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Flexible display devices – Part 6-1: Mechanical test methods – Deformation tests

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FOREWORD

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International Standard IEC 62715-6-1 has been prepared by IEC technical committee 110: Electronic display devices.

This second edition cancels and replaces the first edition published in 2014. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) changed the part title to differentiate it from other parts;
b) added new bending testing methods;
c) added detailed testing procedures.

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

FDIS	Report on voting
110/951/FDIS	110/974/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 the parts in the IEC 62715 series, under the general title *Flexible display devices*, 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- withdrawn,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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FLEXIBLE DISPLAY DEVICES –

Part 6-1: Mechanical test methods – Deformation tests

1 Scope

The object of this part of IEC 62715 is to define the standard test methods to evaluate the mechanical stability of flexible display modules, specifically mechanical stability against deformation, such as bending, rolling, twisting, and stretching. Display modules include displays such as LCD, e-paper, and OLED. This document takes into account, wherever possible, the mechanical test methods outlined under mechanical stress.

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

3 Terms and definitions

No terms and definitions are listed in this document.

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

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

4 Standard atmospheric conditions

The standard atmospheric conditions in IEC 62341-5:2009, 5.3, shall apply as follows, unless otherwise specifically agreed between customer and supplier.

– Temperature: 25 °C ± 3 °C
– Relative humidity: 25 % RH to 85 % RH
– Atmospheric pressure: 86 kPa to 106 kPa

When all the different kinds of tests are carried out, the temperature and humidity condition shall be reported because the temperature and humidity are critical for the bending and rolling stability regarding image quality on the panel.

NOTE Preferably, the specimen and apparatus are kept in a controlled environment for at least 24 h prior to and after assembly, before the start of the mechanical deformation test.

5 Specimen preparation

5.1 General

The specimen shall be the display module since the final evaluation has to be made based on panel image quality such as luminance, chromaticity, uniformity, line defect, and point defect. The bending stress may cause the deterioration of image quality on a panel, [1] to [9][1].

5.2 Sample preparation

For the measurements both before and after the mechanical deformation test, the display module being tested shall be aligned on an appropriate support which has to be a flat surface. In addition, the module for the measurement shall be of the appropriate geometry for mechanical stress testing. Specify that the test apparatus should be designed to prevent added strain by stretching test specimens upon folding.

The preferred method of attachment between the display module and the test apparatus is adhesive transfer tape. The display should be bonded on both sides, and the distance between the centre of the test specimen and the point of attachment should be specified. If use scenarios require it, a clamping attachment may be used instead, in which the display is clamped on one side and allowed to slide on the other. The clamping force should be sufficient to ensure that the test specimen is firmly anchored to the test apparatus throughout the entire duration of the test cycle.

If some modules are difficult to clamp due to narrow edge width, the module should be fixed on a bendable support substrate with a suitable adhesive strip or glue. Neither the adhesive strip nor the glue should affect the measurement.

NOTE In some cases, the testing specimen can have a short length or has a very narrow edge to clamp for mechanical stress testing.

Specify that in the event of cross-instrument variability in the form of location (centre or edge)-response bias, one should investigate bend axis misalignment, bowing or uneven mounting plates.

For precise optical measurements, it is very important to define the alignment of the measurement specimen because the flexible display module can be easily deformed by external force. Measurements of the visual characteristics of a flexible module shall be made in an aligned flat state. If flexible modules are aligned in a curved state, it is difficult to make a precise visual evaluation. The measurement module shall be supported or fixed so that it is flat.

The flatness and size of the specimen shall be determined between the supplier and customer.

6 Mechanical stress test methods

6.1 General

Flexible displays have a diversity of shapes in comparison with any other non-flexible electronic displays. Therefore, a wide variety of mechanical stress test methods are available, such as a cyclic bending (folding) or dynamic bending test, a static bending test, a rolling test, a combined mechanical test and more. The selection of the appropriate test methods shall be based on the requirement of the application. For each mechanical stress test, the relevant test method specification shall be stated along with the explanation of the purpose of each unique test. The allowable critical bending radius of a panel depends on the application of the flexible display. Therefore, the required critical bending radius will be changed based on the applications.

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1 Numbers in square brackets refer to the Bibliography.

There are several factors to consider when designing a reliable and repeatable mechanical folding or deformation test method, as follows:

– Motion profiles controlled by a single hinge (or pivot axis) and which wrap around a mandrel can stretch samples, and if not precisely actuated or controlled can create a great deal of variability in the test response.

– Motion profiles controlled by more than one hinge or pivot axis can prevent added stretching on test specimens, and offer better control of the test response.

– Clamping samples can prevent shear between layers of multi-layer test specimens containing adhesive, and greatly impact test response.

– Additional considerations, such as attaching too close to the apex of the bend, and fold axis misalignment or slight distortions in the shape of the mounting plates, can also impact reliability and repeatability of the test response.

– Samples should be pre-conditioned in a controlled environment for at least 24 h prior to testing as material properties for adhesives and polymers can be affected by temperature and water uptake.

6.2 Cyclic bending test

6.2.1 General

This procedure is for conditioning the specimen 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 a display panel's image quality. The typical parameters of a display panel's image quality might cover the luminance, chromaticity, uniformity, line defect, point defect, pixel shrink, and/or presence or absence of cracks.

6.2.3 Test apparatus

The cyclic bending test equipment includes the clamp to hold a bending test specimen, the moving part to shuttle, and 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. Several kinds of cyclic bending test equipment is available and shown in Figure 1, [4][7][10]. It is not necessary that a certain type of bending test equipment be preferred but the constant bending radius (r), equal to the radius of the rod, should be kept during the bending test.

NOTE If the bending radius of the test specimen is kept constant during the bending test, the bending rod can be removed as it would scratch the surface of the test specimen during the cyclic bending test.

For the cyclic bending test, the following apparatus is considered:

– the specimen experiences a bending stress when the specimen is shuttled back and forth (Figure 1a)) or while the specimen is folded and unfolded (Figure 1b)),

– when the specimen is repeatedly multi-bent in the inward or outward direction, a cyclic multi-inward bending equipment (Figure 1c)) or cyclic multi-outward bending equipment (Figure 1d)) can be used,

– when the specimen is repeatedly multi-bent in a Z-shape, a cyclic multi-bending equipment can be used,

– when the specimen is repeatedly bent in both the inward and outward direction, a cyclic inward and outward bending equipment can be used (Figure 1e) and/or f)).

6.2.4 Test procedure

The cyclic bending test shall be performed using a 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, visual characteristics, test for the prepared specimens and record the result.

c) One edge of the specimen is fixed by the clamp, or fixed with an adhesive, and the other edge is supported properly as stated in 5.2.

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 the bending with the same angular velocity and reversed direction.

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

i) After the test, the specimen is removed from the apparatus.

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

k) The stressed performance, visual characteristics of the mechanically stressed specimen(s) with the required number of testings are measured and the results are recorded. The initial and stressed performances are compared, and the degree of change due to the bend is determined.

l) The test and performance measurement for individual specimens are conducted and recorded in the test report.

6.2.5 Testing conditions and reporting

The testing conditions are specified as follows:

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

a) bending radius

r (bending radius): 20 mm, 10 mm, 5 mm, 3 mm, 2 mm, 1 mm, 0,5 mm, 0,2 mm

b) bending angle and angular 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

c) load

d) number of repeating cycles

e) criteria for acceptance

f) number of specimens

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

h) way of holding specimens and detailed method of holding, such as pressure

i) surface condition (such as treatment) of both specimen and apparatus

j) testing of environmental conditions, such as temperature and humidity.

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

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