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INTERNATIONAL STANDARD

colour inside

Organic light emitting diode (OLED) displays – Part 5-2: Mechanical endurance test methods

IEC 62341-5-2:2019-03(en)

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Organic light emitting diode (OLED) displays – Part 5-2: Mechanical endurance test methods

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FOREWORD

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International Standard IEC 62341-5-2 has been prepared by IEC technical committee 110: Electronic display devices.

This second edition replaces the first edition published in 2013. This edition constitutes a technical revision.

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

a) Vibration and shock tests for large displays (for example, TVs and monitors) are added.

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

FDIS	Report on voting
110/1069/FDIS	110/1083/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 62341 series, under the general title *Organic light emitting diode (OLED) 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- withdrawn,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.

A bilingual version of this publication may be issued at a later date.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

ORGANIC LIGHT EMITTING DIODE (OLED) DISPLAYS –

Part 5-2: Mechanical endurance test methods

1 Scope

This part of IEC 62341 defines test methods for evaluating the mechanical endurance quality of organic light emitting diode (OLED) display panels and modules or their packaged form for transportation. It takes into account, wherever possible, the environmental test methods outlined in IEC 60068 (all parts). The object of this document is to establish uniform preferred test methods for judging the mechanical endurance properties of OLED display devices.

There are generally two categories of mechanical endurance tests: those relating to the product usage environment and those relating to the transportation environment in packaged form. Quasistatic strength, four-point bending and peel strength tests are introduced here for usage environment, while vibration, shock and transportation drop tests are applicable to the transportation environment. Mechanical endurance tests can be categorized into mobile applications, notebook computer or monitor applications and large size TV applications. Special considerations or limitations of test methods according to the size or application of the specimen are noted.

In case of contradiction between this document and a relevant specification, the latter will govern.

NOTE This document is established separately from IEC 61747-5-3, because the technology of organic light emitting diodes is considerably different from that of liquid crystal devices in such matters as:

– used materials and structure

– operation principles

– measuring methods

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 60068-2-6, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*

IEC 60068-2-27:2008, *Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock*

IEC 61747-1-1:2014, *Liquid crystal and solid-state display devices – Part 1-1: Generic – Generic specification*

IEC 61747-5-3:2009, *Liquid crystal display devices – Part 5-3: Environmental, endurance and mechanical test methods – Glass strength and reliability*

IEC 61747-10-1:2013, *Liquid crystal display devices – Part 10-1: Environmental, endurance and mechanical test methods – Mechanical*

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 62341-6-2:2015, *Organic light emitting diode (OLED) displays – Part 6-2: Measuring methods of visual quality and ambient performance*

ISO 2206, *Packaging – Complete, filled transport packages – Identification of parts when testing*

ISO 2248:1985, *Packaging – Complete, filled transport packages – Vertical impact test by dropping*

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

NOTE Most of the definitions used comply with IEC 62341-1-2.

3.1
strength
stress at which a sample fails for a given loading condition

3.2
glass edge strength
measured stress at failure where the failure origin is known to have occurred at an edge

4 Abbreviated terms

B_{10}	the value at the lower 10 % position in the Weibull distribution [1][1]
FEA	finite element analysis
FPCB	flexible printed circuit board
TSP	touch screen panel

5 Standard atmospheric conditions

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

6 Evaluation

6.1 Visual examination and verification of dimensions

The specimen shall be submitted to the visual and dimensional checks in non-operation conditions and functional checks in operational conditions specified by the following:

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

a) visual checks of damage to the exterior body of the specimen including marking, encapsulation and terminals shall be done as specified in IEC 61747-1-1:2014, 4.3;

b) dimensions given in the relevant specification shall be verified;

c) visual and optical performance shall be checked as specified in IEC 62341-6-1.

Unless otherwise specified, visual inspection shall be performed under the conditions and methods specified in IEC 62341-6-2:2015, 6.2.

6.2 Reporting

For the main results in each test, generally the minimum and averaged values or B_{10} value instead of the minimum value shall be reported over the number of specimens depending on the test purposes. The relevant specification shall provide the criteria upon which the acceptance or rejection of the specimen is to be based.

7 Mechanical endurance test methods

7.1 General

Choice of the appropriate tests depends on the type of devices. The relevant specification shall state which tests are applicable.

7.2 Vibration (sinusoidal)

7.2.1 General

Test Fc, specified in IEC 60068-2-6 and IEC 61747-10-1:2013, 5.4, is applicable with the following specific conditions. In case of contradiction between these documents, IEC 61747-10-1:2013, 5.4, shall prevail.

7.2.2 Purpose

The purpose of this test is to investigate the behaviour of the specimen in a vibration environment such as transportation or in actual use.

7.2.3 Test apparatus

The equipment shall be capable of maintaining the test conditions specified in 7.2.4.1. The vibration testing table should not resonate within the test condition vibration frequency range. The required characteristics apply to the complete vibration system, which includes the power amplifier, vibrator, test fixture, specimen and control system when loaded for testing. The body of the device shall be securely clamped during the test. If the device has a specified method of installation, it shall be used to clamp the device. The specimen shall be tested under the non-operational condition.

7.2.4 Test procedure

7.2.4.1 General

The test specimen should be hooked up to the jig as shown in Figure 1 for a large size display.

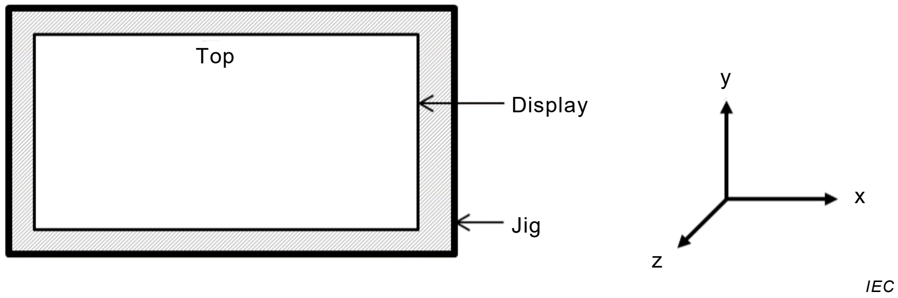
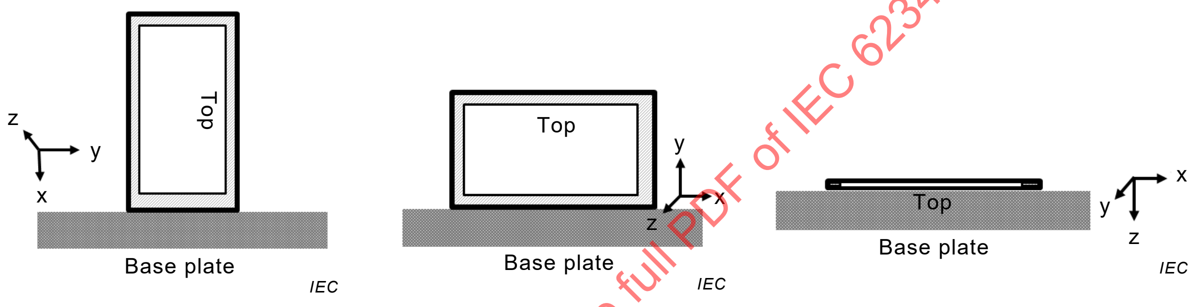


Figure 1 – Example of the specimen and jig

During this test for the large size display, the specimen should be turned off and the test based on the specific time; the specimen quality is checked. The jig is on the base plate, which should be fixed at the plate. The conditions for fixation of the specimen are depicted in Figure 2 according to the different axes.



a) **x-axis** b) **y-axis** c) **z-axis**

Figure 2 – Directions of vibration test

To start, the condition should be as in Figure 2a), and the vibration frequency and the duration time should be reported. After testing the x-axis condition, the specimen should be set as in Figure 2b). The test with the specified vibration frequency and the duration time should be operated. Finally, the test with the z-axis should be done. The test shall be performed as described in 7.2.4.2.

NOTE The large size is defined for TVs. The size would be over 40 in.

7.2.4.2 Test conditions

7.2.4.2.1 Basic motion

The basic motion shall be a sinusoidal function of time and such that the fixing points of the specimen move substantially in phase and in straight parallel lines.

7.2.4.2.2 Spurious motion

The maximum amplitude of spurious transverse motion at the check points in any perpendicular area to the specified axis shall not exceed 25 %. In the case of large size or high mass specimens, the occurrence of spurious rotational motion of the vibration table can be important. If so, the relevant specification shall specify a tolerance level.

7.2.4.2.3 Signal tolerance

Unless otherwise stated in the relevant specification, acceleration signal tolerance measurements shall be performed and signal tolerance shall not exceed 5 %.

7.2.4.2.4 Vibration amplitude tolerance

Reference point: ±15 %.

Check point: ±25 %.

7.2.4.2.5 Frequency tolerances

7.2.4.2.5.1 Endurance by sweeping

±1 Hz from 5 Hz to 50 Hz.

±2 % above 50 Hz.

7.2.4.2.5.2 Endurance at critical frequencies

±2 %.

7.2.4.3 Severities

7.2.4.3.1 General

A vibration severity is defined by the combination of three parameters: frequency range, vibration amplitude and duration of endurance (in sweep cycles or time).

7.2.4.3.2 Frequency range

The frequency range shall be given in the relevant specification by selecting a lower frequency from Table 1 and an upper frequency from Table 2.

Table 1 – Frequency range – Lower end

Lower frequency f_1 (Hz)
5
10
20

Table 2 – Frequency range – Upper end

Upper frequency f_2 (Hz)
55
100
200
300
500

The recommended ranges are shown in Table 3.

Table 3 – Recommended frequency ranges

Recommended frequency ranges, from f_1 to f_2 (Hz)
5 to 100
5 to 200
5 to 500
10 to 55
10 to 200
10 to 300
10 to 500

7.2.4.3.3 Vibration amplitude

The vibration amplitude shall be stated in the relevant specification. Recommended vibration amplitudes with cross-over frequency are shown in Table 4.

Table 4 – Recommended vibration amplitudes

Displacement amplitude below the cross-over frequency	**Acceleration amplitude above the cross-over frequency**	
M_m	m/s²	g_n
0,035	4,9	0,5
0,075	9,8	1,0
0,10	14,7	1,5
0,15	19,6	2,0
0,20	29,4	3,0

NOTE 1 The values listed apply in Table 4 for cross-over frequencies between 57 Hz and 62 Hz.

NOTE 2 Regardless of display size, the same amplitude is calculated and applied at per unit area.

7.2.4.3.4 Duration of endurance

7.2.4.3.4.1 Endurance by sweeping

The duration of the endurance test in each axis shall be given as a number of sweep cycles chosen from the list given below:

1, 5, 10, 20, 30, 45, 60, 120

The sweeping shall be continuous and the frequency shall change exponentially with time. The endurance time associated with the number of sweep cycles or sweep rate in octaves/minute shall be specified. During the vibration response investigation, the specimen and the vibration response data shall be examined in order to determine critical frequencies.

7.2.4.3.4.2 Endurance at critical frequencies

The duration of the endurance test in each axis at the critical frequencies found during the vibration response investigation shall be chosen from the list given below. This test shall be repeated for the number of critical frequencies as specified by the relevant specification.

10 min, 15 min, 30 min, 90 min

7.2.5 Evaluation

After the test, visual, dimensional and functional checks shall be performed and compared as described in 6.1.

7.3 Shock

7.3.1 General

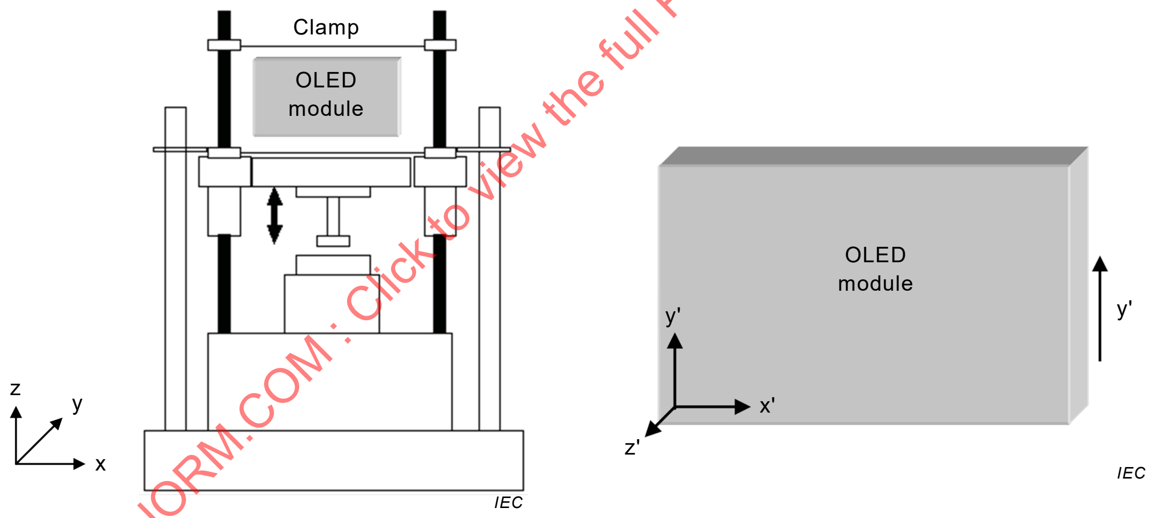
IEC 60068-2-27 and 61747-10-1:2013, 5.5, shall be applied with the following specific conditions. In case of contradiction between these document, IEC 61747-10-1:2013, 5.5, shall prevail.

7.3.2 Purpose

This test aims to provide a standard procedure for determining the ability of an OLED panel or module to withstand specified severities of shock. During transportation or in use, an OLED panel or module can be subjected to conditions involving relatively non-repetitive shocks.

7.3.3 Test apparatus

The body of the specimen shall be securely clamped during the test in the test direction and aligned with the z-axis of the test machine; for example, Figure 3 depicts the shock test along the y'-direction of the specimen. If the device has a specified method of installation, it shall be used to clamp the device.



a) Example of a shock test machine   b) test direction of a specimen

Figure 3 – Configuration of OLED shock test set-up

7.3.4 Test procedure

Test Ea, specified in IEC 60068-2-27, is applicable, with the following specific requirements. The conditions shall be selected from Table 5, taking into consideration the mass of the device and its internal construction.

Table 5 – Conditions for shock test

Peak amplitude A (m/s^2) (g_n)	Corresponding duration D of the nominal pulse (ms)	Corresponding velocity change ΔV	
		Half-sine (m/s)	Trapezoidal (m/s)
50 (5)	30	1,0	-
150 (15)	11	1,0	1,5
300 (30)	18	3,4	4,8
300 (30)	11	2,1	2,9
300 (30)	6	1,1	1,6
500 (50)	11	3,4	4,9
500 (50)	3	0,9	1,3
1 000 (100)	11	6,9	9,7
1 000 (100)	6	3,7	5,3
2 000 (200)	6	7,5	10,6
2 000 (200)	3	3,7	5,3
5 000 (500)	1	3,1	-
10 000 (1000)	1	6,2	-
NOTE Preferred values are underlined.			

The choice of waveform to be used depends on a number of factors, and difficulties inherent in making such a choice preclude a preferred order being given in the document (see IEC 60068-2-27:2008, Clause A.3). The relevant specification shall state the waveform utilized.

Unless otherwise specified by the relevant specification, three successive shocks shall be applied in each direction of three mutually perpendicular axes of the specimen, for a total of 18 shocks. Depending on the number of identical devices available and the mounting arrangements, particularly in the case of components, they can be oriented such that the multiple axis/direction requirements of the relevant specification can be met by the application of three shocks in one direction only (see IEC 60068-2-27:2008, Clause A.7).

7.3.5 Evaluation

Visual, dimensional and functional checks shall be performed and compared as described in 6.1 to the relevant specification.

7.4 Quasistatic strength

7.4.1 General

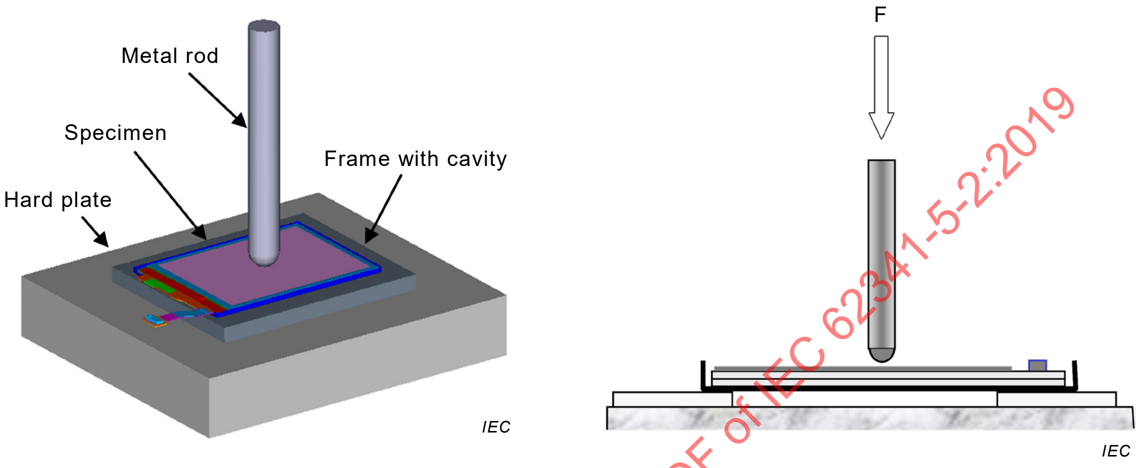
IEC 61747-5-3:2009, 5.4, is applicable with the following specific conditions.

7.4.2 Purpose

The objective of this document is to establish uniform requirements for accurate and reliable measurements of the quasistatic strength of OLED panels or modules. The quasistatic strength of an OLED module may be specified to ensure the mechanical endurance level from the quasistatic external loadings in and around the display area in normal use, such as sitting on the product or touching/pushing a finger-tip in the display area.

7.4.3 Specimen

This document applies to the OLED panels or modules for mobile and IT applications. OLED module products incorporating additional components, for example, a touch screen panel (TSP), protective film and window cover, may be used as an acceptable form of the specimen. In all cases a minimum sample size of at least six panels or modules shall be used to obtain a statistically significant strength distribution representative of quasistatic resistance of the specimen to external loadings induced by handling, processing and fabrication of the specimen specified as a part of the end product.



a) Boundary support with cavity **b) Side support**

Figure 4 – Schematic of quasistatic strength measurement apparatus example

7.4.4 Test apparatus

The quasistatic strength of a specimen is measured by supporting the specimen on the mounting frame and loading it at the centre as shown in Figure 4. The specimen shall be put on the frame with the rectangular cavity as shown in Figure 4a) or on side supports as shown in Figure 4b). The size of a rectangular cavity in the frame (Figure 4a)) shall be specified by the relevant specification and shall be as big as the edge of the supporting area allows. It is recommended to set the cavity to be around the active area size for mobile applications. The tip of the metal loading bar shall be rounded in shape and the diameter of the metal rod varies according to the specimen size under testing. It is recommended to use a metal rod of 10 mm in diameter for the samples which have a display diagonal length of up to 101,6 mm (4 in). For larger modules, such as for notebook computer or monitor applications, a rod of 19 mm diameter is recommended. The same apparatus may also be used for loading the OLED module off-center and obtaining its strength at different locations. For TV applications, this quasistatic strength test is generally not applicable.

7.4.5 Test procedure

7.4.5.1 General

The displacement rate should be slow enough so that there is no significant dynamic response from the loading such that the maximum strain rate upon the specimen shall be of the order of 1,0 × $10^{-4}s^{-1}$ [3]. The typical loading rate or crosshead speed is 3 mm/min or 5 mm/min for small size displays such that failure may occur within the measurement time of 30 s to 45 s. Depending on the purpose of the test, the following test procedure may be applied.

7.4.5.2 Static loading resistance

For this test, a specified load is set to assess module resistance to the external static load from the relevant specification. A specified load is set and applied on the surface of the specimen by lowering the metal rod as shown in Figure 4. After reaching the specified load, the rod is set to return back to the starting position. Multiple loads may be applied in steps. The loading position of the specimen shall be the center of the active area of the display, but multiple loading positions, including the off-center position, may also be applied depending on the area of interest.

7.4.5.3 Quasistatic failure load

In continuation of the specified load test in 7.4.5.2, this test is intended to measure the failure load. The metal rod is lowered to push the surface of the specimen until the specimen breaks. The specimen is categorized as a failure when the applied load from continuing to push the rod into the specimen drops below a designated proportion of the peak load value. The designated proportion is typically 2 % below the peak value.

7.4.6 Evaluation

For the static load test, the relevant specification shall provide the specified load level upon which the acceptance or rejection of the resistance of specimen is to be based. For the failure load test in 7.4.5.3, the average, maximum and minimum values along with the failure load of each test specimen are reported. It shall be noted in the test reporting whether the specimen incorporates any additional component.

7.5 Four-point bending test

7.5.1 General

This document is established separately from IEC 61747-5-3, where the characterization of the glass component is particularly emphasized. The quasistatic strength of the edges of the glass or simply the flexural strength of OLED panels and the integrity of the panel structure are assessed in the four-point bending test configuration. Even though there is no limitation when using the four-point bending test on the size of the display panels, this test is generally applicable for mobile applications, which are at most 101,6 mm in diagonal size.

7.5.2 Purpose

The four-point bending test is important since the result of this test can be used as an indicator of the mechanical endurance level when either the panel sample or module sample is exposed to various mechanical loadings under hostile usage conditions, such as twisting a handset, etc. For the purpose of this test, the glass in OLED display panels is considered brittle and as having the property that fracture normally occurs at the surface of the glass from the maximum tensile stress. The failure strength of the display module is determined when the weakest component in the specimen fails. Depending on the panel structure, the weakest link could be the inferior edge of the glass or some other failure, such as disintegration of the sealing material. The four-point bending test is recommended since it distributes the maximum tensile stress over a larger volume or area in comparison to the three-point bending test.

7.5.3 Specimen

The specimen is a display panel consisting of rear and front glasses. The test specimen may contain a polarizer; however, it is not necessary if the testing is done at production phase where the polarizers have not yet been placed. The use of a polarizer or other low elastic modulus tape is permitted on the specimen surface to hold the cracked fragments and permit observation of the origin of the crack. At least ten specimens shall be used for the purpose of estimating the mean. A minimum of twenty specimens shall be necessary if estimates regarding the form of strength distribution are to be reported. Unless otherwise taken for a specific purpose, the samples shall be taken from several sheets or regions of a single sheet from which the display panels are made. Any specimen may be rejected prior to testing for defects considered likely to affect the quasistatic strength of the edges of the glass. The variation in width or thickness shall not exceed 5 % over the length of the specimen equal to the support span.

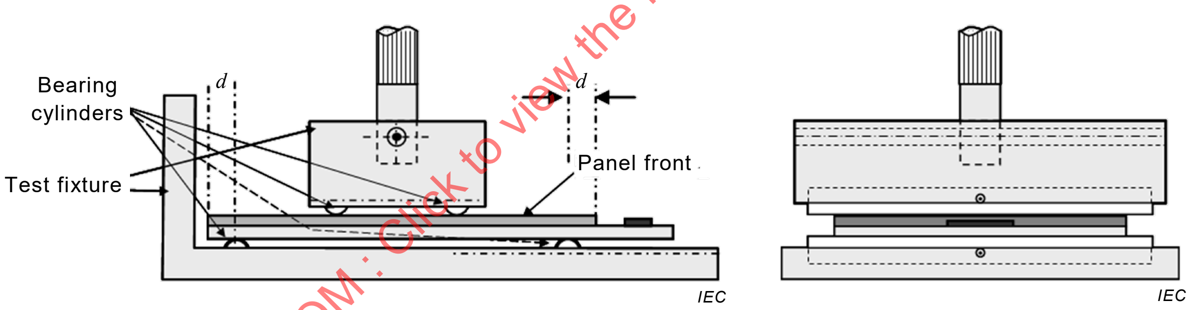
7.5.4 Test apparatus

7.5.4.1 Testing machine

The testing machine consists of a test frame and a four-point bending test fixture. Figure 6 illustrates an example of a four-point bending test fixture with an OLED panel specimen. The test frame consists of a vertical loading machine, which could be electromechanical, servo-hydraulic or pneumatic driven, a load cell mounted and controller software. It is assumed that the fixtures are relatively rigid and that most of the testing-machine crosshead travel is imposed as strain on the specimen. There are also several requirements for a four-point bending apparatus to be met in order to ensure reliable data with minimal variation [2].

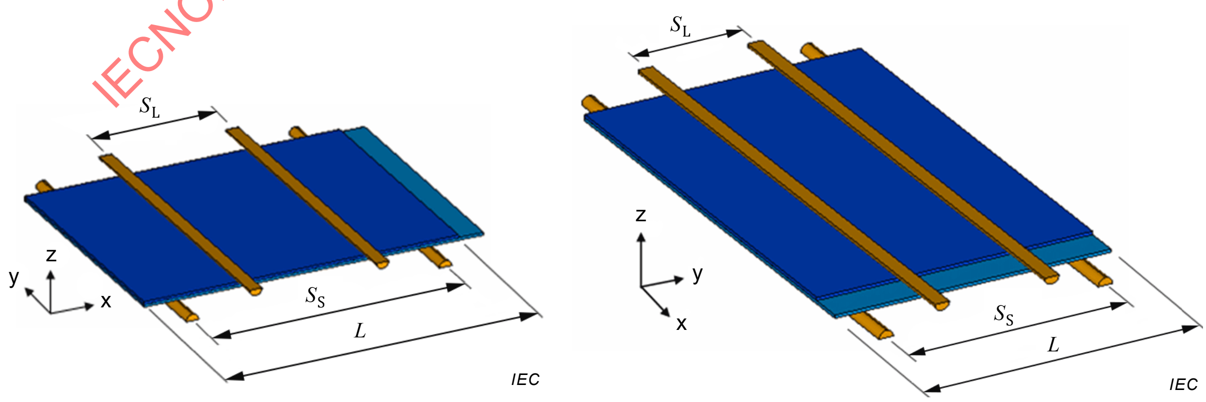
7.5.4.2 Bearing cylinders

Cylindrical bearing edges shall be used for the support of the specimen and for the application of the load. The bearing cylinder radius shall be approximately 2 mm to 5 mm depending on the thickness of the specimen [3]. The cylinders shall be made of sufficiently hardened steel to prevent excessive deformation under load and be free to roll in order to relieve frictional constraints. Moreover two loading bearings and one support bearing cylinder also shall be provided to rotate laterally to compensate for any irregular surface contact with a specimen and to ensure uniform and even distribution of the load between the two inner bearing edges. Figure 5 shows a suitable arrangement using pinned bearing assemblies.



a) side view b) front view

Figure 5 – Schematics of test apparatus and pinned bearing edges



a) x-direction bending b) y-direction bending

Figure 6 – Specimen configuration under four-point bending test

7.5.5 Test procedure

The specimen length, L, is determined as the length of either the long side or short side of the front glass as described in Figure 6a) and Figure 6b), respectively. The amount of overhang of the specimen, d in Figure 5, shall be at least 2 mm beyond the outer bearings to allow the specimen to slide over the support and to eliminate the effect of the specimen's end condition. Slowly apply the load at right angles to the fixture. The maximum permissible stress in the specimen due to initial load shall not exceed 25 % of the mean strength. In the four-point bending test, a specimen is loaded at constant displacement rate until rupture. The displacement rate to be used depends on the chosen spans and it is chosen such that the time to complete one test cycle would be sufficiently long as described in 7.3.4 while the time to failure for a typical specimen ranges from 30 s to 45 s. In Table 6 some examples of the combinations of test configurations and displacement rates are given.

Table 6 – Examples of test parameter combinations

L (mm)	S_S (mm)	S_L (mm)	Displacement rate (mm/min.)
25	20	10	3
45	40	20	5
85	80	40	10

Specifically the span between the test jig and the loading rollers needs to be adjusted for a different specimen size with a specified support span (S_S) and load span (S_L) to cover most parts of the panel edge under bending. On the other hand, to prevent the effect of the bending area size on the glass edge strength and to test under the same strength criteria regardless of the specimen sizes tested, a constant load span and support span may be specified. In any case, the load span shall be half of the support span [3]. The bearing cylinders shall be carefully positioned such that the spans are accurate within ± 0,10 mm.

7.5.6 Post-testing analysis

7.5.6.1 Breakage origin analysis

Since OLED panels can have different structures for various emission mechanisms and encapsulation schemes, they can potentially exhibit unique fracture mechanisms. Hence, the origin of the fracture of a specimen under the four-point bending test can be different. Therefore, it shall be ensured that this four-point bending test method is valid for assessing the mechanical endurance in the area of interest. Frequently, break origin analysis using fractography is conducted to review the failure origin of the panel. Potential failure modes include inferior edge quality, weak integrity of adhesion material, and/or other structural weaknesses.

7.5.6.2 Test result analysis

The mechanical testing unit used for the four-point bending test reports the failure load when a specimen under the test procedures described in this test method fails. It is very important to convert these failure load values into a standardized expression of failure stress, or strength, in the test report. There will be an inherent statistical scatter in the results for finite sample sizes, and Weibull statistical parameters can quantify this variability [1, 6]. There are a few ways of achieving the strength data. FEA simulation is often adopted to estimate the strength value, σ_{max}, from the failure load, F, and flexural stiffness. Usually for the given glass material data, a table of conversion factor B, such as $\sigma_{max} = B \times F$ is constructed from a series of FEA simulation results ranging over the various sizes and thicknesses of the panel. Each test data can be directly converted to its corresponding strength data for the given size and thickness of the specimen by simply multiplying this conversion factor. If the size or thickness of the specimen does not match exactly with that of the table, the value shall be linearly interpolated from the conversion table. If the deformation before failure exceeds a few percent of the support span (S_S), FEA simulation with nonlinear theory shall be employed for accurate stress evaluation. A detailed example of test results analysis using FEA simulation is introduced in Annex A.

There may be a few more methods to extract the strength data. One of the other methods is direct use of strain measurements. In this method, several strain gauges are bonded to the bottom surface of the specimen, where the maximum tensile stress is considered to occur. Because strength value is closely related to failure strain value, the strength value can be converted from the failure strain. It is considered that five or more samples for the strain gauge measurements are used to calculate the averaged conversion factor between the applied load and strain measurements. Further tests for the remaining samples are allowed to convert failure loads to failure strain using the conversion factor. Another method would be the measurement by observation of the fracture surface. The strength can be estimated from the crack origin and its corresponding mirror zone measurement [4, 5]. It shall be noted that if the damaged area originates from the sealing material, the mirror zone measurement in the glass panel is irrelevant due to the residual stresses pre-existing from the sealing material. This method is often used in combination with breakage origin analysis to determine the main cause and effect of the failure.

7.5.7 Evaluation

In the form of test result reporting, the averaged or minimum strength values could be reported in the specification, but B_{10} strength after statistical test data fitting [1] is preferable. The method of strength data extraction and items to be reported in the post-testing analysis are to be given in the relevant specification. The minimum or B_{10} strength, shape factor or standard deviations, mean strength value along with raw data of each specimen shall be reported. The relevant specification shall provide the criteria upon which the acceptance or rejection of the specimen is to be based.

7.6 Transportation drop test

7.6.1 General

ISO 2248 shall be applied with the following specific conditions.

7.6.2 Purpose

The objective of this document is to specify a method for carrying out a vertical impact test by dropping a complete, filled transport product package.

7.6.3 Test sample

The test package shall normally be filled with OLED modules or panels mainly for mobile and notebook computer applications. If the number of test samples is insufficient to fill the package, dummy samples with no mechanical defect may be used. Ensure that the test package is closed normally, as if ready for distribution. The number of transport packages for the test specimen is given in the relevant specification.

7.6.4 Test procedure

The test package is raised above a rigid plane surface and released to strike this surface after a free fall. The atmospheric conditions, the height of drop and attitude of the package are predetermined. The predetermined attitude of the test package shall be expressed in one of the following ways to impact on a specimen as expressed in ISO 2248:1985, Clause 7 and Annex A, using the method of identification given in ISO 2206. Impact on a face, impact on an edge, and impact on a corner are the basic drop attitude types to be chosen, and the multiple drops of one attitude type or the combination of two or three attitude types are more realistic methods to check the mechanical endurance under various vertical impacts during the shipping and handling processes.

The following order of drop attitudes in Table 7 is an example of a sequence of tests for a mobile OLED transport package.

Table 7 – Example of package drop sequence

Drop order	Description
corner a	Corner a on which drop is regarded to be the weakest.
sides b, c, d	Sides that are connected to corner a.
faces e, f, g, h, i, j	Face e is the bottom face when corner a is positioned as shown in Figure 7. Faces f, g, h, i, j are the top face, right-hand side face, left-hand side face, front face and rear face, respectively.

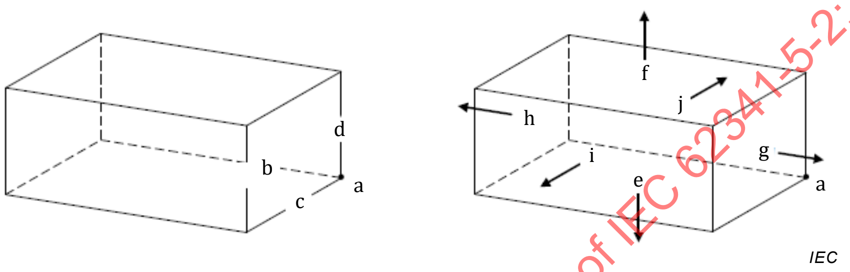


Figure 7 – Order of transportation package drop

The tolerance of the height in the predetermined attitude is within ±2 % of the predetermined drop height. For edge or corner drops, the angle between a predetermined surface and the horizontal surface shall not exceed ±5° or ± 10 % of the angle, whichever is the greater.

7.6.5 Evaluation

Visual, dimensional and functional checks shall be performed and be compared as described in 6.1 to the relevant specification. Visual and optical performance may be compared to the relevant specification.

7.7 Peel strength test

7.7.1 Purpose

The purpose of this test is to measure the bonding strength or to determine compliance with specified bonding strength requirements. This test is intended to show the bonding strength of FPCBs on OLED modules used for mobile applications. Peel strength is regarded as the bonding strength divided by the test span and can be used to compare specimens of various sizes.

7.7.2 Test procedure

After fixing the substrate in an OLED module, an FPCB specimen shall be pulled with a push-pull gauge or equivalent until it is completely removed from the device as shown in Figure 8. There can be various ways of clamping the FPCB specimen and preparation of the FPCB specimen to pull. Due to the difficulty in gripping an FPCB of the full span, it may be necessary to cut out the remnant part of the FPCB for the proper test span after assembly. The recommended test span is 10 mm. The test span location of the full width of the FPCB shall be specified as the left, centre, right or any designated portion. The specimens shall be prepared with one test span position or combination of several test span positions. At least six samples shall be evaluated. The FPCB sample shall be tightly gripped and shall be pulled to failure as depicted in Figure 8. The bonding strength is a maximum value indicated by the gauge. In all cases, whether the specimen is pulled over the full FPCB span or part of the span, the peel strength is regarded as the gauge value divided by the test span. It shall be noted that the direction of the pull and bonded device is kept perpendicular during the test. Pull speed should be sufficiently low as described in 7.4.5.1.

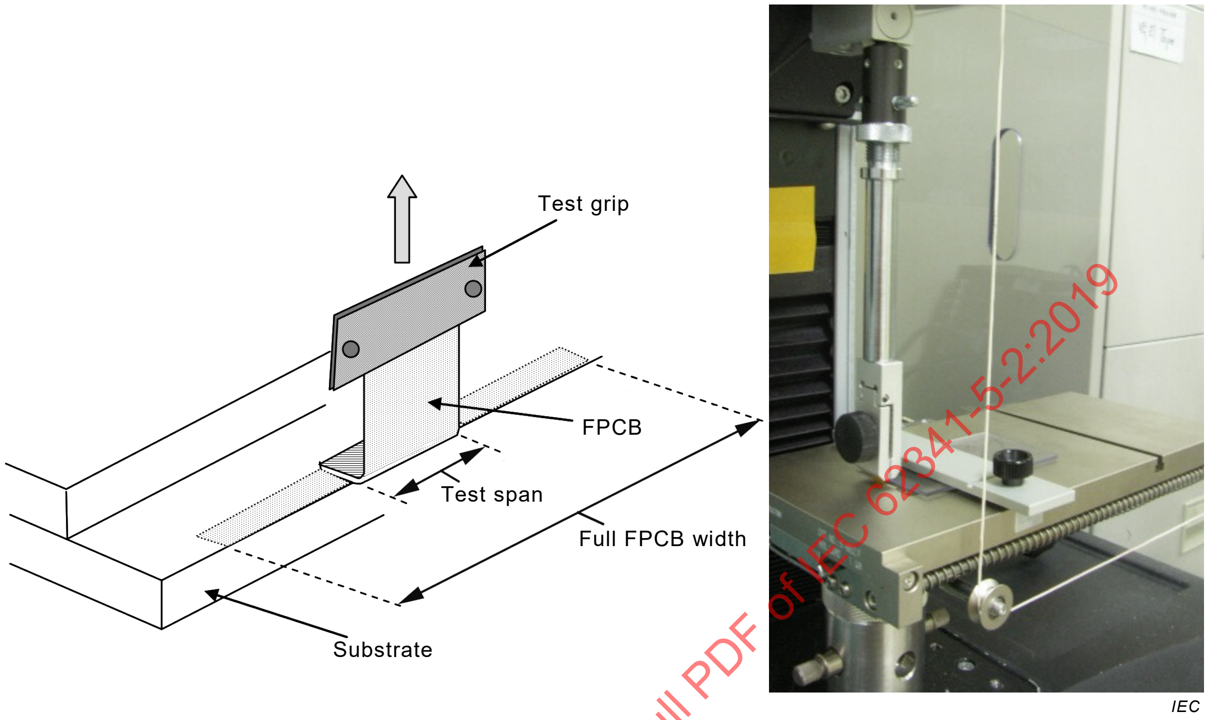


Figure 8 – Example of peeling strength test

7.7.3 Evaluation

The peel strength is equal to the minimum value of test results of the specimens. It shall be noted that the failure due to a defect in the FPCB is eliminated from the data reduction. The minimum and averaged peeling strength per unit length shall be reported. The failure modes, number of specimens and conditions of test can also be reported as requested in the relevant specification.

7.8 Shock test for large size display

7.8.1 Purpose

The purpose of this test is to measure the hardware condition of modules or panels of large size displays during use or the effect of shock during transport.

NOTE The large size is defined for TVs. The size would be over 40 in.

7.8.2 Test procedure

The test specimen, turned-off, should be hooked up to the jig as shown in Figure 1. The jig is placed on the base plate. There are three kinds of directions of the specimen on the plate as depicted in Figure 2. The order of directions is the same as in 7.2.4. The shock force and duration time should be reported.

Annex A
(informative)

Example of raw test data reduction for four-point bending test

A.1 Purpose

The purpose of this example is to explain how to relate the strength of a test specimen to the four-point bending test results as described in 7.4.5.2. By combining the four-point bending test results and a conversion factor from finite element analysis (FEA), failure loads are converted to the corresponding strength data before being fitted to a Weibull distribution for statistical strength estimation. This test example shall be used only for demonstration of the conversion process and shall not be used directly for other purposes without verifying its applicability.

A.2 Sample test results

A 2,0 in OLED panel is selected to demonstrate the data extraction process. The specimen has dimensions of 34,3 mm in width and 48,9 mm in length as shown in Figure A.1. The thickness of the front and rear glasses is 0,4 mm and the sealant thickness is 0,01 mm.

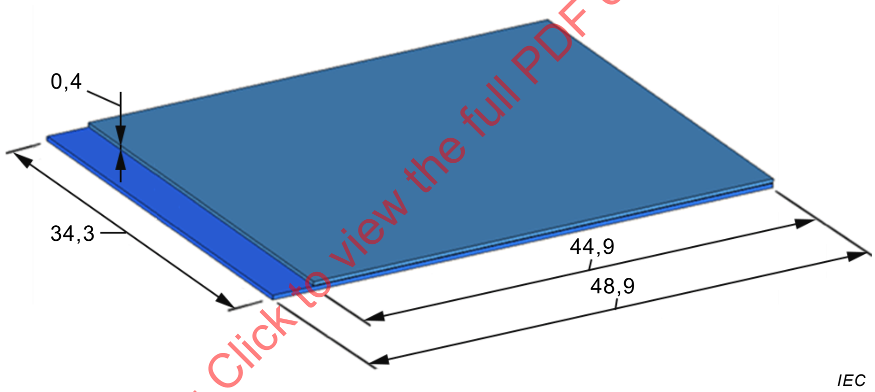


Figure A.1 – Specimen dimensions used for sample test

From the example specification in Table 6, the loading span (S_L) and support span (S_S) can be selected to be 20 mm and 40 mm as shown in Figure 6a), respectively. Representative load-displacement curves for 25 out of a set of 30 specimens are shown in Figure A.2. The failure load is determined to be a peak value before each curve starts to drop sharply. The slope of each curve can be used to monitor or compensate whether or not the specimen under test deviates from others as well as from the expected flexural stiffness for the given specimen structure. The gradual rise in the early linear portion of each curve originates from a slight difference in the timing of the initial contact between the two loading bars and the top surface of specimen. Table A.1 shows the results of raw test data of failure loads and their slopes (load/extension) for this set of specimens.

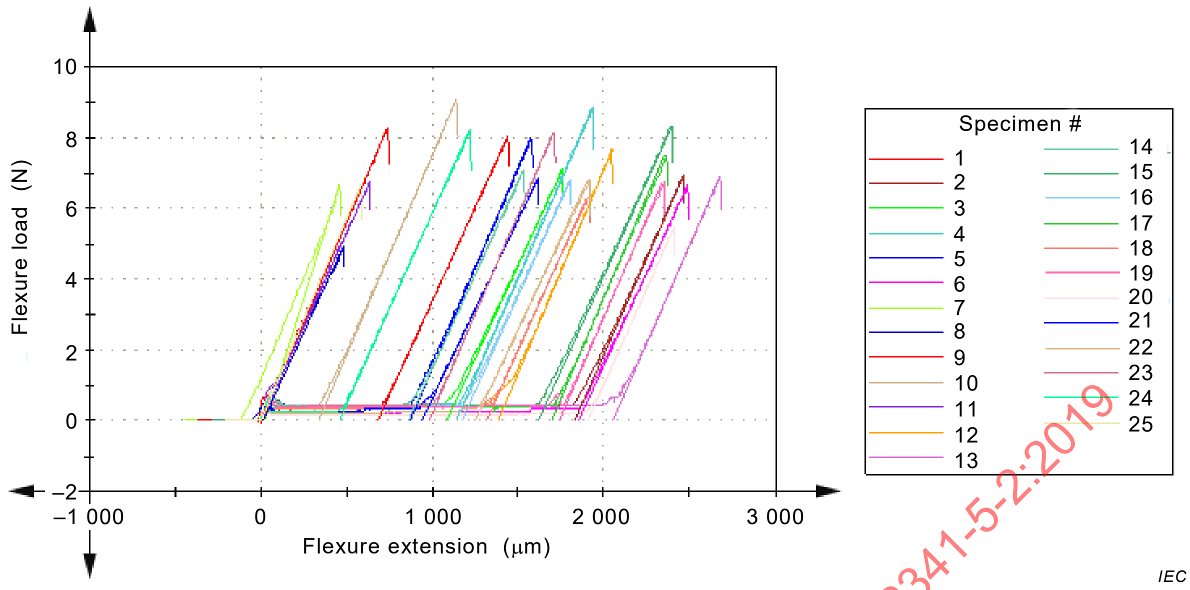


Figure A.2 – Examples of test results: Load-displacement curves

Table A.1 – Results of raw test data

No.	Force (N)	Slope (N/mm)	No.	Force (N)	Slope (N/mm)	No.	Force (N)	Slope (N/mm)
1	81,24	109,5	11	66,35	104,0	21	67,33	99,8
2	68,01	106,7	12	75,07	113,8	22	66,54	101,6
3	69,97	102,8	13	67,62	109,6	23	80,16	110,2
4	87,02	109,0	14	69,19	104,0	24	80,26	106,0
5	78,20	111,0	15	81,73	104,9	25	64,97	111,6
6	65,27	101,6	16	66,93	105,8	26	73,99	109,2
7	65,17	149,2	17	73,40	111,8	27	78,60	108,2
8	47,92	100,8	18	61,64	105,6	28	78,11	108,1
9	78,89	104,8	19	66,05	109,0	29	78,89	109,4
10	89,08	111,4	20	53,31	108,6	30	73,60	115,4

A.3 Finite element analysis

To convert the test failure load data, F, to strength σ_{max} of each specimen, it is usually assumed that there is a linear relationship between F and σ_{max}, such as $\sigma_{max} = B \times F$, where B is a conversion factor. A table of conversion factors may be prepared in advance from a series of FEA simulations for a range of widths and thicknesses of the specimen along with different loading span and support span combinations. The conversion table is usually restricted to a limited use when panel products are similar in both materials and structures. For example, a conversion table may be applied without reservation for a limited range of sizes within a single product line if similar materials and designs are used. Nevertheless, it is not practical to construct a universal conversion table to cover all products because the simulation results involve not only a large number of variables, such as material properties and panel structures, but also due to the variety of numerical error estimates inherent in different implementation approaches of FEA simulation and curve-fitting.

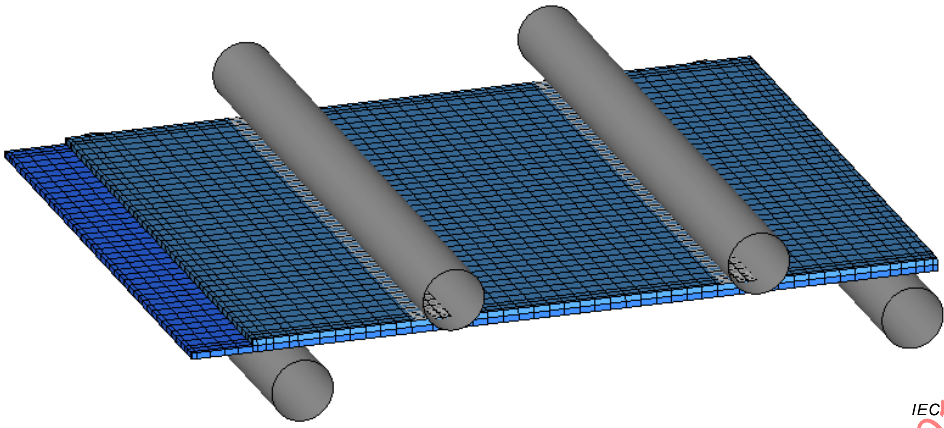


Figure A.3 – Finite element model of test specimen

Even though the detailed steps of finite element analysis are not presented here, a few critical outlines can be introduced. In Figure A.3, a finite element model of the specimen and its test set-up is shown. The geometry of the specimen is used to construct a meshed specimen and the loading and support cylinders in the test set-up are modelled as a rigid body. To simulate the four-point bending test, there are much more detailed steps in this modelling process such as allocating material properties to each component of the system, the choice of element types for the panel and sealing material as well as the contact and boundary conditions to be imposed by the cylinders. Since the test is performed slowly enough to neglect any significant dynamic effect, the simulation can be regarded either as static analysis or quasi-static analysis by using a dynamic analysis scheme with the loading rate in the range of negligible dynamic effect as specified in 7.4.5. In this example, two quadrilateral 3-D continuum elements are used in the thickness direction for modelling both glass layers. Simulations were carried out with a commercial FEA package, ABAQUS implicit code, ver.6.9 [2]. For thin specimens, deformation before failure may exceed more than a few percent of the support span and exceed the thickness of the specimen. In this case, as pointed out in 7.5.6.2 the membrane stress which develops on the surface of the specimen becomes non-negligible, and nonlinear geometry theory [7] should be applied. Accordingly the conversion factor B will no longer be a constant, but a variable dependent on the level of failure load. In this example, the linear theory applied because the failure occurred at less than 2 % of the support span.

Figures A.4 through A.6 show an example of the simulation results for the specimen with a width of 40 mm when loading bars are set to move down toward the specimen by 2 mm. In Figure A.5, the maximum principal stress around 570 MPa has been developed near the edge on the bottom surface of the specimen. Because the strength of the specimen is much weaker along the edge than inside the surface, the maximum stress along the edge shall be collected and used to construct the relationship between the applied load and the maximum stress incurred. In Figure A.6, the maximum principal stress and maximum edge stress are indicated on the bottom surface of the specimen.

The edge stress near the maximum principal stress location can be found by searching neighbouring edge nodes. As the test is controlled by downward displacement of loading bars, the load and stress relationship due to this external loading is coupled with the displacement level of the loading bars. For each incremental displacement of the loading bar, the maximum edge stresses and corresponding reaction forces from two support bars can be extracted from the simulation results and both values are cross-related with each other.

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2 ABAQUS implicit code, ver. 6.9, is the trade name of a product supplied by Dassault Systèmes. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

The final form of the relationship between the given failure load and its corresponding strength after the simulation is shown in Figure A.7. Due to the slight nonlinearity in curve-fitting over the full loading range (2 mm), only the lower portion of the failure load range was adopted for accurate linear fitting as shown in Figure A.8. Note that the measured failure load shall fall within the range of the linear fit, with a relatively high correlation coefficient (at least 95 %). In this example, the failure load from the test is at most within 100 N and it is well within the fitting range. The final conversion factor B is found to be 1,74 for the specimen with a width of 40 mm and a thickness of 0,4 mm. Finally, it is advised to cross-check the validity of the conversion factor by checking whether the flexural stiffness of the panel from simulation matches closely with the corresponding slopes of the test data in Table A.1.

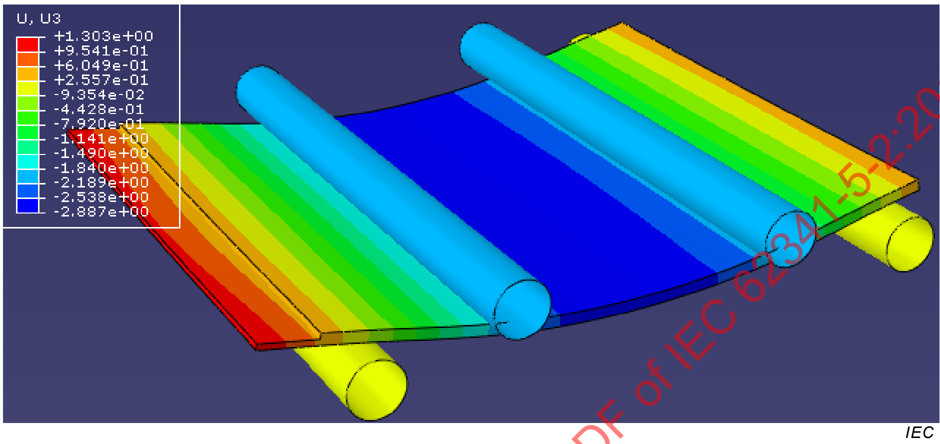

Figure A.4 – Displacement contour map after moving the loading bar down by 2 mm

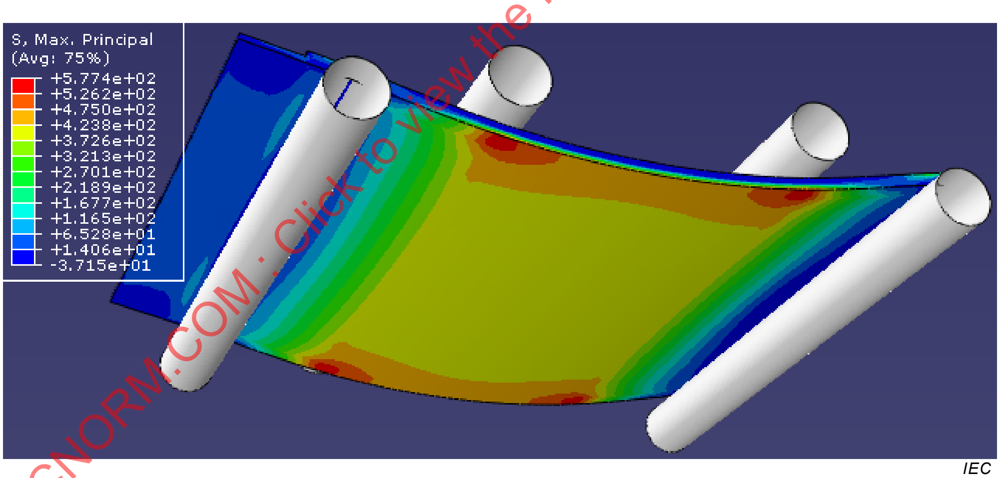

Figure A.5 – Contour map of maximum principal stress distribution

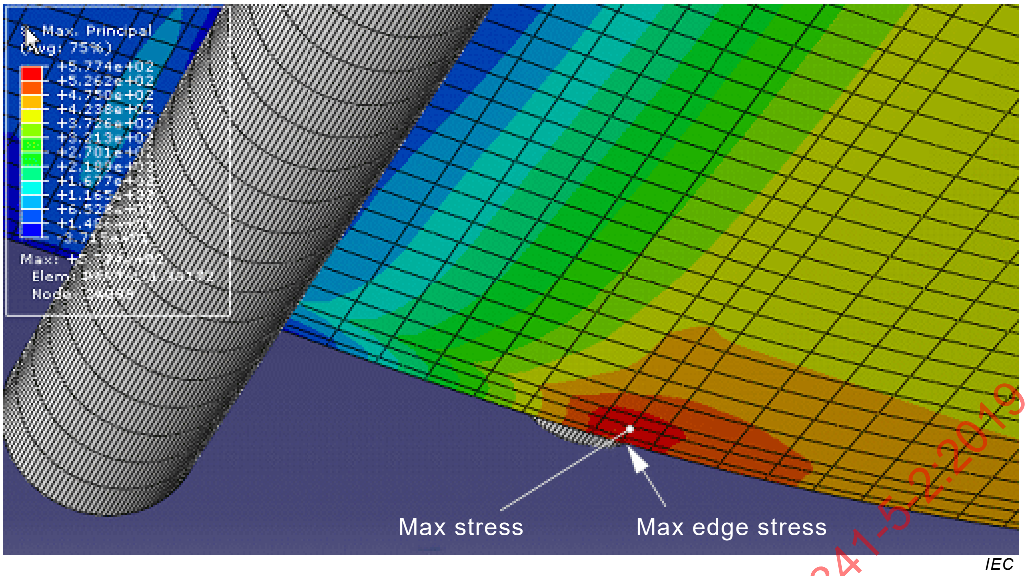

Figure A.6 – Maximum principal stress and maximum stress along the edge

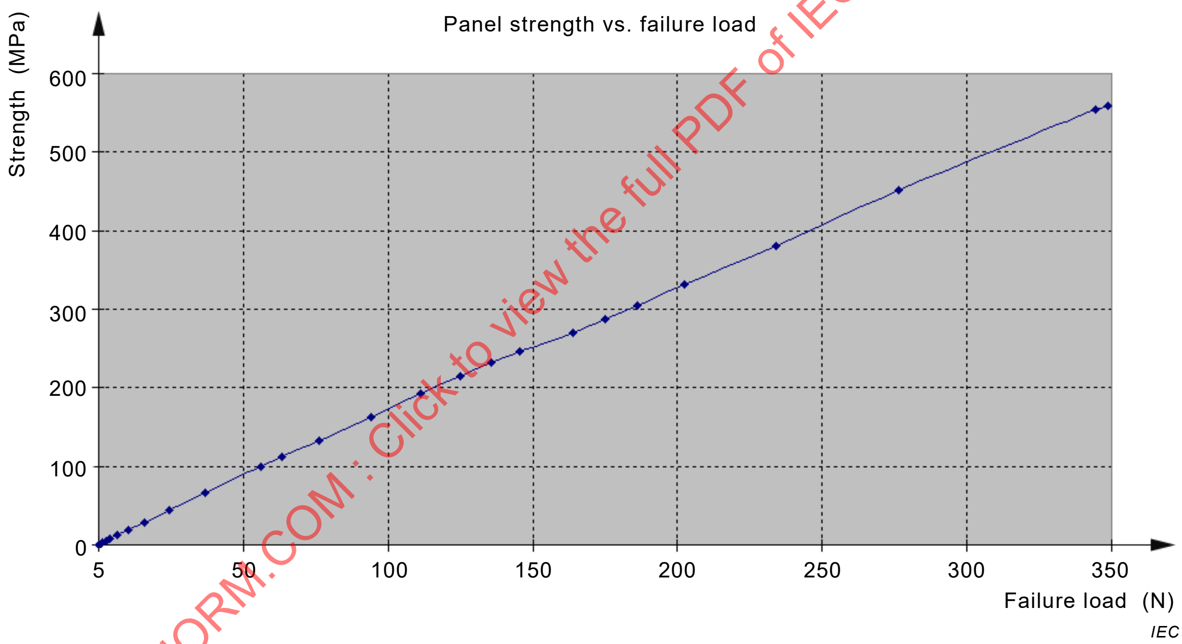

Figure A.7 – Final relationship between panel strength and failure load