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INTERNATIONAL STANDARD

colour inside

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

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FLEXIBLE DISPLAY DEVICES –

Part 5-3: Visual assessment of image quality and defects

FOREWORD

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

FDIS	Report on voting
110/844/FDIS	110/867/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- withdrawn,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.

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.

INTRODUCTION

This part of IEC 62715 was developed in response to demands for the standardization of the general rules and detailed procedures that are used in the visual assessment of flexible display devices.

Visual assessment is an essential means for evaluating flexible display devices and is intended to complement objective display measurements [1][1]. The advantages of visual assessment are as follows:

a) It is speedy, e.g. defects are instantly recognized by a human observer.

b) It allows the evaluation of various device shapes and allows evaluation from various directions and distances, which can lead to higher sensitivity for detecting defects.

c) It completely covers the area of even the largest display, allowing identification and selection of regions of interest for objective measurements.

d) It is sensitive, e.g. for some defects, visual assessment is the most sensitive means of detection.

e) It corresponds to the perception of humans.

f) It can detect unexpected changes or defects that can be overlooked by predetermined measurements with equipment.

Visual assessment is a necessary first step for specifying types of measurements and the regions of interest for measurements.

Evaluation results from visual assessment depend on the observer, region of interest for the assessment, lighting and geometrical conditions of the assessment, criteria in making judgments, and various other factors. Therefore, it is important to standardize the general rules, including the terms, conditions, criteria and reporting of results from visual assessments.

Regarding the procedures for visual assessment of electronic display devices, the following standards can be consulted: IEC 62341-6-2 [6] and IEC 61747-20-3 [7].

Visual assessment is usually performed by comparing a test sample with a limit sample or a set of grade samples. This document stipulates the framework and procedures to be used in the assessments; it also describes the preparation of a limit sample or a set of grade samples.

This document also applies when a limit sample or a set of grade samples are not available for the same type of defect. Concerning defects of flexible display devices, many kinds of defects can be observed. Even within the same category of defect, factors, such as the shape, size, luminance, colour, gradation of the edge, width of the edge, solitary or repetitive, position in the display area, can differ. Therefore, in most cases, it is practically impossible to prepare the same type of limit sample or comparison samples for visual assessment.

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1 Numbers in square brackets refer to the Bibliography.

FLEXIBLE DISPLAY DEVICES –

Part 5-3: Visual assessment of image quality and defects

1 Scope

This part of IEC 62715 provides the framework and procedures for performing the visual assessment of flexible display devices.

Visual assessment stipulated in this document is applicable to flexible display modules in the following states:

– initial states and ageing states under standard ambient conditions,
– mechanically or environmentally stressed conditions,
– states after mechanical endurance test(s), after environmental endurance test(s) and after a combination of mechanical and environmental endurance tests.

NOTE Visual assessment under the mechanical or environmental stress is usually difficult to do, but this document can be applied when it is possible.

Visual assessment is performed by comparing a test sample to a limit sample or to a set of grade samples. This document provides the framework and procedures for visual assessments that use a limit sample or a set of grade samples. This document describes the framework and procedure that are followed while preparing limit samples and a set of grade samples. This document also describes visual assessment when limit samples and grade samples are not available for the same type of defect.

This document provides sets of test patterns that can be used in visual assessments.

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 61747-30-1, *Liquid crystal display devices – Part 30-1: Measuring methods for liquid crystal display modules – Transmissive type*

IEC 62715-1-1, *Flexible display devices – Part 1-1: Terminology and letter symbols*

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

IEC 62715-6-2[2], *Flexible display devices – Part 6-2: Environmental testing methods*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62715-1-1 and the following apply.

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2 Under preparation. Stage at the time of publication: IEC/AFDIS 62715-6-2:2017.

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 In cases where the terms and definitions are duplicated between this document and IEC 62715-1-1, the definitions in this document take precedence.

3.1
visual assessment
process in which human visual observation is used to evaluate image quality by detecting and classifying defects or by recognizing any adverse changes in image quality

3.2
grade sample
sample that represents a specific level of defect or deterioration in image quality

Note 1 to entry: Grade samples are usually prepared as grades 1 to 3 or grades 1 to 5, ranging from best to poorest.

3.3
limit sample
sample that represents a specific type of defect or deterioration in image quality that corresponds to an acceptance limit for a certain product

Note 1 to entry: Limit samples are applicable to defects that can be tolerated to a certain extent (e.g. uniformity defects, point defects). They can be either one sample providing the maximum acceptable defect level or a set of samples providing variations in defect level. The variations should represent a classification range for the strength or number of the specific defect, thus providing a reference for an acceptable defect level.

3.4
ND filter
nutral density filter
optical filter that reduces the intensity of all wavelengths of light equally, giving no changes in hue of color rendition

3.5
paired comparison method
psychophysical method involving a choice between two simultaneously presented stimuli that exhibit greater or lesser image quality, or an attribute thereof, in accordance with a set of instructions given to the observer

3.6
single stimulus method
psychophysical evaluation method inspecting only the objective sample without comparison, in accordance with a set of instructions given to the observer

3.7
psychophysical method
method for examining something relating to the physical stimuli and sensory response

Note 1 to entry: ISO 20462-3:2012, 3.12 [3] defines the psychophysical method as an "experimental technique for subjective evaluation of image quality or attributes thereof".

3.8
reference stimulus
image provided to the observer for the purpose of anchoring or calibrating the perceptual assessments of test stimuli

Note 1 to entry: The plural is reference stimuli.

[SOURCE: ISO 20462-3:2012, 3,15, modified – last part of definition deleted] [3]

3.9
observer
individual performing the subjective evaluation task in a psychophysical method

[SOURCE: ISO 20462-3:2012, 3.9] [3]

4 Procedures of visual assessment [2][3]

4.1 General

Procedures for assessment of image quality are described in Clause 4. The following items are covered;

- image defects, such as subpixel defects, clustered defects, line defects, and mura,
- physical defects, such as scratch, abrasion, dent, and change in gross
- image quality, such as change in luminance, colour, or distortion.

Especially the changes of these items before and after the environmental and/or mechanical stress tests are described.

NOTE Classification of defects and the naming and definitions of defects are described in IEC 62341-6-2 [6] and IEC 61747-20-3 [7].

4.2 Setup of displays and driving conditions

Turn on the power supply and pattern generator and warm up for stabilization. Supply the driving voltage and pattern to the display module as specified for each assessment. The warm-up time of the device under test (DUT) and illumination shall be sufficiently long to obtain a stable signal, which is necessary for visual assessment. It is recommended that when the display is first turned on, it should be operated for at least 30 min.

4.3 Observers for visual assessment [4][5]

Observers shall be periodically trained for visual assessment by a qualified person using a document of specified procedures and grade samples. Qualified persons are certified by each organization based on their criteria. The criteria may be discussed by the customer(s) and the provider(s). To ensure effectiveness, grade samples shall be maintained by a qualified person.

Observers should adapt to lighting conditions for a period of 10 min or more before beginning an assessment session.

4.4 Ambient conditions for visual assessment

4.4.1 Standard environmental conditions

Visual assessment shall be carried out under standard environmental conditions: a temperature of 23 °C ± 3 °C, a relative humidity of 45 % to 75 % and a pressure of 86 kPa to 106 kPa. When other environmental conditions are used, they shall be noted in the report.

4.4.2 Standard lighting conditions

4.4.2.1 General

Dark room conditions shall be used for the visual assessment of the image quality of emissive-type displays in operational states. Controlled external lighting shall also be used for the visual assessment of the emissive- and reflective-type displays and for physical damage to both the display types.

4.4.2.2 Dark room conditions for emissive-type display modules

The luminance contribution from background illumination reflected off the test display shall be small enough for visual assessment. It is recommended that the luminance contribution from background illumination reflected off the test display be less than or equal to 0,01 cd/m^2 or less than 1/20 of the display's full screen black luminance.

It should be noted that, in case of mura defect in a black background, even low level of background illumination can hinder the detection of mura.

To avoid the emitted light from the display being reflected back onto the display, the clothes of the observer(s) and walls of the room shall be sufficiently dark.

4.4.2.3 Lighting conditions for reflective-type display modules

For reflective-type displays modules, visual assessment shall be carried out in a dark room, as described in 4.4.2.2, however the display shall be illuminated by higher than 500 lx of diffuse broadband illumination, such as hemispherical lighting.

Lighting conditions for visual assessment have several functions:

1) lighting is necessary for viewing reflective displays,
2) the spectral distribution, lighting geometry and display surround have to be specified so that viewing conditions for visual assessment are reproducible,
3) lighting geometry has to be designed carefully so that lighting does not interfere with the assessment of the display. For example, specular reflections of the light source by the display into the field of view should be avoided because they can create a glare that can hide defects that confound the observer.

4.4.2.4 Light conditions for assessment of physical damages

Physical damages shall be assessed using external lighting for both emissive-type display and reflective type display devices.

The average illuminance on the display area shall be between 500 lx and 1 000 lx, as measured at the display surface. The other illumination condition can be selected based on the requirement of the customers, but the illuminance on the display shall not be less than 100 lx. Care shall be taken to block direct viewing of the light source by the observer. Either a fluorescent light with the illuminant of FL1 illustrated in CIE 15 or other fluorescent lights can be used [8].

Physical defects and changes in the gloss of the surface of display modules should be inspected with oblique directional lighting while changing the incident and observation angles. Diffuse illumination can also be used when it is appropriate.

Diffuse illumination is best for inspection of electro-optical properties, and directional lighting from an oblique direction for mechanical defects.

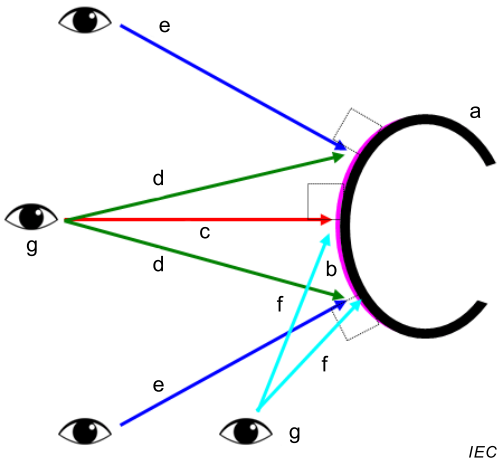
4.5 Viewing geometry

4.5.1 General

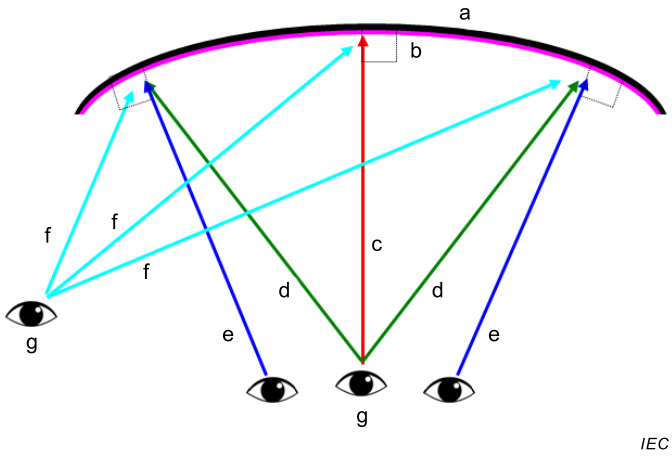
In 4.4, the following geometries are defined on the basis of the purpose of the evaluation:

1) Designed viewing geometry: The position with the designed viewing distance and direction of the device as defined by the manufacturer.
2) Standard usage viewing geometry: The viewing positions defined in this document.

The conceptual image of the viewing geometry is shown in Figure 1.



a) convex display



b) concave display (top view)

Key

a) display

b) screen area of the display

c) viewing from the normal direction of the centre of the screen

d) viewing from the vantage point

e) viewing from the normal direction of a point on the screen

f) viewing from the other direction

g) observer (centre of the right eye and the left eye)

NOTE In this figure, all the viewing directions are on the same plane.

Figure 1 – Illustrative viewing geometries of flexible display devices

The display module should be installed on a rotatable fixture to enable changes in horizontal, vertical and/or oblique viewing directions. Furthermore, the display module can be fixed, while the observer moves around it. For a mobile-type display, the display module can be held by the observer during the assessment [9].

4.5.2 Designed viewing geometry

For visual assessment with the designed viewing geometry, the viewing distance and angle that are defined by the manufacturer shall be used.

If there is no information on the designed viewing position, then the standard viewing geometry described in 4.5.3 shall be applied.

4.5.3 Standard usage viewing geometry

In the standard usage viewing geometry, the viewing position shall be the normal direction from the centre of the active area of the display and the viewing distance shall be $3H$ from the display when the display device is flat, where H is the vertical length of the active area of the display module. However, the viewing distance shall be no smaller than 25 cm.

When the display device is not flat, i.e. curved or waved, the display shall be viewed normal to the centre of the active area, and the viewing distance shall be $3H$. In addition to the normal of the centre of the active area, the following viewing geometry shall be applied.

The standard nine-point positions in the active area of the display stipulated in IEC 61747-30-1 shall be observed, from the normal position of the each point, and/or from the vantage point. The selection of the viewing position, normal position or vantage point, should be specified in the specification and shall be reported. It should be determined considering the use case.

Actual viewing points are usually variable and are different from the designed viewing positions defined by the manufacturer of the device. It is important to assess the devices not only from the designed viewing position but also from the standard usage viewing positions.

For visual assessment with the standard usage viewing geometry, the ranges of the viewing distance and angle that are specified in this document shall be applied. The range should be defined in the specification depending on the purpose of the assessment and standard usage as described in the following examples. The range should be agreed upon between the provider and the customers.

In case of assessment of the image quality of televisions in living rooms, an example of the recommended range of viewing angle measurement is 60º to the right and left, and 10º up and down, from the normal direction of the centre of the screen.

In case of assessment of the image quality of mobile phones, an example of the recommended range of viewing angle measurement is 30º to the right and left, and 30º up and down, from the normal direction of the centre of the screen [9].

Regarding the assessment mechanical defects, it should be done from all the possible viewing directions. Some mechanical defects are more clearly observed from the oblique angle, which can be disturbing.

The geometry of assumed usage for mobile displays shall be determined on the basis of the actual usage of those displays. Visual assessment shall be done from the position that corresponds to the average distance and direction of the typical viewing geometry. The visual assessment shall be performed over the range that corresponds to presumed actual usage. It is recommended that the range of the angle from the designed viewing direction for assessment should cover the 90^{th} percentile of the usage.

4.5.4 Geometry for rigorous assessment

For rigorous assessment, the shorter viewing distance shall be used. The display should be viewing at the specified viewing distance. If no viewing distance is specified, then the following guidance is recommended:

- The viewing distance should be 50 cm for a 4 K / 30 inch (about 375 mm x 665 mm) display.

NOTE 1 This equals a pixel distance of 0,02° per pixel, which means the human eye is the limiting factor.

- The viewing distance should be 25 cm for a 4,5 inch cell phone display with a 55 mm x 98 mm size.

NOTE 2 The maximum resolution of the human eye with eyesight 1,0 or over is 0,017°. The human eye can detect pixels that are 0,073 mm apart in a 250 mm viewing distance which equals 13,75 pixels per mm. This is approximately the resolution of a retina display. Given a retina display, the resolution of the display itself is approximately 1 280 x 720 which equals 0,0176° per display pixel, the display resolution can be neglected because the human eye is the limiting factor. This equals a pixel distance of 0,02° per pixel, which means the human eye is the limiting factor.

5 Test charts (test signals)

5.1 General

Test patterns for visual assessment shall be specified on the basis of the purpose of the evaluation. Test charts shall be selected or shall be created on the basis of the following perspectives:

- detection and evaluation of defects
- image quality (such as, uniformity, resolution, colour and distortion)

5.2 Full-screen patterns

The full-screen pattern is the most fundamental test signal and can be used for all evaluations, including evaluations of defects.

The input signal level may be 0 %, 10 %, 25 %, 50 %, 75 % and 100 % grey and pure colours, such as red, green, blue, yellow, magenta and cyan, as shown in Figure 2. An example of the set of input signal levels for an 8-bit system is shown in Table 1.

The area of the screen can be divided into the centre part and the peripheral part as shown in Figure 2b). The radius of the circle for the border shall be specified in the detailed specification. As an example, the radius of the circle can be half of the height of the display screen and/or can be 80 % of the width of the screen.

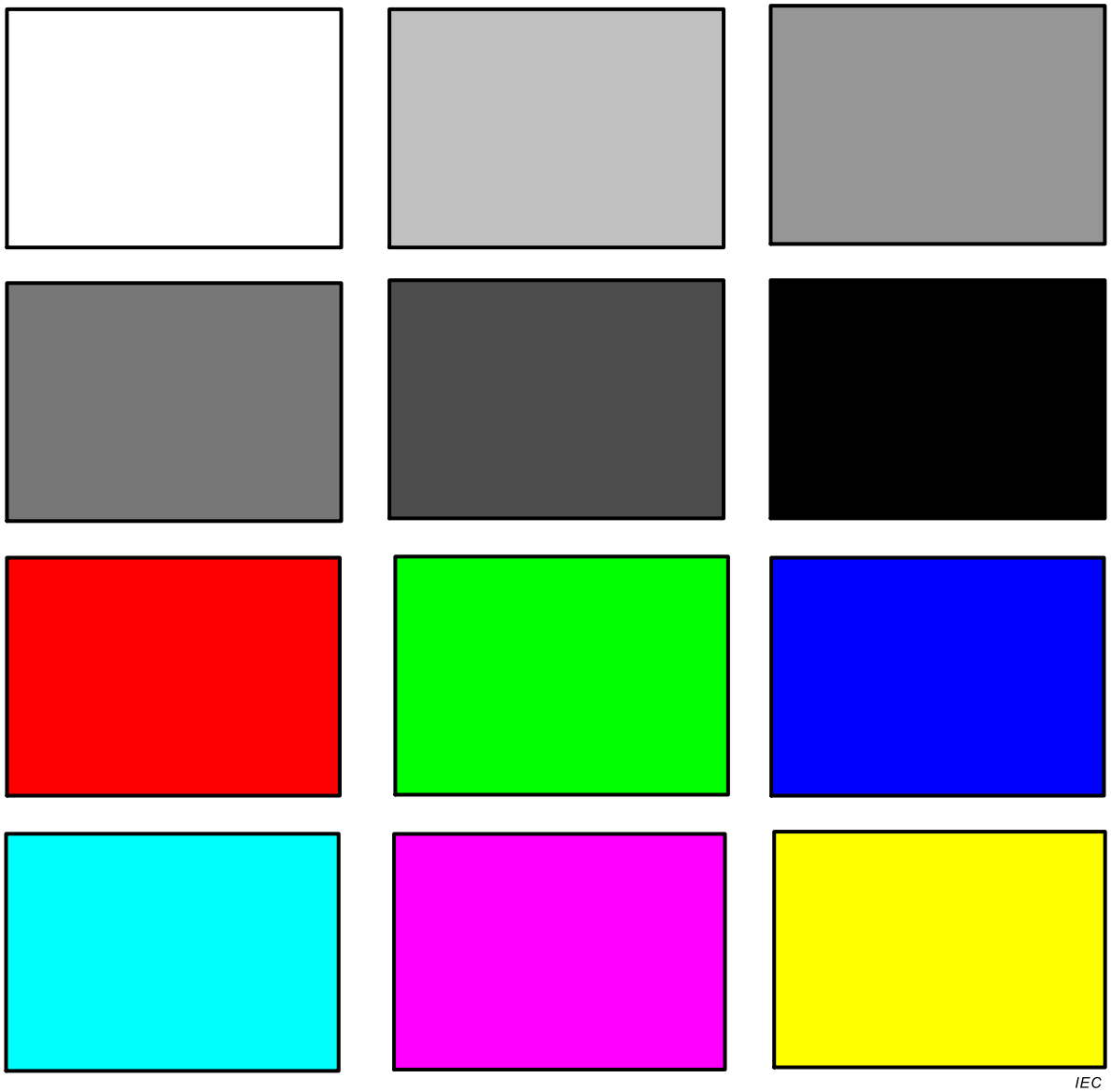
Table 1 – Example of the set of input signal levels for an 8-bit system

	R	G	B
White	255	255	255
75 % grey	191	191	191
50 % grey	127	127	127
25 % grey	63	63	63
10 % grey	25	25	25
Black	0	0	0
Red	255	0	0
Green	0	255	0
Blue	0	0	255
Yellow	255	255	0
Magenta	255	0	255
Cyan	0	255	255

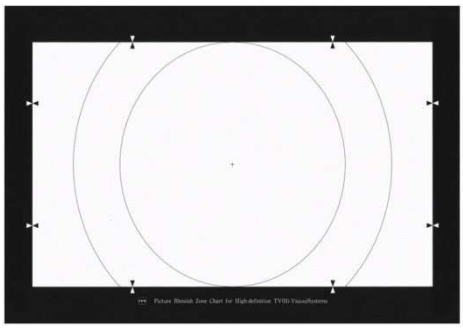
When other levels are appropriate for the evaluation, the levels shown in Table 2 should be used.

Table 2 – Other input signal levels for an 8-bit system

Number of levels	Input signals for an 8-bit system
3	0, 127, 255
5	0, 63, 127, 191, 255
9	0, 31, 63, 95, 127, 159, 191, 223, 255
17	0, 15, 31, 47, 63, 79, 95, 111, 127, 143, 159, 175, 191, 207, 223, 239, 255
33	0, 7, 15, 23, 31, 39, 47, 55, 63, 71, 79, 87, 95, 103, 111, 119, 127, 135, 143, 151, 159, 167, 175, 183, 191, 199, 207, 215, 223, 231, 239, 247, 255



a) full-screen raster



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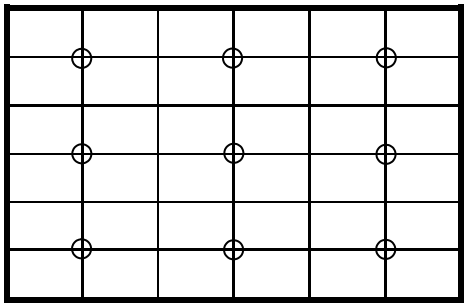
b) full-screen with borderline

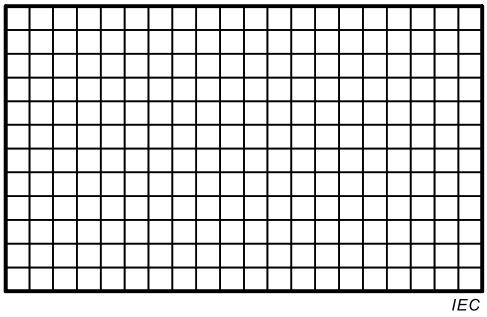
Figure 2 – Example test patterns

5.3 Periodic patterns

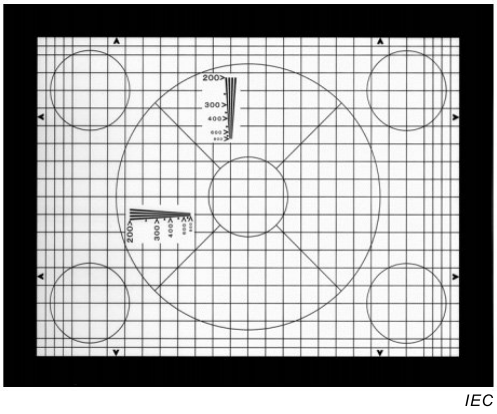
Periodic patterns are used to evaluate distortion or for other purposes. Some examples are shown in Figure 3. The linearity of the each line and the regularity of the gap between the lines or grids shall be assessed. These patterns can be used for evaluate the distortion of images when the flexible display is bended or deformed. These patterns are also used for evaluation of the distortion of images after the mechanical stress test of the flexible display.



a) alignment pattern



b) grid box



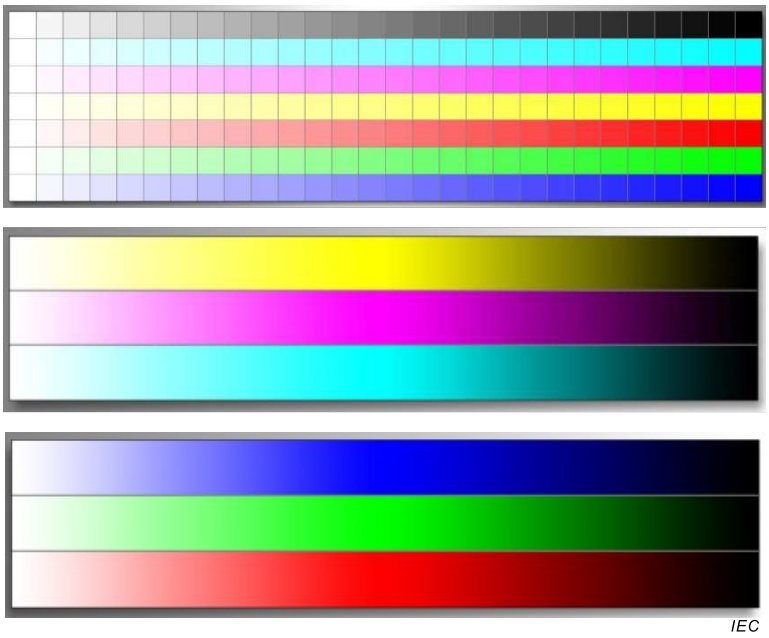
c) ball pattern

Figure 3 – Examples of periodic patterns

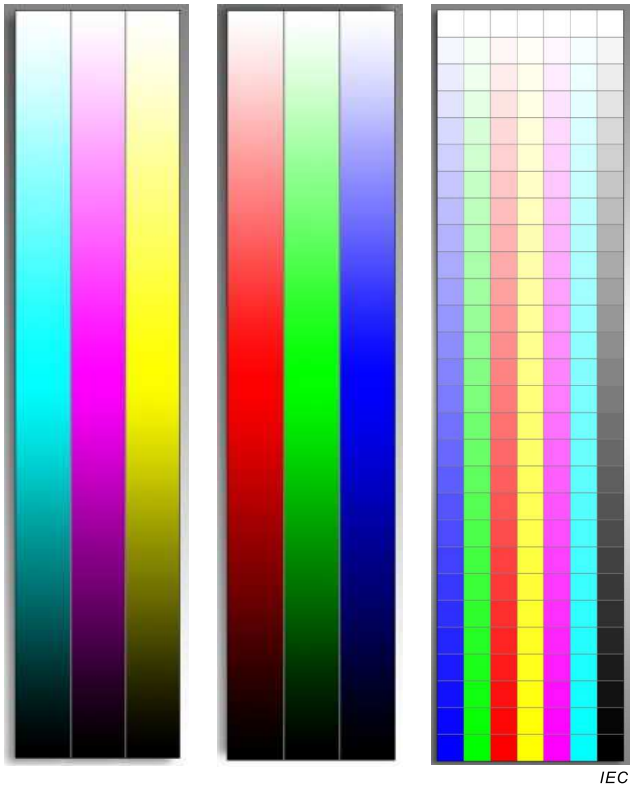
5.4 Tone and colour gradation patterns

Gradation patterns are used to evaluate tone and colour reproduction. Some examples are shown in Figure 4. It is recommended that this evaluation be done for displays that are returned to a flat shape when it is possible and appropriate, considering the use case of the products, because deviations from the flat state influence the evaluation. For vertically curved displays, the pattern in Figure 4a) should be used. For horizontally curved displays, the pattern in Figure 4b) should be used.

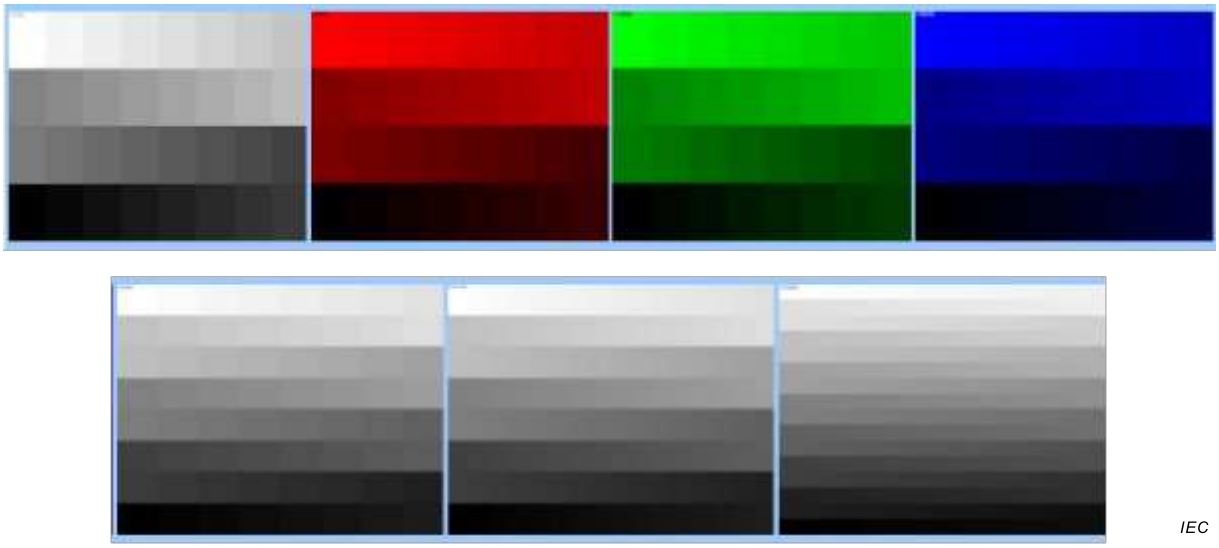
In each case, the pattern rotated 180º should also be used to check the effect of the deformation of the display on the assessment.



a) mainly for vertically deformed displays



b) mainly for horizontally deformed displays



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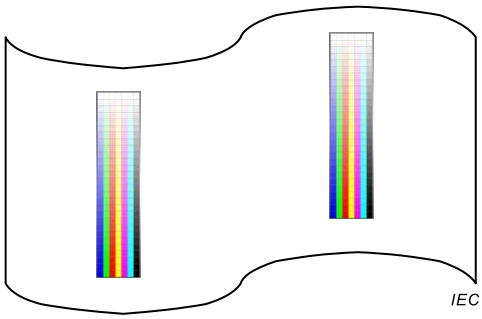
c) test charts for tone and colour reproduction

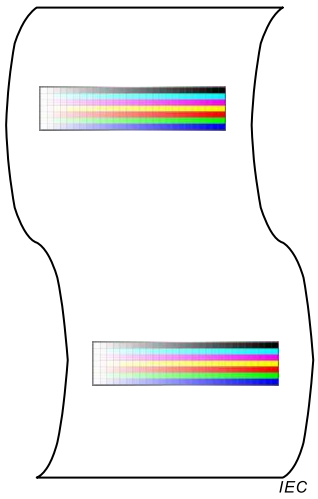
Figure 4 – Example test charts for tone and colour reproduction

These patterns should be displayed on the screen of the DUT in an adequately small size so that the pattern will not be influenced by the deformation of the DUT, as shown in Figure 5.

These patterns shall be observed from the normal position of the centre of the pattern. Any abnormity or malfunction of the displayed images shall be assessed in respect of luminance, colour, and uniformity of those for the each patch.



a) example of horizontally deformed DUT



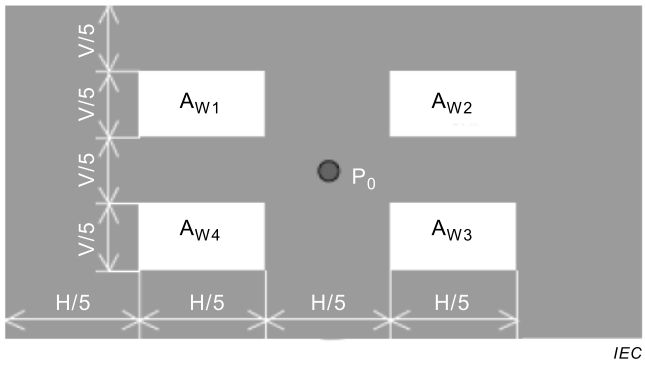
DUT

b) example of vertically deformed DUT

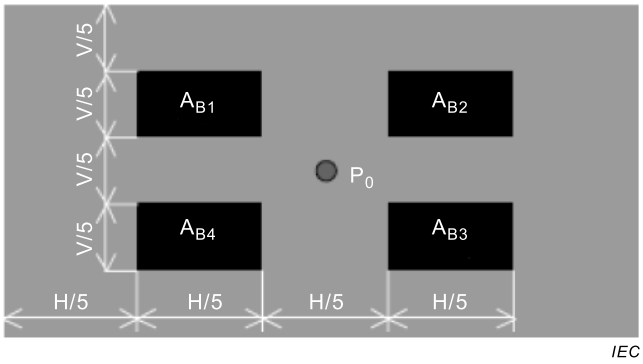
Figure 5 – Examples of a test chart displayed on the screen of deformed DUTs

5.5 Test chart for cross-talk

For evaluation of cross-talk, the test patterns illustrated in Figure 6 can be used. The uniformity of the grey area surrounded the white or black boxes shall be observed.



a) Cross-talk pattern with 4 % white window boxes



b) Cross-talk pattern with 4 % black window boxes

Figure 6 – Cross-talk patterns window boxes on grey background diagonal from the position at P_0

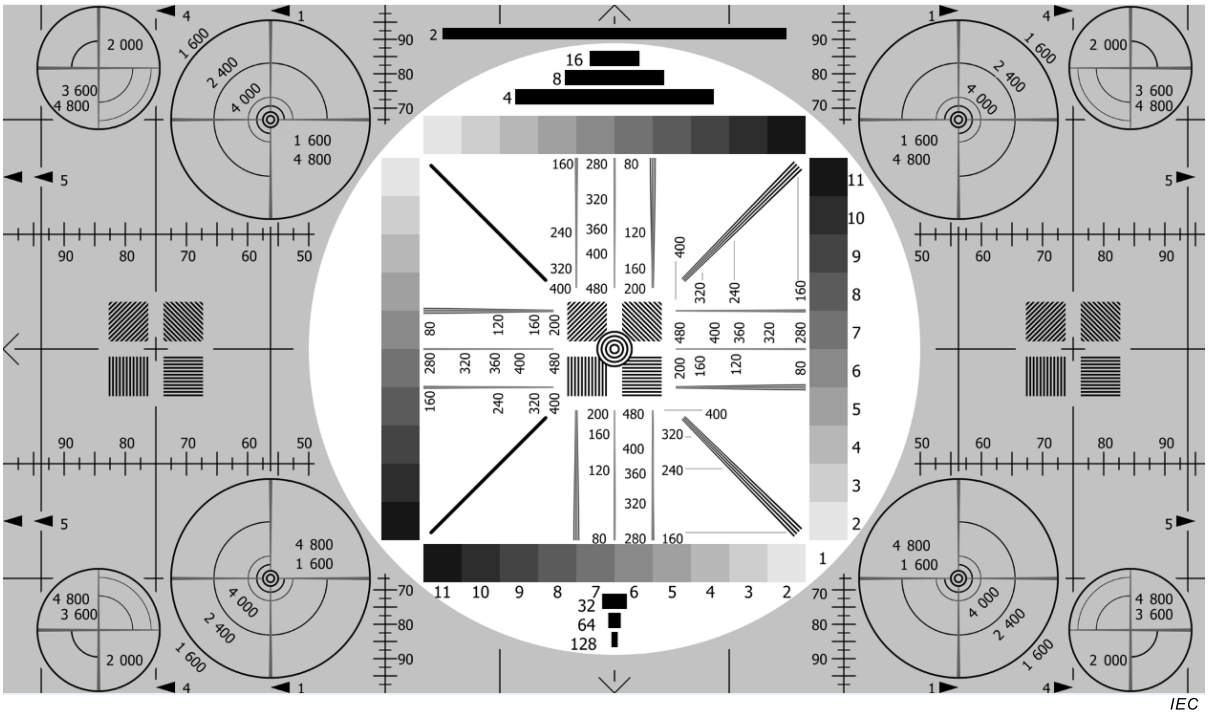
5.6 Test chart for electro-optical defects

A full-screen black test pattern (0 % grey level, display in turned-on state) is applied to inspect for bright sub-pixel defects.

A full-screen test pattern of between 10 % and 30 % grey level is applied for mura defects inspection. A grey level of 10 % shall be used unless otherwise specified in the detailed specification. The luminance level shall be recorded in the visual assessment report. Observed defects shall be compared against limit samples.

5.7 Test chart for static image resolution

A monoscopic pattern such as that shown in Figure 7 can be used for assessment of static image resolution. The resolution capability shall be assessed by judging whether the adjacent fine lines are separated from each other, and by observing the set of fine lines arranged vertically, horizontally, and obliquely.



(Source: Astro 4K evaluation chart; VT-7004/VT-7004A)

Figure 7 – Monoscopic pattern for assessment of ultra high definition screen

5.8 Natural and synthetic images

Natural and synthetic images shown in ISO 12640-2 can be used for practical evaluations of image quality [10].

6 Visual assessment during and after stress tests

6.1 General

Visual assessment may be done during or after a mechanical stress test and/or an environmental stress test.

NOTE It is usually not easy to perform a visual assessment during mechanical or environmental testing, because the display is usually in an enclosed chamber and may not be viewed directly, especially for reflective displays, which require a defined illumination environment. However, this document is applicable when the visual assessment is possible.

Mechanical stress tests shall be in accordance with IEC 62715-6-1. Environmental stress tests shall be in accordance with IEC 62715-6-2.

6.2 Number of duplicate and reference DUTs

At least four duplicates of the DUT shall be prepared. It shall be confirmed that the image quality of the four duplicates is the same or is within the required evaluation precision. One of the four duplicates shall be chosen as the reference DUT. The reference DUT, which serves as the reference stimulus, shall be kept in standard ambient conditions or under a controlled condition, where no changes occur in the DUT. The remaining three DUTs shall be exposed to the environmental and/or mechanical stress.

6.3 Procedures of visual assessment after exposure to environmental stress

The sample shall be removed from the environmental chamber and shall be left in the standard environmental condition for at least 1 h for acclimatization. It shall be visually inspected for defects, or it shall be visually inspected for any visual changes by comparing it with the reference sample. The reference sample should be the virgin sample that was not exposed to the environmental stress.

6.4 Procedures of visual assessment after exposure to mechanical stress

When the product is designed to be viewed in the flat state or in a certain designed shape, the sample shall be returned to the flat or designed shape before visual assessment.

When the product is designed to be viewed in a non-flat or other shape, the sample shall be assessed while the sample is under mechanical stress, such as bent, rolled or inflected.

The sample shall be visually inspected for defects, or it shall be visually inspected for visual changes by comparing it with the reference sample. The reference sample should be the virgin sample that was not exposed to the mechanical stress.

7 Criteria for judgments

7.1 General concept

Judgments shall be reached in accordance with a set of instructions given to the observer.

Visual assessment is usually performed by comparing a test sample with 1) a limit sample or 2) a set of grade samples. The observer shall judge whether the level of defects or the level of image quality is better than, the same as, or worse than a) the limit sample or b) the rank of the sample in relation to grade samples.

When a limit sample or a set of grade samples is not available for a specific type of defect or a specific mode of image deterioration, observers shall make visual assessments in accordance with a set of instructions that are given after they have been trained using a limit sample or a set of grade samples that, as far as possible, is near to the observed defects or the observed image deterioration.

Criteria for visual assessment should be determined by considering the true needs of the product end-users. The limit sample or the set of grade samples should be prepared to meet the true needs of the end-users.

The criteria can be set for image quality, distortion and other defects in response to the purpose of the assessment.

7.2 Judgment using a limit sample

Observers shall compare the DUT and the limit sample with double stimulations, i.e. apples-to-apples comparisons, based on instructions. They shall then assess whether the DUT is better than, the same as, or worse than the limit sample.

7.3 Ranking using a set of grade samples

Observers shall compare the DUT with the set of grade samples, based on instructions. Grade samples usually have three or five grades, i.e. grades 1 to 3 or grades 1 to 5 from the best level to the poorest level. The observers shall rank the DUT at the grade in which the DUT is the nearest. The observers can also rank a DUT at an intermediate value between grades, such as 2,5 or 3,5, provided that the instructions allow an intermediate grade when it is appropriate.

NOTE This kind of ranking can be used in the following manner.

Example 1 Grade 4 or over is suitable for shipping. Grade 3,5 is OK for shipping but improvements should be made. Grade 3,0 is OK for shipping but should be improved by the next lot. Grade 2 or under cannot be shipped.

Example 2 Grade 4 or over is suitable for shipping. Grade 3 is OK for shipping but only to market X. Grade 2 or under cannot be shipped.

7.4 Preparation of a limit sample or a set of grade samples

7.4.1 General

A limit sample represents a specific type of defect or deterioration in image quality that corresponds to an acceptable limit for a certain product. A set of grade samples represents a specific type of defect or deterioration in image quality that corresponds to the certain grades.

The acceptable limit shall be determined by considering the perspective of the product's end-users, who actually use the products. It is preferable that the acceptable limit is not lower than end-user needs. In addition, it is preferable that the acceptable limit not be unnecessarily higher than the end-user needs. Regarding defects or changes in image quality, care should be taken that the detection capability of the observer can be enhanced by experience and that the proficiency of the visual assessment and corresponding criteria do not become unnecessarily strict.

NOTE The observers of the visual assessments are generally professional and not end-users. The observers do the assessment based on the criteria which correspond to the perspective of the end-users.

7.4.2 Procedures

The limit sample or the grade samples should be prepared by a professional or professionals who understand the true needs of end-users.

It is common practice to prepare some samples at different levels, preferably three or five levels, from good to poor. Then a professional or professionals pick the sample that corresponds to the acceptable limit for a certain product, taking into account the true needs of end-users. The selected sample is then designated as the limit sample.

In other cases, the limit sample is determined from discussions between the manufacturer and the customer or customers of the product, taking the end-user true needs into account.

7.4.3 Affirmation of end-user true needs

The true needs of end-users can be affirmed using assessments by non-expert ('naïve') observers who have no expertise in image artefacts that may be introduced by the system under test. In any case, non-expert observers should not be, or have been, directly involved (i.e. they should not have been involved enough to acquire specific and detailed knowledge) in the development of the system under study. At least 15 non-expert observers should be used.

It is also recommended that end-user true needs be confirmed in the actual usage tests, such as possible actual ambient lighting, possible actual image patterns, possible actual geometry of observations.

For defects, non-expert observers shall assess the sample or the samples on the basis of the following criteria:

1) imperceptible
2) barely perceptible, but not annoying
3) perceptible and slightly annoying
4) clearly perceptible and distractive

5) clearly perceptible and seriously distractive

The observers shall also be asked to identify the level they would accept for a commercial product.

Defects or changes in image quality can be evaluated by paired comparisons with a reference stimulus. This method is usually applied for the evaluation of the DUT after environmental and/or mechanical endurance tests. In this case, after an endurance test, the DUTs are compared with the virgin DUT that was not exposed to the stress. For image quality deterioration by the stress test, non-expert observers shall assess the sample or the samples on the basis of the following criteria:

1) no change is visible
2) changes are barely visible but can be ignored
3) changes are visible and slightly bothersome
4) changes are clearly visible and distractive
5) changes are clearly visible and seriously distractive

The observers shall also be asked to identify the level they would accept for a commercial product.

7.5 Judgments without a limit sample or a set of grade samples

7.5.1 General

This document also applies when a limit sample or a set of grade samples is not available for the same kind of defect or the same mode of image deterioration. For defects of flexible display devices, many kinds of defects can be observed. Even within the same category of defect, the shape, size, luminance, colour, gradation of the edge, width of the edge, solitary or repetitive, position in the display area and various other factors can differ. Therefore, in some cases, it is practically impossible to prepare a limit sample for visual assessment.

7.5.2 Procedures

Observers shall assess the sample under single stimuli to determine whether it is acceptable.

Observers shall be periodically trained by a qualified person with a set of graded samples. Although graded samples for the same kinds of deterioration or defects are preferred, graded samples for other kinds of defects can be used to adjust the grading criteria of observers.

7.6 Assessment using an ND (neutral density) filter

7.6.1 General

For some kinds of defects, detection sensitivity can be changed by inserting an ND filter in front of the DUT. In this case, the acceptance of defects can be judged based on whether the defect is visible through an ND filter having a certain density. Examples of the densities of the ND filter are 1 %, 2 %, 5 % and 10 %. The density of the ND filter used shall be agreed upon by the manufacturer and the customer, and it shall be stated in the detailed specifications.

ND filters for visual assessment are more generally used for extensive diagnosis of the defect once it is observed by the unaided eye. If the unaided eye cannot observe the defect, then the use of the ND filter is not needed.

7.6.2 Procedures

When using an ND filter for judging mura defects, place the ND filter near the mura defect and get close to the surface of DUT. The distance between the surface of the DUT and the ND filter shall be less than 5 cm, but the ND filter shall not touch the surface of the DUT. The

defects shall be assessed from straight above the position of the defects. The assessment shall be completed within 3 s in order to prevent adaptation of the eye to the darker view.

7.7 Assessment method for mechanical defects

Mechanical defects, such as scratches, abrasions, dents and cracks, shall be observed while the DUT is on and off. Lighting should be determined on the basis of the usage and the kinds of defects. Some defects are clearly observed with directional lighting.

8 Reporting

8.1 Requirements for reporting

The report shall include the following items:

a) identification of display module
b) visual assessment results

8.2 Recommendations for reporting

The report should include the following items:

a) date and time of assessment
b) identification of display module
   – product name, type, lot
   – date of production
   – reference sample(s)
c) observer(s) – number and type
d) ambient conditions during assessment
   – environmental conditions
   – lighting conditions
e) geometry of assessment
f) test patterns
g) results of assessment
   – grade
   – others
   – other observations or remarks
h) conclusions

Annex A
(informative)

Ranking of mura defect using ND filter

ND filters for visual assessment are more generally used for extensive diagnosis of the defect once it is observed by the unaided eye. If the unaided eye cannot observe the defect, then the use of the ND filter is not needed.

An example of the procedures and ranking of mura defect using an ND filter is shown in Table A.1.

Table A.1 – Example of ranking of mura defect using an ND filter

Step	ND filter	Assessment results of mura	Rank
1	No	Not evident even without ND filter	A
2	No ➔ 10 %	Evident without ND filter, but not evident with 10 % ND filter	B
3	10 % ➔ 5 %	Evident with 10 % ND filter, but not evident with 5 % ND filter	C
4	5 % ➔ 2 %	Evident with 5 % ND filter, but not evident with 2 % ND filter	D
5	2 % ➔ 1 %	Evident with 2 % ND filter, but not evident with 1 % ND filter	E
6	1 %	Evident with 1 % ND filter	F
NOTE x % indicate that the optical transmittance of the ND filter is x %			

At first, the DUT is assessed without filter. If mura is not evident even without an ND filter, the DUT is ranked A.

If mura is evident without an ND filter, insert a 10 % ND filter. If mura is not evident with a 10 % ND filter, the DUT is ranked B.

If mura is evident with a 10 % ND filter, insert a 5 % ND filter. If mura is not evident with a 5 % ND filter, the DUT is ranked C.

If mura is evident with a 5 % ND filter, insert a 2 % ND filter. If mura is not evident with a 2 % ND filter, the DUT is ranked D.

If mura is evident with a 2 % ND filter, insert a 1 % ND filter. If mura is not evident with 1 % ND filter, the DUT is ranked E.

If mura is evident even with a 1 % ND filter, the DUT is ranked F.

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