IEC 63211-3-5

Edition 1.0 2020-09

INTERNATIONAL STANDARD

Durability test methods for electronic displays – Part 3-5: Mechanical tests – Surface durability

IEC 63211-3-5:2020-09(en)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ICS 31.120

ISBN 978-2-8322-8899-3

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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DURABILITY TEST METHODS FOR ELECTRONIC DISPLAYS –

Part 3-5: Mechanical tests – Surface durability

FOREWORD

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International Standard IEC 63211-3-5 has been prepared by IEC technical committee 110: Electronic displays.

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

FDIS	Report on voting
110/1222/FDIS	110/1244/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 63211 series, published under the general title *Durability test methods for electronic 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- withdrawn,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.

INTRODUCTION

This document relates to the common durability test methods applicable in the field of electronic displays, which may overlap with some of the parts of existing TC 110 documents that describe the durability test methods of the individual technologies, such as LCD, OLED, PDP and others. This document is intended to be used as the reference document in future standards and in revisions of existing. The existing standards will be revised in their maintenance time to refer to this document to the largest extent possible.

DURABILITY TEST METHODS FOR ELECTRONIC DISPLAYS –

Part 3-5: Mechanical tests – Surface durability

1 Scope

This part of IEC 63211 defines common procedures for surface durability mechanical test methods. This document generally describes the test equipment and procedures used for each method when applied on all levels, from parts (i.e. outermost surface parts of products, display panels and modules) to final products (i.e. finished displays or products).

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

IEC 62368-1, *Audio/video, information and communication technology equipment – Part 1: Safety requirements*

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

IEC 62977-2-2, *Electronic displays – Part 2-2: Measurements of optical characteristics – Ambient performance*

ISO 15184, *Paints and varnishes – Determination of film hardness by pencil test*

ISO 19252, *Plastics – Determination of scratch properties*

3 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
scratch
mark or groove created by a sharp or pointed object cutting a surface in a single one-directional lateral movement of the object

3.2
abrasion
process of wearing away or deformation of a surface by repeatedly rubbing the surface

3.3
abrader
equipment for conducting abrasion tests

3.4
steel wool
special alloy steel which is processed into a thin and long fibrous form

Note 1 to entry: The cross section of the steel wool is polyhedral with edges.

Note 2 to entry: Steel wool is generally used as an abrasive.

4 Standard measuring conditions

4.1 Standard environmental measuring conditions

Mechanical and optical measurements shall be carried out under standard environmental conditions as follows:

- temperature: 25 °C ± 3 °C
- relative humidity: 50% ± 10%
- atmospheric pressure: 86 kPa to 106 kPa

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

4.2 Safety

All appropriate safety equipment shall be worn during testing. Guards shall be used to protect operators from being injured during testing. Specimen devices shall include safeguards in accordance with IEC 62368-1.

5 Mechanical test methods

5.1 Ball drop

5.1.1 General

This test evaluates the ability of the display surface to resist the point shock stresses that occur during impact when an object is dropped on it.

5.1.2 Test apparatus

5.1.2.1 Outline

The following components are important characteristics of the test apparatus (see Figure 1).

5.1.2.2 Height adjustment column

The height adjustment column shall be long enough to allow a drop height of at least 180 cm. An attached scale, or other measurement method, shall be used to measure the drop height to compensate for specimen thickness. Drop height is the distance from the test surface to the bottom of the ball when attached to the release mechanism.

5.1.2.3 Release mechanism

The release mechanism shall be attached to a beam that is perpendicular to the height adjustment column and be able to be repositioned on it. The release mechanism shall be powered by either an electromagnet, in the case of a steel ball, or a vacuum for any ball material. The release mechanism shall be actuated remotely via an electrical or pneumatic switch. The design shall allow free gravitational acceleration of the ball upon release.

5.1.2.4 Specimen holder

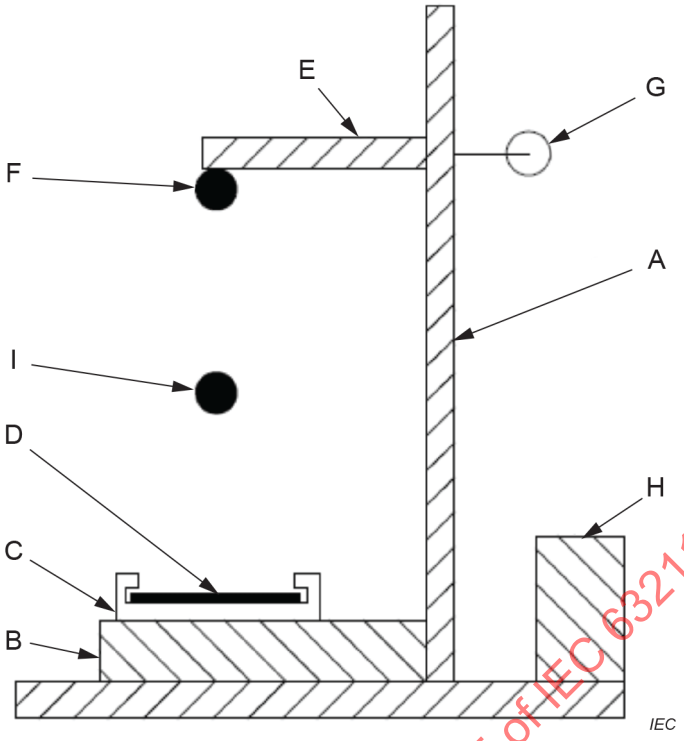
The specimen holder shall be made of a rigid material that minimizes damage to specimens when mounted in it. Flat or flexible specimens shall be allowed to rest securely in the specimen holder or can be secured using clamps. Specimens with curved backs will need custom specimen holders that stabilize them when secured to the base to prevent movement during testing. The use and purpose of other specialized specimen holders shall be stated in the results.

5.1.2.5 Base

The base shall be a dense rigid plate that is thick enough not to deform during testing and ensure minimal energy absorption. Steel or cast iron are ideal materials for the base, however, granite and other stone materials are also acceptable provided they are inspected prior to and after testing for chips or cracks and replaced if damage is found.

5.1.2.6 Ball

Ball materials shall be rigid materials that do not deform permanently or shatter on impact. A steel alloy with a hardness of C60 to C67 is the most common material. The diameter tolerance shall be no greater than ±0,05 mm from nominal, and the deviation from sphericity shall be no greater than 0,025 mm. The ball mass shall be within ±2,0 % of the specified value.



Key

A Height adjustment column
B Specimen base
C Specimen holder
D Specimen
E Ball release armature
F Ball release mechanism
G Armature height adjustment
H Ball release controller
I Ball (in freefall)

Figure 1 – Example of ball drop apparatus

5.1.3 Specimen preparation

The sample size shall be great enough to demonstrate repeatability of failure at the minimum height to induce damage as well as to determine the minimum height to induce damage via trial and error. Full display assembly specimens are also mounted on the display device. If damage is localized, multiple areas of a single specimen may be tested. Specimens with pre-existing damage shall either be excluded, or the damage shall be marked prior to testing if it will not influence further testing. All test point locations shall be included when reporting the data.

5.1.4 Test procedure

The test procedure shall be as follows:

a) Place the specimen in the specimen holder and align the impact zone with the test area of the specimen.
b) Secure the specimen holder to the base.
c) If required, clamp the specimen in place.
d) Set the ball release armature to the minimum drop height.
e) Load the ball.

f) Release the ball.

g) Catch the ball after the first bounce by hand.

NOTE 1 If the drop height is great enough that operator safety is of concern, alternative strategies for preventing a second hit can be employed such as a mechanical ball catch or strategically placed foam padding. A camera can also be used to record damage after the first impact but before additional impacts occur.

h) Inspect for damage and record the result.

i) Confirm the specimen is correctly positioned or reposition the specimen if another test is done.

j) Increase the drop height to the next increment and repeat e) to h).

NOTE 2 For heights ≤ 100mm, the tolerance for drop height will be ±1 mm. For heights greater than 100 mm the tolerance will be ±1 % of the height.

k) Continue increasing the drop height and retesting until failure has been observed. Report the failure height and note any observation from the test.

l) Clean the specimen area and repeat a).

5.1.5 Failure criteria

Manufacturers shall provide limit samples for defining failure criteria for each specimen type.

Failure is most likely to occur in the following modes:

a) Mechanical failure – fracture, delamination, denting, plastic stress-induced whitening or pixel damage.

b) Functional failure – failure of the display to update the image, most likely caused by damage to electronic components.

c) Sensitivity failure – failure of the touch screen functions.

5.2 Tapping test

5.2.1 General

This test measures the display's robustness in response to repetitive loading similar to a finger, stylus or other writing instruments touching the display in normal use.

5.2.2 Test apparatus

5.2.2.1 General

The following components are important characteristics of the test apparatus.

5.2.2.2 Specimen holder

The specimen holder shall be made of a rigid material that minimizes damage to specimens when mounted in it. Flat or flexible specimens shall be allowed to rest securely in the specimen holder or can be secured using clamps. Specimens with curved backs will need custom specimen holders that stabilize them when secured to the base to prevent movement during testing. The use and purpose of other specialized specimen holders will be stated in the results.

5.2.2.3 Base

The base plate shall be a dense rigid plate that is thick enough not to deform during testing. Steel or cast iron are ideal materials for the base, however granite and other stone materials are also acceptable provided they are inspected prior to and after testing for chips or cracks and replaced if present.

5.2.2.4 Tapping mechanism

The mechanism shall consist of a linear actuator capable of cyclically moving the tip into and out of contact with the surface. The actuator shall be capable of cycle times of 0,2 s to 5 s and able to conduct at least one million cycles per test. The tapping force produced shall be consistent to within 0,1 N of the set point. The mechanism shall be able to apply 2 N to 30 N of force during each tap.

5.2.2.5 Tapping tip

The tip shall be made from a material that will not permanently deform during testing. Tip design shall either be an analogue for a typical stylus or a human finger. Stylus analogues shall be either conical or spherical points with a radius between 0,5 mm to 1,5 mm and made from rigid materials such as rigid thermoplastics or metals. Stylus tip surface shall be smooth unless otherwise noted. Finger analogues shall be made from an elastomer with properties similar to human skin and diameters ranging from 4 mm to 12 mm. The tip shall be inspected between tests to ensure no damage or permanent changes have occurred. This can be done with a loop or with an optical microscope to measure radius and flatness. Tip dimensions and material properties shall be reported with results.

5.2.2.6 Force monitoring

A load cell and data acquisition system shall be present to ensure the tapping force is consistent and set correctly during testing. The load capacity of the load cell shall be selected such that the intended impact force shall be larger than the 10 % capacity and smaller than the 90 % capacity. The load cell shall be accurate to within 1 % of applied load.

5.2.3 Specimen preparation

Display module specimens shall be either flat or flexible enough to flatten with clamping without damage. Full display assemblies with curved cases shall be secured to prevent movement of the display during testing. Since case design is product dependent, the fixture shall be customized to accommodate the curve of the case. Full display assembly specimens are also mounted on the display device. Specimens that are still functional after localized damage has occurred can be used for multiple tests. All specimens shall be inspected prior to testing and pre-existing damage shall be marked. Specimen texture is assumed to be flat. Any manufactured texture shall be noted in the results.

5.2.4 Test procedure

The test procedure shall be as follows:

a) Set the controller for the cycle count between1 K and 100 K, the impact force between 1 N and 6 N, and the surface contact time between 0,1 s and 1 s.

b) Adjust the impact force to the set point.

c) Inspect the specimen and mark the existing damage prior to mounting. Discard the specimen if damage will inhibit testing.

d) Install the specimen and align the test area with the tip.

e) Start the test.

f) Monitor the impact force to ensure it matches the set point and is consistent with 0,1 N.

g) After the test stops, inspect the test area for failure and record the results.

h) Repeat the process for all other set points and specimens.

5.2.5 Failure criteria

Manufacturers shall provide limit samples for defining the failure criteria. Failure inspection shall consist of visual inspection and/or functionality testing. Failure is mostly likely to manifest as one or all of the following:

a) Mechanical failure – cracking, denting, or other physical damage.

b) Display malfunction – failure of the display to update images correctly.

c) Sensing malfunction – failure of touchscreen functions.

5.3 Scratch test

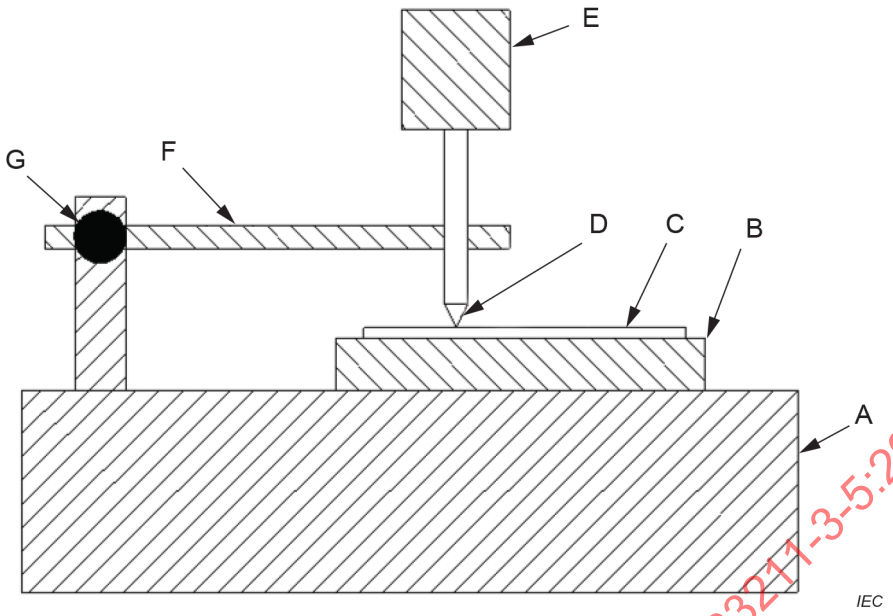
5.3.1 General

This test measures the resistance of a display surface to scratch damage. The scratch test of 5.3 consists of two scratch tests, that is, a stylus scratch test and pencil hardness scratch test. These tests are considered to be most applicable for determining display durability from sharp contact events such as the use of a sharp tip as a stylus or accidental gouging during storage. In both tests control parameters are set at minimums and then increased until damage is observed. In some cases, this is also applicable for durability in abrasive environments.

5.3.2 Stylus scratch test

5.3.2.1 Test apparatus

The apparatus consists of a stylus holder that brings the stylus into contact with the specimen surface at a fixed angle. The apparatus shall be automated or manually driven, but in either case, the stylus shall move at a constant speed of between 5 mm/s and 10 mm/s for a distance of at least 25 mm in accordance with ISO 19252. The apparatus shall have a way of adjusting normal force applied to the stylus (see Figure 2).



Key

A Base with controller and slide mechanism
B Specimen holder
C Specimen
D Stylus
E Weight for normal force
F Support arm
G Support arm pivot

Figure 2 – Example of scratch apparatus

5.3.2.2 Specimen holder

The specimen holder shall consist of a rigid plate with a way of securing the specimen in place. Specimens with curved backs will need custom specimen holders that stabilize them when secured to the base to prevent movement during testing. The use and purpose of other specialized specimen holders will be stated in the results.

5.3.2.3 Stylus

Stylus materials are typically diamond, sapphire, tungsten carbide, or other materials that will not deform permanently during testing. The stylus shape shall be a conical or spherical point and the tip radius shall be stated with the results. The stylus shall be inspected for damage (i.e. chipping, deformation, or flattening) with a loop or optical microscope to measure the radius and roundness of the tip between tests.

5.3.2.4 Specimen

Specimens shall be inspected for damage prior to the start of testing. Display module specimens shall be either flat or flexible enough to flatten with clamping without damage. Full display assemblies with curved cases shall be secured to prevent movement of the assembly during testing. Since case design is product dependent, the fixture may need to be customized to accommodate the curve of the case. Full display assembly specimens shall also be mounted on the display device. Existing damage shall be marked and any damage that alters overall specimen functionality will lead to the specimen being discarded prior to testing. Specimens that can still function with localized damage can be reused for multiple tests. Sample size shall allow for at least five tests per test setting.

5.3.2.5 Test procedure

The test procedure shall be as follows:

a) Inspect specimens for damage, marking the existing damage and discarding specimens that are non-functional.

b) Set up the scratch apparatus with the selected stylus and adjust the speed setting.

c) Secure the specimen and position the stylus in the test area.

d) Run the test.

e) Inspect the test area for damage. This can consist of either noting visually apparent damage or by measuring the depth and width of the scratch using profilometry or another depth measurement method.

f) Repeat the test in a new area after either increasing the speed, load, or stylus hardness until the criteria for unacceptable damage are met. Report the lowest set points at which damage occurred.

g) Repeat the test five times in new areas and record the results.

5.3.3 Pencil hardness scratch test

5.3.3.1 Test apparatus

The instrument and pencil hardness scale shall conform to that described in ISO 15184.

5.3.3.2 Test procedure

The procedure shall be as follows:

a) Prepare each pencil by removing 5 mm to 6 mm of the end using the special sharpener described in ISO 15184.

b) Test each sample in accordance with the procedure described in ISO 15184.

NOTE A typical length of stroke is 7 mm. A typical normal force is 4,9 N ± 0,1 N [2][1] or 7,35 N ± 0,15 N (see ISO 15184).

c) Assess the sample surface just after the mechanical test, i.e. within 10 min, and one day after the mechanical test.

5.3.4 Failure criteria

Manufacturers shall provide limit samples for defining the failure criteria. Failure inspection shall consist of visual inspection and/or functionality testing. Failure is most likely to manifest as one or all of the following:

a) Mechanical failure – scratch, stress whitening, chipping, or micro fractures. The evaluation described in 5.4.5 is applicable.

b) Display failure – failure of the display to update the image as intended, likely due to damage to electronics or failure of the barrier coatings.

c) Sensing failure – failure of touchscreen functions.

[1] Numbers in square brackets refer to the Bibliography.

5.4 Abrasion

5.4.1 General

The purpose of this test is to evaluate the robustness of the display surface against abrasion typical from actual use such as storage with abrasive objects or outdoor installations in abrasive environments. This test is especially valid for evaluating the surface if it consists of a film or is coated with organic compounds that can be susceptible to abrasion.

5.4.2 Specimen

Specimens shall be inspected for damage prior to the start of testing. Display module specimens shall be either flat or flexible enough to flatten with clamping without damage. Full display assemblies with curved cases shall be secured to prevent movement of the display during testing. Since case design is product dependent, the fixture may need to be customized to accommodate the curve of the case. Full display assembly specimens are also mounted on the display device. Existing damage shall be marked and any damage that alters overall specimen functionality will lead to the specimen being discarded prior to testing. Specimens that can still function with localized damage can be reused for multiple tests.

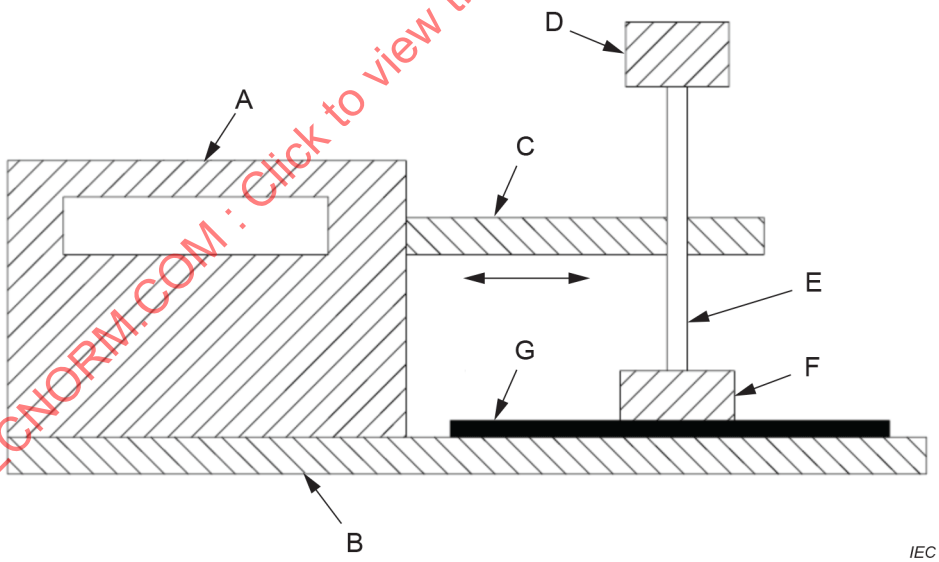
5.4.3 Test apparatus

5.4.3.1 General

The following components are important characteristics of the test apparatus.

5.4.3.2 Instrument

The instrument will be a linear abrader-style abrasion instrument (see Figure 3).



Key

A Motor controller
B Base
C Reciprocating arm
D Normal force weight
E Adjustable height rod
F abrasive pad and holder
G Specimen

Figure 3 – Example of linear abrader