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Flexible display devices –
Part 6-3: Mechanical test methods – Impact and hardness tests

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

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

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FOREWORD

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

FDIS	Report on voting
110/1225/FDIS	110/1247/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 62715 series, published 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- withdrawn,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.

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FLEXIBLE DISPLAY DEVICES –

Part 6-3: Mechanical test methods – Impact and hardness tests

1 Scope

The object of this part of IEC 62715 is to define the standard test methods to evaluate the mechanical robustness of flexible display modules, especially mechanical robustness regarding impact and hardness, which include displays such as liquid crystal displays (LCDs), e-paper, and organic light emitting diode (OLED) displays, against external forces applied to a panel.

2 Normative references

The following documents are referred to in the text in a way that some or all of their content constitutes requirements for 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 displays – Part 5: Environmental testing methods*

ISO 19252, *Plastics: Determination of scratch properties*

ASTM D7207-13, *Standard Test Method for Evaluation of Scratch Resistance of Polymeric Coatings and Plastics Using an Instrumented Scratch Machine*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions.

For the purposes of this document, the following terms and definitions 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

3.1.1
pendulum side impact test
evaluation of the mechanical robustness properties of the material against an external impact applied from the side using a pendulum

3.1.2
steel wool
special alloy steel which is processed into a thin and long fibrous form to be used as an abrasive

Note 1 to entry: The cross section surface is polyhedral with edges.

Note 2 to entry: There are several kinds of steel wool depending on the diameter of the used fibre. The steel wool type is #0000. The average line diameter of #0000 is about 0,012 mm.

3.2 Abbreviated terms

LCD liquid crystal display

OLED organic light emitting diode

TFT thin film transistor

4 Standard atmospheric conditions

The standard atmospheric conditions defined in IEC 62341-5:2009, 5.3, shall apply as follows:

– temperature: 25 °C ± 3 °C

– relative humidity: 25 % RH to 85 % RH

– atmospheric pressure: 86 kPa.to 106 kPa

unless otherwise specifically agreed between customer and supplier.

When different tests are carried out, the temperature condition shall be specified because the temperature is critical for the robustness properties as they relate to TFT characteristics and panel image quality characteristics. These robustness tests shall be done at the standard atmospheric conditions.

5 Sample preparation

5.1 General

The specimen shall be the display module since the final evaluation has to be made based on the quality of the panel image such as luminescence, colour chromaticity, uniformity, line defect, and point defect. The mechanical robustness test can cause the deterioration of image quality on a panel [1] to [9] [1].

5.2 Sample preparation

The display module being tested shall be flat during the impact and hardness tests to get the correct test results. The module should be fixed on a plate using additional instruments or materials (for example, adhesive or holder). Both adhesive and holder should not affect the measurement. The flatness and size of the sample shall be determined between the supplier and customer. The temperature, humidity, and storage time (for example, 24 h) prior to testing for sample preparation shall be controlled and reported to obtain reproducible test results.

6 Mechanical test methods – Impact and hardness tests

6.1 General

The selection of the appropriate test methods shall be based on the requirements of the application. For each mechanical robustness test, the relevant test method specification shall be stated along with the explanation of the purpose of each unique test.

6.2 Ball drop test

6.2.1 General

This test is especially applicable for the evaluation of the mechanical robustness properties of flexible display devices by measuring their performance change after ball drop.

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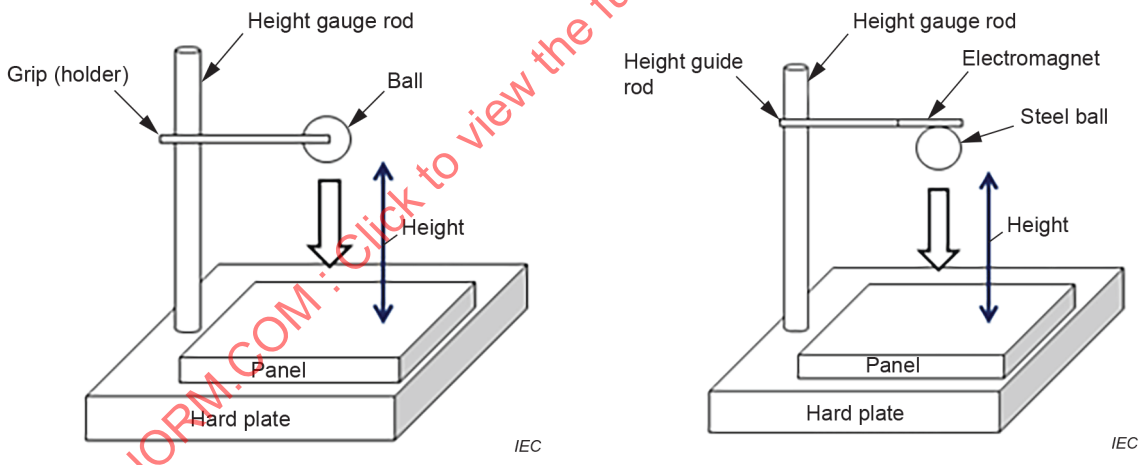
1 Numbers in square brackets refer to the Bibliography.

6.2.2 Purpose

The purpose of this test is to evaluate the mechanical robustness properties of the specimen against a point shock which shall happen in actual use of the flexible display product. The ball drop test might cover several typical characteristic parameters of the display panel image quality. The typical parameters of the display panel image quality might include luminescence, colour chromaticity, uniformity, line defect, and point defect.

6.2.3 Test apparatus

The ball drop test equipment includes a metal (or rubber or plastic) ball and a hard plate as shown in Figure 1. The body of the specimen shall be put on the hard plate. The test conditions of the ball drop test, such as the height of the ball from the panel (for example, 5 cm to 10 cm) which can be different from the panel size (for example, size of mobile or size of tablet or bigger size), the type (quality) of the ball (for example, metal, rubber, or plastic), the diameter of the ball, the weight of the ball (for example, 10 g to 50 g), the hitting position of the panel during the ball drop test, and the number of ball drop tests, shall be mentioned because the characteristics of the display panel image quality might depend on the test conditions mentioned above. In order to obtain consistent ball drop height during the test, special equipment to drop the ball at a reproducible height is available such as a mechanical grip and a magnetic plate. Different designs and materials of the hard plate beneath the specimen have significant impact on the test result. The design and materials of the hard plate shall be precisely mentioned or defined. An electromagnetically assisted ball drop test can be available as shown in Figure 1 where the steel ball can be attached by an electromagnet. After the first hit, the ball shall not successively collide against the panel in order to prevent additional damage caused by the second hit of the ball which can cause inconsistent result.



a) Mechanical ball drop test

b) Electromagnetic assisted ball drop test

Figure 1 – Apparatus for ball drop test equipment

6.2.4 Test procedure

The ball drop test shall be performed by dropping a metal (or rubber or plastic) ball at a constant height and hitting the panel perpendicularly. In order to correctly evaluate the mechanical robustness of the panel, several positions of the panel (for example, a total of nine points per panel, three points for each of the left, centre, and right area) shall be selected equally to represent the overall robustness of the panel; if necessary, an identical ball drop test might be carried out on several panels to obtain more accurate overall performance. After the first hit, the ball shall not successively collide against the panel in order to prevent additional damage coming from the second hit of the ball which can cause inconsistent results. The evaluation of the panel image may be carried out in a period of time after the ball drop test (time interval), which shall be mentioned.

6.3 Hitting test (tapping test)

6.3.1 General

This test is especially applicable for evaluating the mechanical robustness properties of flexible display devices. Since this test simulates "touching" or "pushing" by a finger, it is often called "tapping test"

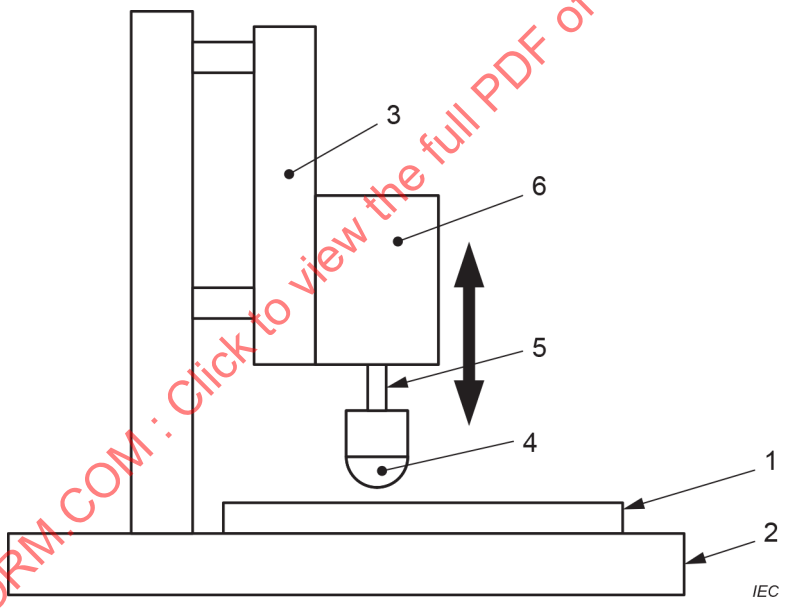
6.3.2 Purpose

The purpose of this test is to evaluate the mechanical robustness properties of the specimen against a repetitive external loading representing repetitive touching or pushing by finger(s) or a stylus onto the panel of the flexible display, which shall happen in actual use of the flexible display product.

The hitting test would cover several typical characteristic parameters of the display panel image quality. The typical parameters of the display panel image quality might include the luminescence, colour chromaticity, uniformity, line defect, and point defect.

6.3.3 Test apparatus for hitting test

Figure 2 shows an example of an apparatus for the hitting test.



Key

1	flexible display	4	hitting tip
2	hard plate	5	hitting rod
3	reciprocation mechanism	6	force measuring device

Figure 2 – Example of apparatus for hitting test

6.3.4 Test procedure

The hitting test shall be performed as follows:

a) select a proper tip for the test, such as the material and shape of the tip;
b) select the hitting position of the specimen;
c) set the tip to the proper distance from the specimen;

d) apply reciprocating moving with the desired force. Figure 3 shows an example of movement of the tip and applied force;

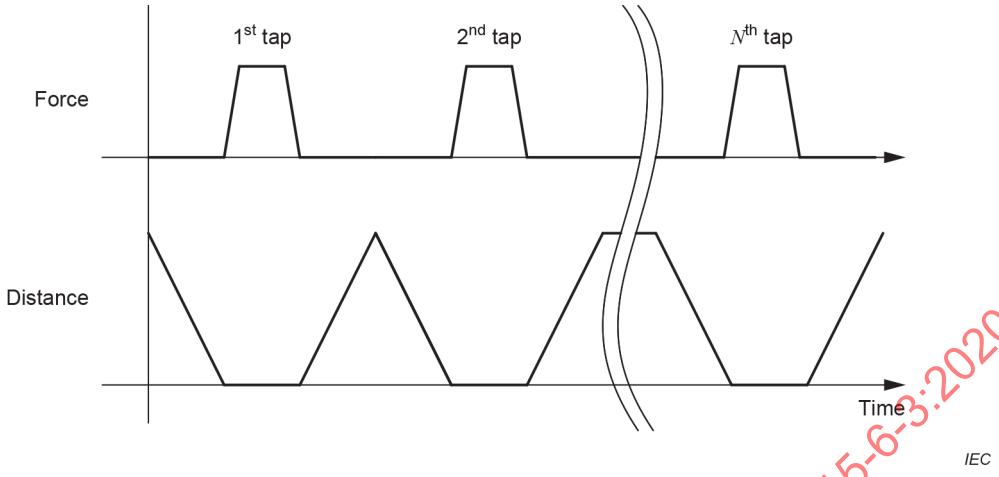


Figure 3 – Example of the tip movement and applied force

NOTE The acceleration and deceleration speed and the holding duration are dominant parameters to simulate touching or pushing by an applied force profile. Those parameters are decided in order to reproduce use case conditions.

e) hit the specimen for the required cycles;

f) inspect the specimen after hitting, to check whether there are any defects;

g) if needed, repeat d) to f);

h) if needed, change the parameters, such as a), b) and/or c).

6.3.5 Report

Report the evaluation conditions as follows;

– material of the tip
– shape of the tip
– movement and applied force, for example as described in Figure 3
– hitting position on the display device
– number of hits
– evaluation of result after hitting

NOTE 1 In order to correctly evaluate the robustness of the panel, several positions of panel are selected equally to represent the overall robustness of panel (for example, a total of nine points per panel, three points for each of the left, centre, and right area).

NOTE 2 If necessary, an identical hitting test might be carried out on several panels to obtain more accurate overall performance.

NOTE 3 The evaluation of the panel image can be carried out in a certain period of time after the hitting test.

6.4 Pendulum side impact test

6.4.1 General

This test is especially applicable for the evaluation of the mechanical robustness properties of flexible display devices by measuring their performance change after a side impact, because flexible display devices include very thin dielectric layers and metal layers, which are very flexible but relatively weak against a side impact on them.

6.4.2 Purpose

The purpose of this test is to evaluate the robustness properties of the specimen against an external side impact to represent the shock environment from the side, which shall happen in actual use of the flexible display product. The pendulum side impact test might cover several typical characteristic parameters of the display panel image quality. The typical parameters of the display panel image quality might include the luminescence, colour chromaticity, uniformity, line defect, and point defect.

6.4.3 Test apparatus

The pendulum side impact test equipment includes metal (or plastic) as the pendulum material, a ball (or cylindrical pendulum) as the pendulum shape, and a hard plate as shown in Figure 4. The pendulum arm can be made from a rigid material like metal. The specimen shall be fixed on the hard plate by a clamp. The pendulum arm material connected to the ball or hitting part shall be rigid to reproduce the consistent collision force. The test conditions of the pendulum side impact test such as the angle, type (quality) of ball (plastic or metal), weight of ball, diameter of ball, length of pendulum arm, distance from a position of the ball dropping to a position of the ball colliding the panel, the hitting position of the panel, and the number of hits, should be mentioned, because the characteristics of the display panel image quality might depend on the test conditions mentioned above. To get a better reliable result, several hitting positions should be tested. The kinetic energy of the impact shall be estimated for each test to better ensure repeatability of the method. The kinetic energy can be calculated from the mass of the ball and the length of the pendulum arm. The calculated energy is the applied energy at impact and not the energy to cause damage as the energy will be lost due to pendulum rebound. The pendulum shapes mentioned shall allow the reporting of other shapes, for example, the long end of a cylinder of wedge shape. This is because there are different shapes that can impact the panel during manufacturing like hitting alignment pins.

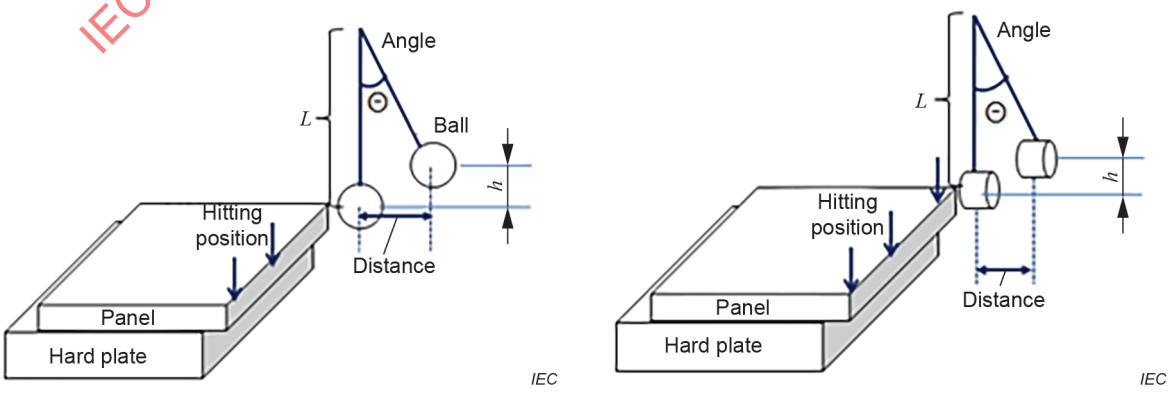
Assuming the sample edge is placed where the angle of the pendulum arm is 0, all the energy of the pendulum will be kinetic at impact. The total energy of the pendulum can be calculated using Formula (1). For the method to be repeated, the pendulum shall always deliver the same impact energy to the sample.

$$E = \frac{1}{2}mV^2 = mgh = mgL(1-\cos\theta) \rightarrow V = \sqrt{2gL(1-\cos\theta)} \quad (1)$$

where

m is the mass of pendulum,

V is the velocity of the pendulum at θ = 0.



a) Ball type pendulum **b) Cylindrical type pendulum**

Figure 4 – Apparatus for pendulum side impact test

6.4.4 Test procedure

The pendulum side impact test shall be performed by dropping a ball from the side and hitting the panel sideways. In order to correctly evaluate the robustness of the panel, several positions of the panel should be selected equally to represent the overall robustness of the panel, if necessary, several tests of the pendulum side impact test (example: n = 2 times to 5 times) might be carried out at the same position of the panel to obtain more accurate average performance. The evaluation of the panel image may be carried out in a certain period of time after the pendulum side impact test.

6.5 Scratch and abrasion test

6.5.1 General

This test is especially applicable for the evaluation of the robustness properties of a flexible display device by measuring its performance change after a scratch, because flexible display devices using mainly a thin plastic window instead of a glass window are relatively weak against scratch.

The following two test methods are described in 6.5:

a) stylus scratch test

b) steel wool abrasion test

Each of the above two tests shall be selected depending on the purpose of the test considering the above-mentioned features of each test. The damage of the surface and the change of the image quality are assessed after the tests.

6.5.2 Stylus scratch test

6.5.2.1 General

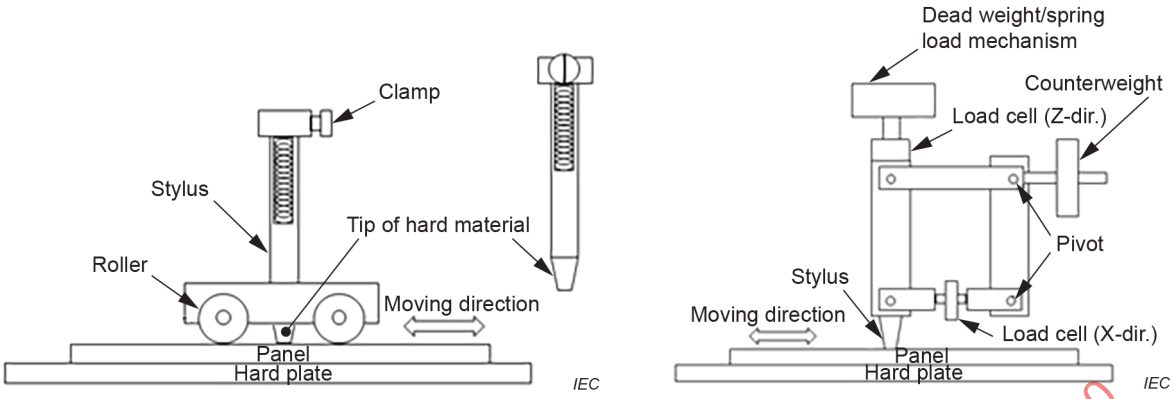
The stylus scratch test is intended to simulate a scratch by a sharp and/or hard object which can occur in actual use. However, the stylus scratch test is not sensitive to the difference of the hardness in the surface materials compared to the pencil hardness test.

6.5.2.2 Purpose

The purpose of this test is to evaluate the robustness properties of the specimen against a scratch which shall happen in actual use of the flexible display product. A stylus is pushed over the surface. The load is increased in steps until the surface is marked by visible defects. The lowest load at which any damage is observed shall be reported. The test might cover several typical characteristic parameters of the display panel image quality. The typical parameters of the display panel image quality might include the luminescence, colour chromaticity, uniformity, line defect, and point defect.

6.5.2.3 Test apparatus

The apparatus (Type A) specified in ISO 19252 shall be used (see Figure 5 a)). The test procedures shall be in accordance with those specified in ISO 19252. Another apparatus (Type B) specified in ASTM D7207-13, shall be used as well (see Figure 5b)). The stylus shall be composed of a hard material, such as diamond, sapphire, or tungsten alloy. The test results vary according to the material of the stylus; therefore, the test results with different stylus materials cannot be compared.



a) Stylus scratch test (Type A)

b) Stylus scratch test (Type B)

Figure 5 – Apparatuses for stylus scratch test using a stylus holder with different pressures available by modulating the spring load

6.5.2.4 Test procedure

The radius of the stylus shall be recorded (for example, a radius range of 0,2 mm to1 mm) and the stylus shall be moved in one direction at a constant distance for a fixed number of times. The experiment shall start from the lower load to the higher load (N) (for example, from 1 N to 10 N). The load shall be increased until any damage on the surface is observed. The angle of the stylus to the surface of the specimen shall be normal (90º ± 1º). The speed of the scratch shall be recorded (for example, a speed range of 5 mm/s to 10 mm/s). The stylus test apparatus shall be controlled manually or automatically and the stylus shall be cleaned before each test. Other test conditions can be used based on agreement between the provider and the customer; however, any deviation from the standard test conditions, which are described above, shall be reported. The lowest load at which any damage occurs shall be reported. Any deviation from the standard test conditions shall be reported. The material of the stylus shall be also reported.

6.5.3 Steel wool abrasion test

6.5.3.1 General

The steel wool abrasion test is commonly used to evaluate the surface damage of display panels, which occurs in actual use.

6.5.3.2 Purpose

The purpose of this test is to evaluate the robustness properties of the specimen against an abrasion which shall happen in actual use of the flexible display product. The surface of the sample shall be abraded with a steel wool with a stipulated load. The surface is abraded for a specified number of cycles and the robustness of the surface is evaluated after these abrasions. This test causes visible defects such as scratches and dents and might include several typical characteristic parameters of the display panel image quality. The typical parameters of the display panel image quality might include the luminescence, colour chromaticity, uniformity, line defect, and point defect.