.2.2 Measurement apparatus

The apparatus for IVL measurement shall possess the following functions (an example of the apparatus is shown in Figure A.1):

a) A supporting plate for OLED elements aligned on a flat surface as defined in 5.2, which is fixed perpendicularly to the detector of the luminance measurement.

b) Variable distance between the OLED surface and the detector of the luminance measurement.

c) Current power source to detect the current on the OLED elements.

d) Luminance measurement equipment to detect the luminance of the OLED elements.

e) OLED elements and luminance measurement equipment installed in a dark state defined in IEC 62341-6-1.

A.2.3 Measurement procedure

IVL measurements of the OLED elements are conducted using the following procedure:

a) The sample is conditioned according to 5.2 for individually defined samples.

b) The conditioned sample is aligned in the IVL measurement apparatus defined in A.2.2.

c) The measurements conditions and the results of the individually specified applied voltage, current and luminance of each measurement point in the light emitting area on the supplied flexible OLED element(s) are recorded.

A.2.4 Acceptance

Acceptance of IVL characteristics shall be determined between the supplier and customer.

A.2.5 Items for the relevant specification

In addition, the following items will be defined:

a) Number of samples being tested.

b) Maximum applied voltage and voltage step width for measurement of the current/voltage relationship.

c) Measurement points in the light emitting area on the supplied flexible OLED element(s).

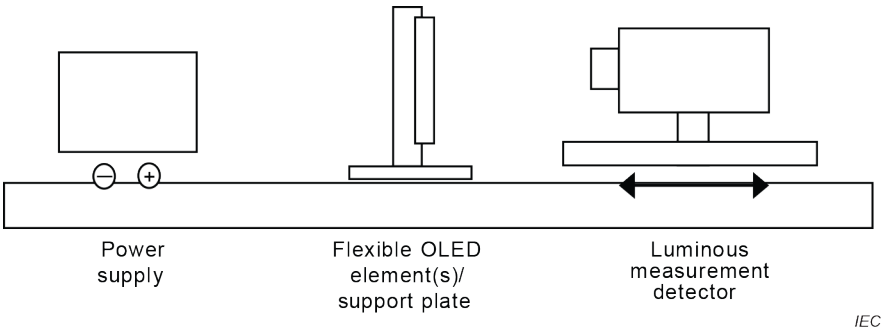


Figure A.1 – Layout of luminous measurement system