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INTERNATIONAL STANDARD

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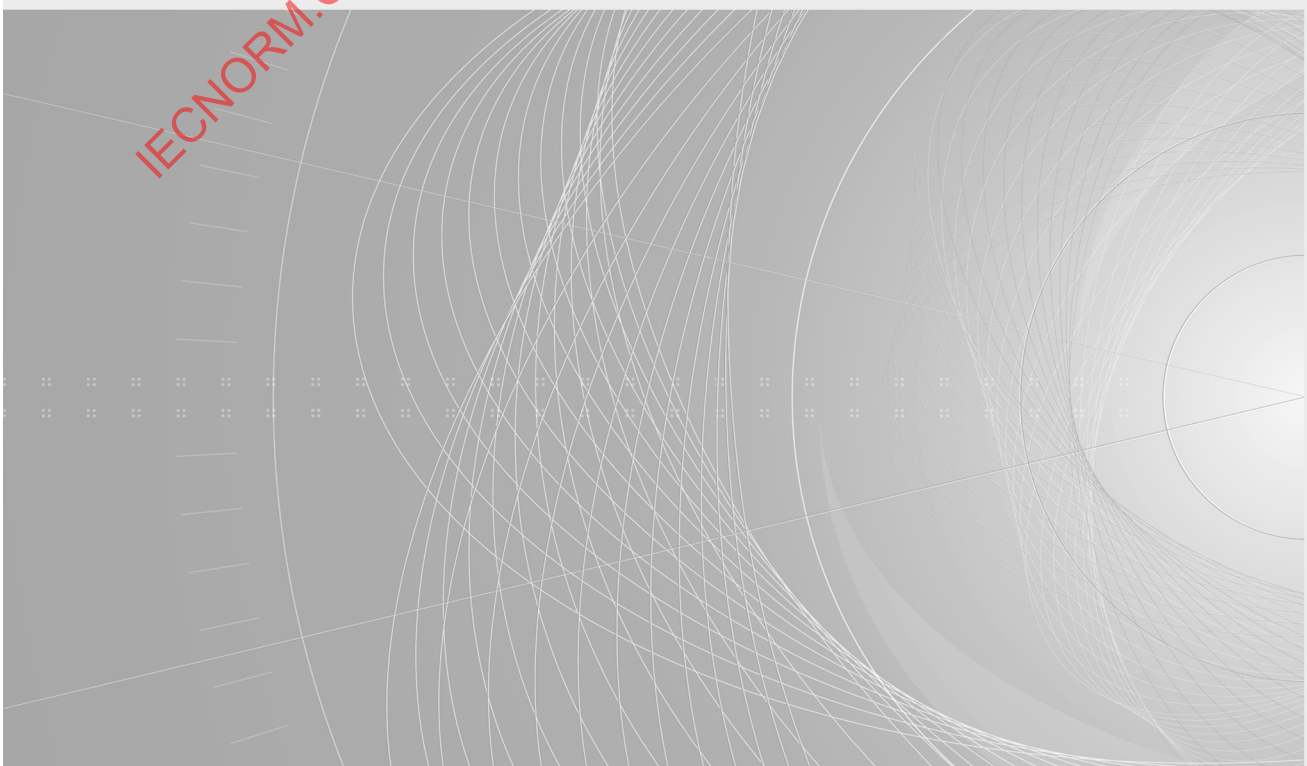
Printed electronics –
Part 502-1: Quality assessment – Organic light emitting diode (OLED) elements – Mechanical stress testing of OLED elements formed on flexible substrates



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

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

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PRINTED ELECTRONICS –

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

FOREWORD

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International Standard IEC 62899-502-1 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
119/138/FDIS	119/148/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- withdrawn,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

In contrast to existing lighting tiles formed on heavy and rigid substrates, printed flexible organic light emitting diodes (OLED) are expected to be thin and light-weight, and to be used as flexible lighting elements for emerging applications such as newly designed lighting for, architecture, automobile, aircraft and so on.

It is highly beneficial to standardize quality assessment methods of printed flexible OLED elements for both manufacturers and users at an early stage of the growing market for the devices. In addition, the standardization helps to settle the contents for the technological development. The standardization of testing conditions for mechanical stress is very much expected to evaluate the printed flexible OLED elements and to accelerate the expansion of the printed electronics (PE) market opportunities for flexible device applications.

This document defines testing conditions for mechanical stress, in the form of curving, rolling, and/or folding on printed flexible OLED elements. The mechanical stresses for the test are applied as specific forms under defined conditions, which depend on the specific applications including rigidly fixed lighting for the printed flexible OLED elements. This document also defines coexisting environmental conditions such as temperature, humidity and air pressure. This document includes evaluation methods of optical and electrical properties for the performance change induced by the stress test on the printed flexible OLED elements.

PRINTED ELECTRONICS –

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

1 Scope

This part of IEC 62899 specifies the quality assessment methods, especially the mechanical stress test methods, for reliability assessment.

This document is applicable to flexible OLED elements formed on flexible substrates by printed electronics technology *excluding those OLED products, which are intended to be used for lighting purposes.*

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 62715-6-1, *Flexible display devices – Part 6-1: Mechanical stress test methods*

IEC 62341-5:2009, *Organic light emitting diode (OLED) displays – Part 5: Environmental testing methods*

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

IEC 62595-2-1:2016, *Display lighting unit – Part 2-1: Electro-optical measurement methods of LED backlight unit*

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 62922 and IEC 62715-6-1, 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 General terms

3.1.1
OLED element
light emitting element formed with at least one light emitting organic semiconductor film layered with an anode electrode and a cathode electrode and classified into two categories, lighting and display

Note 1 to entry: For display usage, printed OLED elements are applicable for back-lighting, etc.

3.1.2
printed OLED element
light emitting element formed with at least one printed layer in OLED structure, where the printed layer is selected from an anode electrode, hole injection layer, hole transport layer, light emitting layer, electron transport layer, electron injection layer, charge generation layer, cathode electrode, passivation layer, smoothing layer, etc.

3.1.3
flexible substrate
substrate with flexibility on which a flexible light emitting element is attached such as plastic film, thin glass, metal foil, paper, or cloth

3.1.4
flexibility
mechanically bendable property upon stress, which is restored to its original state after removal of the stress and which is deformed from its initial state

3.1.5
flexible OLED element
mechanically bendable element in at least one step among substrate handling, manufacturing storage, use, operation, shipping and relocation

3.2 Terms related to optical and electrical properties

3.2.1
IVL characteristics
correlation between electric power, product of current (I) and voltage (V), applied to the OLED element with a defined electrical condition and light flux (L) emitted from the OLED element

3.2.2
luminous flux
total flux from the light source

Note 1 to entry: This is expressed as lumen (lm).

3.2.3
maintenance of luminous flux
changes in the luminous flux of the OLED element for driving and/or storage to the initial luminous flux

3.2.4
luminance uniformity
qualifying value of the distribution of luminance on OLED element(s) luminance uniformity or non-uniformity of the OLED element is evaluated as defined in IEC 62595-2-1:2016

3.3 Terms related to mechanical stress test

3.3.1
bending test
deformation caused by external stress in the perpendicular direction on the flat plane of the OLED element

3.3.2
rolling test
deformation caused by external stress which forms a rolled shape from a flat shape, on at least one area of the front-side surface facing the back-side surface of the OLED element

3.3.3
torsion test
deformation which twists the OLED element plane, pulling each edge in different directions

3.3.4
tension test
pulling force applied to at least one direction of the OLED element along the plane

4 Standard atmospheric condition for measurements and tests

Standard atmospheric conditions defined in IEC 62341-5:2009, 5.3, shall apply.

5 Evaluation methods of optical and electrical properties

5.1 General

Both before and after mechanical stress testing in Clause 6, the following measurements on the electrical and optical 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 measurement defined in 5.3 and 5.4. IEC 62922 and IEC 62341-6-1 apply for measuring the optical and electro-optical parameters.

a) IVL characteristics (5.3)

b) luminous flux (5.4)

Measurements of maintenance of luminous flux are important parameters for OLED elements however these measurements may cause degradation of OLED elements which will disturb the evaluation of mechanical stress on OLED elements. Since these measurements would be made as final products, these measurements shall be eliminated for evaluating the OLED elements both before and after mechanical stress testing.

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

For the measurements both before and after mechanical stressing, the OLED(s) sample being test shall be aligned on an appropriate support that should be a flat surface. In addition, OLEDs element(s) for the measurement shall be appropriate form for mechanical stress testing. If some of the OLED element(s) are small or have a narrow edge where clamping for mechanical testing will not be possible, the OLED element(s) should be fixed on a bendable support substrate with a suited adhesive strip or glue. Both adhesive strip and glue should not influence the measurement. Flatness and size of the sample shall be determined between supplier and customer.

NOTE In some cases, the testing sample is small to clamp for the mechanical stress testing. Then it is possible to fix on a support substrate for the testing.

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

external force. Measurements of optical and electrical characteristics of flexible element(s) shall be made with a light emitting area aligned in a flat state. If flexible element(s) are aligned in a curved state, it is difficult to make precise optical measurements. The measurement element(s) should be supported or fixed so that they are flat.

5.3 IVL characteristics

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

5.4 Luminous flux

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

5.5 Luminance uniformity

Luminance uniformity or non-uniformity of the OLED element is evaluated as defined in IEC 62595-2-1:2016.

6 Mechanical stress test methods

6.1 General

Several kinds of mechanical stress testing modes such as bending, rolling, applying tension, defined in 6.2 to 6.5, are applied. The testing mode shall be determined by the applied condition of manufacturing, storage, and application, since flexible OLED elements have a variety of shape in comparison with non-flexible OLED elements.

6.2 Bending test

6.2.1 General

The bending test shall be performed according to 6.2.2 to 6.2.5.

The bending test is applied to evaluate the durability of the element(s) during transport, storage, and application.

6.2.2 Testing apparatus

The testing apparatus for the bending test shall possess the following functions (an example of the apparatus is shown in Figure 1):

a) have a clamp to fix one edge of OLED element(s),

b) changeable bending radius depending on the bending condition,

c) selective bending direction (forward or backward), and selective bending angle,

d) controllable bending velocity.

6.2.3 Testing procedure

The bending test shall be performed according to the following steps.

a) The OLED element(s) with the required number of tests are prepared according to 5.2.

b) Initial performance, electrical and optical characteristics of OLED elements with the required number of tests are measured and the results are recorded.

c) One edge of the testing OLED elements is fixed on the clamp as shown in Figure 1 and the other edge is supported with an individually defined load.

d) Bending of the OLED elements with a rotating clamp in the counter-clockwise direction is performed with defined conditions such as rotation angle of clamp roll and bending angular velocity.

e) Bended OLED elements are returned to the initial state before the bending with the same angular velocity and reversed direction.

f) If required, bending of the OLED elements with a rotation clamp in the clockwise direction is performed with defined conditions such as rotation angle of clamp roll and bending angular velocity.

g) Bended OLED elements are returned to the initial state before bending with the same angular velocity and reversed direction.

h) The bending unit of procedures d) and g) is defined as one cycle.

i) The cycle bending test with a defined number of cycles is performed.

j) After the bending test, the testing elements are removed from the apparatus and stored in the ambient conditions defined in Clause 4.

k) Bending tests for the defined number of samples are performed according to c) to j).

l) Stressed performance, electrical and optical characteristics, of mechanically stressed OLED elements with the required number of the testing are measured and the results are recorded. In comparison to the initial and stressed performance, the degree of change due to the bending is determined.

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

6.2.4 Evaluation

Testing conditions and acceptable levels of electrical and optical performance shall be determined between supplier and customer.

6.2.5 Testing conditions

Testing conditions are specified as follows:

a) roll radius

b) rotating angle and angular velocity, procedure of one cycle

c) load

d) number of repeating cycles

e) criteria for acceptance

f) number of samples

g) bending inner surface is light emitting surface or backside surface.

NOTE Criteria for acceptance include electrical and optical performance and sample geometry both before and after the stressing.

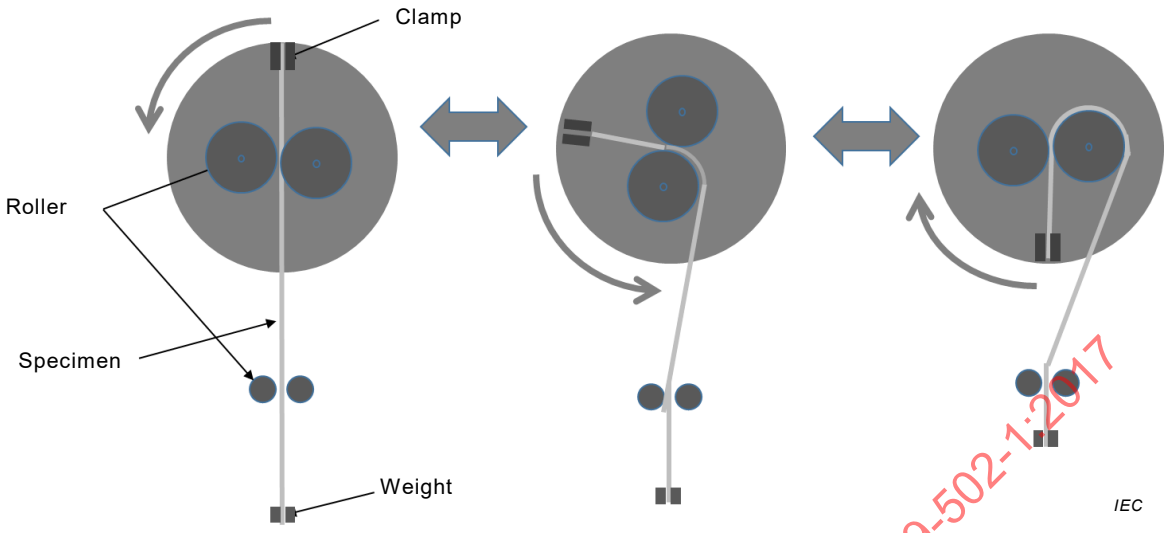

Figure 1 – Apparatus for bending test

6.3 Rolling test

6.3.1 General

The rolling test shall be performed according to 6.3.2 to 6.3.5.

The rolling test is applied to evaluate the durability of the elements which happen during transport, storage, and application.

6.3.2 Testing apparatus

The testing apparatus for the rolling test shall possess the following functions (an example of the apparatus is shown in Figure 2).

a) One edge of the OLED elements can be supported with a clamp and the other edge is fixed on the roller surface.

b) The clamp is connected to the wire attached with a load to stretch the OLED elements.

c) The roller with a defined diameter can be changed.

d) The clamp can slide smoothly in both directions (forward and backward) tothe roller.

e) The roller can rotate clockwise and counter clockwise with controllable rolling angular velocity.

6.3.3 Testing procedure

The bending test shall be performed according to the following steps.

a) The OLED elements with the required number of tests are prepared according to 5.2.

b) Initial performance, electrical and optical characteristics, of each OLED element with the required number of testings are measured and the results are recorded. Each sample size is measured and recorded.

c) One edge of the testing OLED elements is fixed on the roll as shown in Figure 2 and the other edge clamp is supported with an individually defined load. Alignment of the testing OLED elements is made with the light emitting surface on the inside or outside of the roller.

d) Rolling of the OLED elements is performed with defined conditions such as rolling diameter, rolling distance, rolling angular velocity and load.

e) The rolled OLED elements are returned to the initial state before the rolling, with the same angular velocity and reversed rotation direction.

f) The rolling unit of procedures d) and e) is defined as one cycle.

g) The cycle rolling test with a defined number of cycles is performed.

h) After the rolling test, the testing elements are removed from the apparatus and stored in the ambient conditions defined in Clause 4.

i) It is optional to test the rolling of the other surface side of the tested condition in c) under agreement between supplier and customer. In this case, alignment of the testing elements is made by clamping the reverse surface side to the testing apparatus and performing procedures d) to h).

j) Stressed performance, electrical and optical characteristics, of mechanically stressed OLED elements with the required number of tests are measured and the results are recorded. In comparison with the initial and stressed performance, the degree of change due to the bending are determined.

k) Roll testing and performance measurement for individual samples are conducted and recorded in the test report.

6.3.4 Evaluation

Testing conditions and acceptable levels of electrical and optical performance shall be determined between supplier and customer.

6.3.5 Testing conditions

Testing conditions are specified as follows:

a) roll radius

b) rotating angle and angular velocity, procedure of one cycle

c) load

d) number of repeating cycles

e) criteria for acceptance

f) number of samples

g) rolling inner surface is light emitting surface or backside surface

NOTE Criteria for acceptance include electrical and optical performance and sample geometry both before and after the stressing.

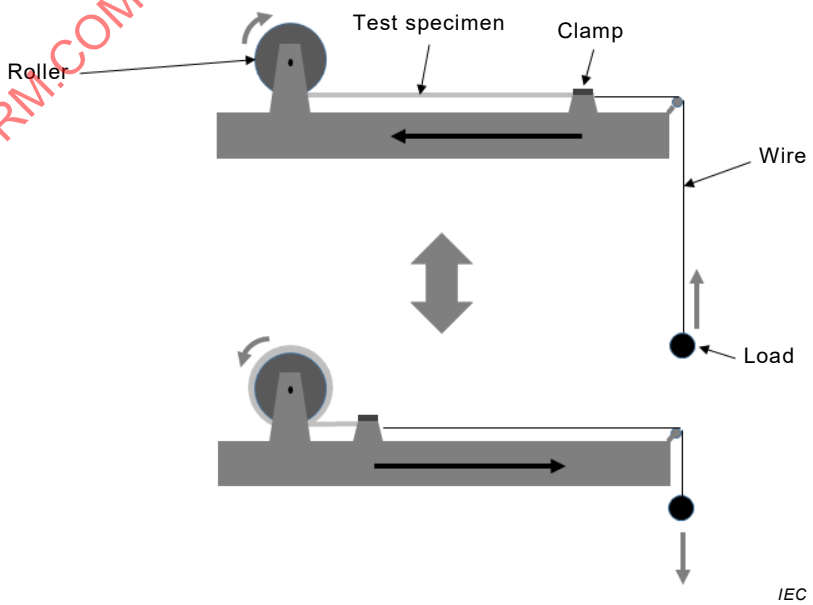

Figure 2 – Apparatus for rolling test

6.4 Torsion test

6.4.1 General

The torsion test shall be performed according to 6.4.2 to 6.4.5.

The torsion test is applied to evaluate the durability of the elements which happen during transport, storage, and application.

6.4.2 Testing apparatus

The testing apparatus for the torsion test shall possess the following functions (an example of the apparatus is shown in Figure 3 and Figure 4).

a) Four edges of the OLED elements can be supported by gripping four clamps, where two clamps are fixed on the oscillation side and the other two clamps are fixed on the stationary side, respectively.

b) The distance between the stationary part and the oscillation part can be adjustable for the OLED elements.

c) Movement for oscillation within the torsion angle range.

d) The stationary side clamp can slide to change the distance between the stationary clamp and griping clamp to reduce the tension of the OLED element(s) on the torsion axis.

e) The oscillation (rotation) angle velocity is controllable.

6.4.3 Testing procedure

The torsion test shall be performed according to the following steps.

a) The OLED element(s) with the required number of tests are prepared according to 5.2.

b) Initial performance, electrical and optical characteristics, of each OLED element with the required number of tests are measured and the results are recorded. Each sample size is measured, visually inspected and recorded.

c) Four edges of the testing OLED elements are fixed on the gripping parts as shown in Figure 3.

d) Torsion of the OLED elements is conducted with defined conditions such as clockwise angle and oscillation velocity.

e) Twisted OLED elements are returned to the initial state before the torsion, with the same rotation velocity and reversed direction.

f) Torsion of the OLED elements is conducted with defined conditions, such as counterclockwise angle and oscillation velocity.

g) Twisted OLED elements are returned to the initial state before the torsion, with the same rotation velocity and reversed direction.

h) The repeating procedures d) to g) are defined as one cycle.

i) The cycle torsion test with a defined number of cycles is performed.

j) After the torsion test, the testing elements are removed from the apparatus and stored in the ambient conditions defined in Clause 4.

k) Stressed performance, electrical and optical characteristics, of mechanically stressed OLED elements with the required number of the testing are measured and the results are recorded. In comparison with the initial and stressed performance, the degree of change due to the torsion is determined.

l) Torsion testing and performance measurement for individual samples are conducted and recorded in the test report.

6.4.4 Evaluation

Testing conditions and acceptable levels of electrical and optical performance shall be determined between supplier and customer.

6.4.5 Testing conditions

Testing conditions are specified as follows:

a) number of samples
b) performance range for initial and stressed electrical and optical performance
c) torsion angle and rotation angular velocity
d) number of cycles
e) criteria for acceptance

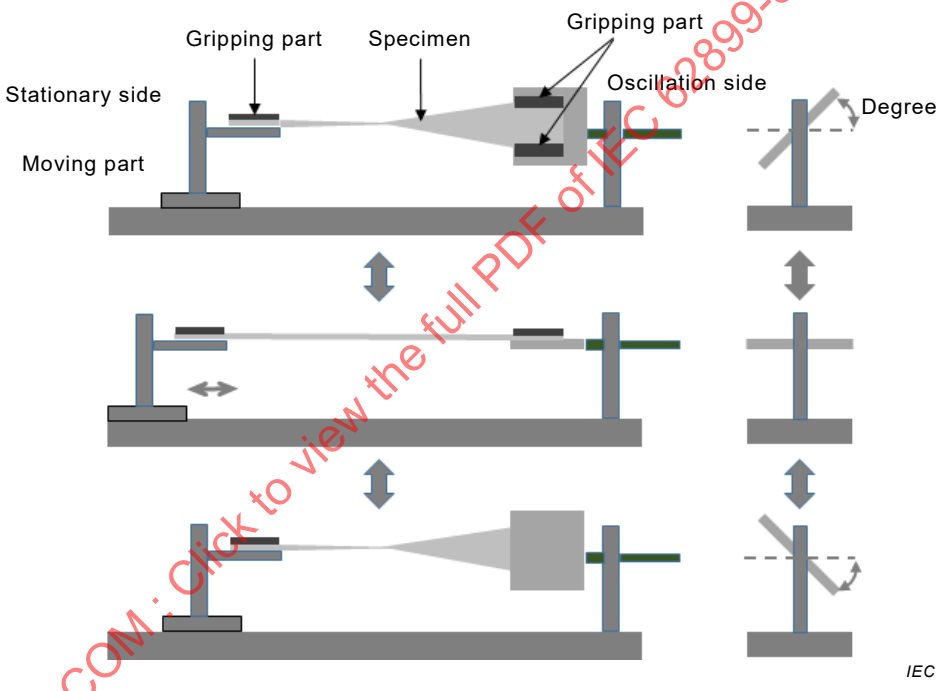

Figure 3 – Apparatus for torsion test

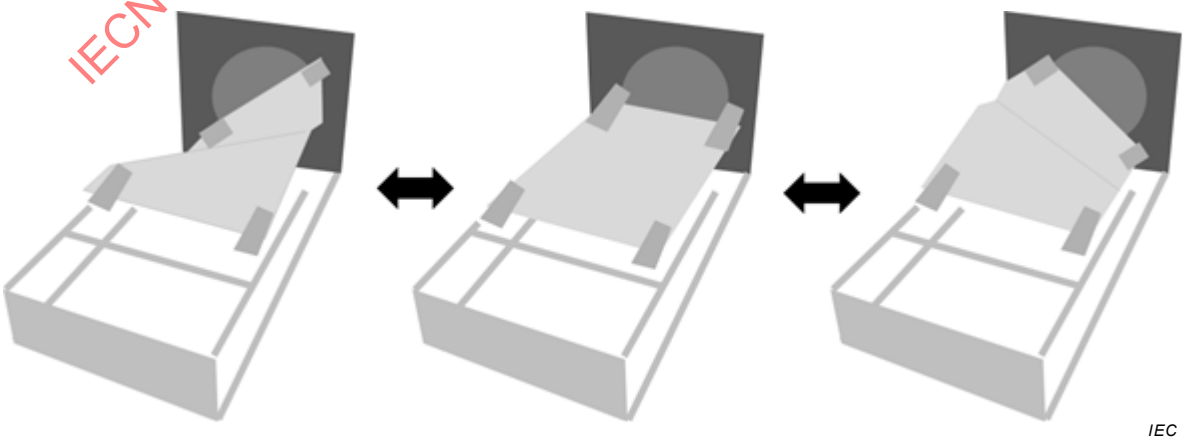

Figure 4 – Example of sample alignment for torsion testing

6.5 Tension test

6.5.1 General

The tension test shall be performed according to 6.5.2 to 6.5.5.

The tension test is applied to evaluate the durability of the elements which happen during transport, storage, and application.

6.5.2 Testing apparatus

The testing apparatus for the tension test shall possess the following functions (an example of the apparatus is shown in Figure 5).

a) Both edges of the OLED elements can be supported with clamps of the gripping part.

b) Tension force is applied between two edges.

c) The changeable force between two edges or distance between two edges are defined in the testing conditions.

d) The tension force to the specimen can be periodically changed.

6.5.3 Testing procedure

The tension test shall be performed according to the following steps.

a) The OLED elements with the required number of tests are prepared according to 5.2.

b) Initial performance, electrical and optical characteristics, of each OLED element with the required number of tests are measured and the results are recorded.

c) Both edges of the testing OLED elements are fixed on the gripping part as shown in Figure 4.

d) The tension of the OLED elements is applied with defined conditions such as tension force or strained distance.

e) The OLED elements are returned to the initial state.

f) The tension unit of procedures d) and e) is defined as one cycle.

g) The cycle tension test with a defined number of cycles is performed.

h) After the tension test, the testing elements are removed from the apparatus and stored in the ambient conditions defined in Clause 4.

i) Stressed performance, electrical and optical characteristics, of mechanically stressed OLED elements with the required number of the testing are measured and the results are recorded. In comparison with the initial and stressed performance, the degree of change due to the torsion is determined.

j) Tension testing conditions and performance for individual samples are conducted and recorded in the test report.

6.5.4 Evaluation

Testing conditions and acceptable levels of electrical and optical performance shall be determined between supplier and customer.

6.5.5 Testing conditions

Testing conditions are specified as follows:

a) maximum tension force or maximum deformation distance applied to the sample

b) tension application procedure such as time dependent tension force, duration time between tension application

c) number of cycles

d) criteria for acceptance

e) number of samples

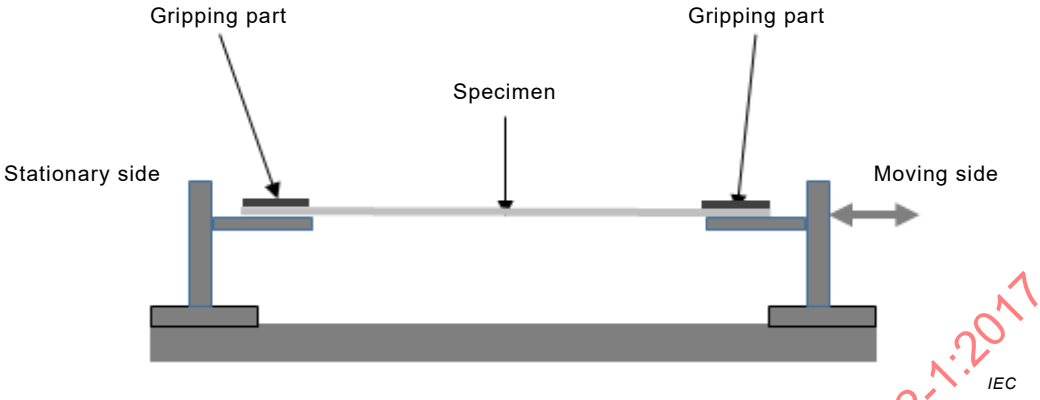

Figure 5 – Apparatus for tension test

7 Failure criteria

A flexible OLED element is regarded to be in failure state if

a) electrical and optical performance is outside the acceptance criteria determined between supplier and customer;

b) its laminated film or foil is obviously and unintentionally perforated or delaminated;

c) one or both of its electrical contacts are damaged, broken, or missing, so that a proper electrical contacting is not possible; or

d) there is an electrical short between the contacts or between the contacting package parts and its contacts, or between the anode electrode and cathode electrode inside the element.

Annex A
(normative)

Measurement methods of IVL characteristics

A.1 General

Annex A defines measurement methods of 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

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

a) Supporting plate for OLED elements to align to be flat defined in 5.2, which surface is fixed perpendicularly to the detector of luminance measurement.

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

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

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

e) OLED elements and luminance measurement equipment are installed in the dark state defined in IEC 62342-6-1.

A.2.3 Measurement procedure

IVL measurements of OLED elements are conducted according to 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 results of individually specified applied voltage, current and luminance of each measurement point in the light emitting area on the supplied flexible OLED elements are recorded.

A.2.4 Acceptance

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

A.2.5 Items for relevant specification

In addition, the following items will be defined:

a) testing number of samples

b) maximum applied voltage and voltage step width for measurement of current/voltage relationship

c) measurement points in the light emitting area on the supplied flexible OLED elements